# Lehigh

# 1970
# 1971

# LEHIGH UNIVERSITY

## UNIVERSITY CATALOG ISSUE

## 1970 - 1971

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# LEHIGH UNIVERSITY

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. A liberal man, his political power grew. 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.

In 1865, Judge Packer foresaw the great industrial development that was just beginning and which he has 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, by providing opportunities for young men to carry on the work in which he felt such a lively interest. He asked Episcopal Bishop William Bacon Stevens to help him plan a university.

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

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

Lehigh's founder was also in the avant-garde of public industrialists. During his lifetime, and by request, 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 maintained at less than 3,200 men—Lehigh desires to remain a small university, and with its faculty of more than 300, to provide the best possible education for a 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 house of national social fraternities which maintain chapters at Lehigh.

The students currently enrolled come from 900 public and private secondary schools in 40 states and 26 foreign countries. The last freshman class of 850 men was selected from over 3,300 candidates for admission.

Forty-nine per cent of the undergraduate student body are enrolled in the College of Engineering; thirty-one per cent in the College of Arts and Science; and sixteen per cent in the College of Business and Economics. The remaining four 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 76,000, 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 exclusively for playing fields. With the addition of land acquired through a cooperative venture with Bethlehem's Urban Renewal program, the University has added new library, classroom, and laboratory facilities.

Settled in 1741 by Moravians seeking religious asylum, the city of Bethlehem is rich in historic tradition. The city became an important point for early colonial travelers stopping between New York and Philadelphia. Twenty-one remarkably preserved pre-Revolutionary War buildings remain in the heart of the city. Many have been restored and others will be reconstructed. Each spring, the city and the campus receive thousands of music lovers who come to hear the famous 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), St. Frances de Sales (men), 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.

## RECENT DEVELOPMENTS AT LEHIGH

Certainly the most dynamic aspect of Lehigh's current growth has been the Centennial Development Program. It has been observed that no university is the same after a major fund-raising campaign, and this can be seen in the results of Lehigh's seven-year Centennial fund drive. The $25-million raised in that drive has provided Lehigh with the Whitaker Metallurgical and Chemical Engineering Laboratory, the Centennial Residence Halls, more than $8-million for faculty salaries and student financial assistance, new facilities or renovations for twenty-three fraternities, and the Saucon Valley Playing Fields and Varsity House. The funds also have provided a new science-engineering library, power plant, and hall of liberal arts.

Developments in the academic program are less obvious and dramatic but even more important. Numerous honors have been bestowed upon Lehigh faculty members in recent years, including Fulbright awards, honorary degrees, Ford Foundation and Guggenheim grants, and the Pulitzer Prize in History. Within recent years, Lehigh seniors have been chosen for Woodrow Wilson, Marshall, and Rhodes scholarships.

## UNDERGRADUATE ADMISSION REQUIREMENTS

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

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

### (1) 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 certain prescribed subjects and sufficient electives to make up the totals listed in the accompanying 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 mathematics, 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

| Subjects | Units |
|---|---|
| English | 4 |
| Foreign Language (4 units are recommended) | 2 |
| College Preparatory Mathematics | 4 |
| Electives | 6 |
| Total | 16 |

*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.*

### (2) 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 four to five times as many candidates apply for admission to the University as 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.

### (3) 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. (The 1970-71 schedule is shown below.)

ACHIEVEMENT TESTS: Each candidate is required to write *three* additional afternoon College Board Achievement Tests. One of these must be English Composition. Candidates for a science program, for engineering, and for arts-engineering are required to write Mathematics, either *Level I* (*Standard*) *or Level II* (*Intensive*), and Chemistry or Physics Achievement Tests. Other candidates are required to write two tests which they may choose in consultation with their advisers. The Achievement Tests should be written in December, or January of the senior year unless satisfactory results were submitted to Lehigh University from junior year tests.

SCHEDULE OF COLLEGE BOARD TESTS 1970-71

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|---|---|---|
| November 7, 1970 | | |
| December 5, 1970 | *Note:* The SAT and Achieve- |
| January 9, 1971 | ment Tests, will be offered on |
| March 6, 1971 | all testing dates, except No- |
| May 1, 1971 | vember when only the SAT is |
| July 10, 1971 | offered. |

Information and application forms for the tests 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 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 blank or, if he failed to do this, by special request to the College Board office. In addition to requesting College Board scores, the candidate must submit an application for admission to the freshman class at Lehigh.

### (4) OTHER CRITERIA AND INTERVIEWS

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

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 at 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 blank 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. Lehigh gives first consideration to applications returned promptly after receipt. 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.

The candidate should arrange with his school adviser to register for morning and afternoon tests administered by the College Entrance Examination Board. As indicated in the section on Entrance Examinations (No. 3), Lehigh recommends that the SAT be written in November, December or January of the senior year and the three afternoon Achievement Tests in December or January.

Most important of all he should maintain a good academic record. He should learn how to budget his time. He should work hard to develop study habits which will assure a strong record in secondary school and will give him a good start in his freshman year in college.

## 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 $10.00. 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

Many candidates have asked about "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, Lehigh's decisions will be made by December 1. If the decision is favorable, it is assumed the 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 should promptly withdraw 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.

It is important to remember that admission to college is a "two-way street": seniors select colleges to which to apply; from these candidates colleges select their freshmen. The "early decision" plans are designed to reduce multiple applications, to encourage candidates to make early choices and to help colleges determine their freshman classes.

For instance, candidates definitely have Lehigh as their first choice, but seldom is it known who these candidates are. Lehigh's plan gives the well-qualified candidate an opportunity to make his selection known as early as possible.

However, 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.

## 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 of 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.

## ADVANCED STANDING FROM SECONDARY SCHOOLS

Advanced standing for freshman courses may be earned by secondary school students in two ways: through Advanced Placement Tests administered by the College Entrance Examination Board or by advanced standing examinations administered at Lehigh University. Both methods require that the candidate shall have studied significantly advanced work.

A few private and public secondary schools now offer truly advanced courses for limited numbers of selected students. If a candidate has completed, or expects to complete, such a course in an approved secondary school, he may establish advanced standing by taking an Advanced Placement Test or a Lehigh test in the subject. In either case he should confer with his school principal and with the Director of Admission of Lehigh University.

The privilege of taking an advanced standing examination at Lehigh is granted only on written request to the Director of Admission not later than July first of the year the student plans to enter college. Such examinations are scheduled by the University usually at the beginning of Freshman Orientation.

## ADVANCED STANDING FROM ANOTHER COLLEGE

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 $10 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. Such a transcript must include a complete list of all courses taken, a list of entrance credits accepted for admission, and a statement of honorable dismissal. 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.

## UNDERGRADUATE FEES

The comprehensive tuition in all the undergraduate colleges is $2,300 a year. A student regularly enrolled in any of the undergraduate divisions of the University who registers for fewer than the normal hours of work will pay either $96 for each semester-hour carried or the regular tuition, whichever amount is lower.

There are no fees for athletics, health service,

library, student activities, or student concerts-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.

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 add or drop any course except on the recommendation of the director of his curriculum. There will be a $10 change-of-roster fee for each such 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. Refer to General Regulations — Notice of Candidacy for Degree, page 24.

APPLICATION FOR ADMISSION FEE. A fee of $10 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 $96 for each such course attended.

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

## Refunds

UNDERGRADUATE. If a student withdraws from the University, he is entitled to receive a refund of his tuition less $50 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. In the event of the death of a stu-

dent 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. 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.

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 corresponding relative date in a summer session.

RESIDENCE HALL RENTAL. Residence hall rental paid in advance is refundable in its entirety for any term in which the student does not register in the University or on a proportional basis for cancellation due to the student's death or involuntary induction into the armed forces. Otherwise, refunds are limited to the proportional charge for the unexpired portion of the student's lease less a charge of $25, and to cases of (a) withdrawal from the University (for reasons not involving misconduct) or (b) transfer of lease to another student (for whom no other accommodations exist), subject to approval of the Dean of Residence Halls. Refunds authorized under this regulation shall be certified to the Bursar by the Dean of Residence.

Note: Rooms are rented in September on an annual lease basis only. A freshman who does not live at home is required to live in the residence halls during his first year. An upperclassman who signs a lease is expected to occupy a room in the residence halls for the full college year.

DINING SERVICES. Refunds will be allowed only on written request to the Treasurer approved by the Dean of Residence. Normally such requests will be approved in cases of confining illness requiring absence from all University activities for a period longer than 14 consecutive days or in cases of voluntary withdrawal from the University, involuntary induction into the Armed Forces, or death of the student. Refunds will be computed on the basis of the cost per day for the board plan involved for each full day of absence.

If a student is suspended or expelled from the University, he may be allowed as a refund 50 per cent of the amount representing the unexpired portion of his original dining service contract for the semester.

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.

## ESTIMATE OF EXPENSES

Items of personal expense are dependent upon each student's personal habits and circumstances. There are certain basic expenses, however, which must be met by all students. An *estimate* of annual cost is listed below:

| | |
|---|---|
| Tuition | $2,300 |
| Books and Supplies | 150 |
| Room (average) | 430 |
| Subsistence (estimate) | 640 |
| | $3,520 |

(Note: Students taking military or air science or band are required to make a $25 deposit which is refundable at the end of the school year.)

Books, stationery, and drawing instruments may be purchased at the Supply Bureau in the University Center.

Students living in Residence Halls are required to eat in the University Center. Board will be billed on a semester basis payable prior to registration.

## LIVING ARRANGEMENTS

Lehigh undergraduates live in eleven University residence halls (45 per cent), or in 31 fraternity houses by invitation (35 per cent), or off-campus (20 per cent). All freshmen who do not live at home are required to live in the residence halls, which are staffed by a corps of carefully selected upperclass counselors responsible to the Dean of Residence.

### Dining Services

Each student who lives in the Residence Halls is

provided with board in the University dining service in the new University Center. The following three board plans are available:

A. Twenty-one meals per week (3 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) — $630 per school year.

B. Seventeen meals per week (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, and meals during the examination periods ending with the noon meal of the last day of examinations) — $570 per school year.

C. Fifteen meals per week (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, and meals during the examination periods ending with the noon meal of the last day of examinations) — $546 per school year.

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 only to students of the Residence Halls. 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 at the University dining service at the University Center during Freshman Orientation. There will be an additional charge of $8 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 others 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.

## Residence Halls

Room rents in the residence halls range from $215 to $235 per student per semester with maid service included. Rooms are rented in September on an annual lease basis only. The typical room is shared by two students. For each student there is provided a bed, box spring, mattress, chest of drawers, desk and chair; residents supply desk lamps, waste baskets, bedding, etc. Commercial linen service is available at a rate presently $29.70 per year. Personal laundry on a commercial contract basis is available at $90.10 a 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 or 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 students live in fraternity houses. Such accommodations are available only to upperclassmen who receive invitations to join the groups.

Of the thirty-one social fraternities with chapters at Lehigh, twenty-six occupy houses on the campus. The remaining houses are in Bethlehem adjacent to the campus.

Many commodities and services needed by the fraternities are provided by the co-operative Fraternity Service Association organized on campus in 1967.

Membership in a fraternity is, of course, by invitation from the group. Freshmen are "rushed" during the second semester of the freshman year, but they do not move into fraternity houses until the sophomore year.

The following Greek letter social fraternities maintain chapter houses at Lehigh University

| | |
|---|---|
| Alpha Chi Rho | Phi Kappa Theta |
| Alpha Sigma Phi | Phi Sigma Kappa |
| Alpha Tau Omega | Pi Kappa Alpha |
| Beta Theta Pi | Pi Lambda Phi |
| Chi Phi | Psi Upsilon |
| Chi Psi | Sigma Alpha Mu |
| Delta Chi | Sigma Chi |
| Delta Phi | Sigma Nu |
| Delta Sigma Phi | Sigma Phi |
| Delta Tau Delta | Sigma Phi Epsilon |
| Delta Upsilon | Tau Delta Phi |
| Kappa Alpha | Tau Epsilon Phi |
| Kappa Sigma | Theta Chi |
| Lambda Chi Alpha | Theta Delta Chi |
| Phi Delta Theta | Theta Xi |
| Phi Gamma Delta | |

## STUDENT PERSONNEL SERVICES

General counseling of individual students, especially in the freshman year, is largely the responsibility of the student personnel services—a group of cooperating agents and agencies. For the new student and his parents, such services begin in their earliest discussions with the Director of Admission and his staff. Most of the student's early contacts after his entrance are 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 advisers 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 beginning of his course as an individual and his choice of studies is carefully organized in terms of his specific backgrounds of preparation and his future objectives. Individual counseling continues throughout the student's four years in the College. In the College of Business and Economics faculty advisors work with the individual student and his individual problems for the same purposes. Similarly, the Associate Dean of the College of Engineering curriculum spends much time with the freshman engineering students in an effort to help in the adjustment of academic difficulties and in better definition of vocational objectives. These forms of advisement are carried on through the following years with the student's academic advisors.

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

If a student is 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. (See page 17).

Financial problems can become a serious hazard for a student. The Executive Secretary of the Committee on Undergraduate Financial Aid is always available for conference and may find 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. (See page 17).

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, chaperones at social affairs, 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 institutions. 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. Twelve beds are available for short periods of observation. 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. Routine care provided by the regular Health Center physicians, nurses, etc., is provided at no cost to students.

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 physician 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.

A necessarily limited emergency service is extended by the Health Service to faculty members and other employees.

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 his 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 his disability discussed with him confidentially.

Close cooperation between the Department of Physical Education and the Health Service permits the establishment of rehabilitation measures, etc., as indicated. All students are classified for the physical education program according to their abilities to participate in physical activities.

IMMUNIZATIONS. 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 IN-SURANCE. 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, and we urge all students 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 Center, 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 oppor-

tunity 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 Admission 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 men an opportunity to develop satisfactory reading and study habits. The following services are available to all students:

Analysis of reading and study skills; Reading and study improvement programs; and, Individual guidance on problems of academic adjustment.

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

The improvement programs are offered periodically during the fall and spring semesters. Small group instruction is scheduled for interested students. The instruction is adapted to the needs of the individual in well-equipped facilities.

## STUDENT ACTIVITIES

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.

Approximately eighty professional, interest, avocational, and honorary groups are recognized by the Committee on Student Activities. Within the wide and varied scope of these organizations each student can find an outlet for his professional and avocational interest and an opportunity to learn how to be a leader and how to be a member of an organization of the University. Through such experiences he becomes a more useful citizen in the Lehigh community and, after graduation, in the large community in which he will make his home.

### The Joint Commission

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, the University created the Joint Commission on University Life. The commission serves as a forum at which any component group of the University can raise issues of interest to

the Lehigh community. The commission is composed of students, faculty, trustees, and administrators.

While not a policy-making agency, the Commission does serve as a media through which policy can be discussed. In its initial efforts in 1969, JCUL considered recommendations of the University Goals Committee, a student-faculty-alumni committee appointed by the president to study Lehigh's educational philosophy and program.

### Student Government

The student council of Lehigh, known as "Arcadia," has undergone many changes since it was established in 1884 by Richard Harding Davis. Arcadia is composed of twenty men elected in the spring from the student body and delegates elected or appointed to represent different student groups such as class governments, residence halls, and fraternities.

Lehigh has long recognized the value both to students and to the University of joint student-faculty committees. Students currently hold membership on most University faculty committees including the Educational Policy Committee, the Committee on Awards and Prizes, Campus Facilities Committee and the Committee on Discipline, the Student Life Committee, the University Center Advisory Committee, the Board of Publications, the Committee on Student Activities, Committee on Performing Arts, Committee on Financial Aid, Committee on Admission, and the Arts College Committee. Student members are recommended by Arcadia; faculty members are elected by the faculty of the University. Though these committees are not unique to Lehigh, few other colleges and universities have as many.

Other forms of student government are concerned largely with the major residence groups: the residence halls, fraternities, and the commuting students. Each of these groups elects its own officers to administer its affairs.

Students also have an organization for selecting speakers who will come to campus; this is the student-faculty Forum for Visiting Lecturers Committee operated under Arcadia.

### National Honorary and Recognition Societies

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

### Volunteer Service Organizations

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 Community Relations and Volunteer 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 aid society which provides volunteer 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 progressive 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 Ameri-

can college students devote their summers to community work projects in Africa supervised by Africans.

A new addition to the volunteer services program is a six-week tutoring program during the summer to introduce Bethlehem area high school students from black, Puerto Rican, and white families to the excitement of learning. The remedial instructional program for the disadvantaged will involve fifteen Lehigh students who will serve as private tutors.

**Student Organizations**

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*, a weekly supplement for the arts and opinion, the *Sunday Review*, magazine of general literary interest, *Paisley*, 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 each year sponsors two or three Conferences on Religion with a leader representing one of the major religious faiths. The Conference on Religion consists of lectures in classrooms, seminars for faculty and students, and informal group discussions in residence halls and fraternity houses. More recently the Council has sponsored 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 the 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, and 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.

## SOCIAL LIFE

The social life of students at Lehigh is an important part of the educational experience. Not only does it provide opportunities for recreation and a change of pace from strictly academic activities, but also a chance to associate with girls who come to the campus for parties and other events and who provide an agreeable alternative to the all-male climate of the classroom and laboratory. In addition, the social life program at Lehigh provides many opportunities for the personal development of the individual student because of the great measure of self-determination and self-governance associated with student programs.

Because this introduction to self-governance in social as well as academic areas is experienced by the freshman in a new setting at the same time other demands are being faced initially, several student organizations and University offices assume the responsibility of facilitating the freshman's adjustment to the pattern of social life. The social program begins early in the fall with a dance for Lehigh freshmen and girls from neighboring colleges.

Parties are generally held each weekend there is a home athletic event. There are often frequent concert performances by major musical organizations on campus arranged in association with a football game or wrestling meet, and the "big weekends" which offer such a combination are often the high points of the social agenda. On the so-called "off weekends" there are frequently more modest events. It is the custom at Lehigh for major lectures, concerts, and other special events to be followed by receptions to which students, dates, faculty, and members of the University community are invited. Many of these receptions are held in residence halls, fraternity houses, or the student-operated coffeehouse.

## 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 Foundation, 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 Ginsburg, Howard Zinn, Charles V. Hamilton, and Barry Goldwater. A special feature of the program has been the six-week series on Negro history and the eight-week series on urban planning.

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, and W. Averell Harriman. 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, is a pioneer in the petroleum industry and an international statesman of some note.

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.

## SPECIAL ACADEMIC PROGRAMS

### 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 summer language and literature programs abroad. This program is open to students from Lehigh and other institutions at the undergraduate and graduate levels.

### THE WASHINGTON SEMESTER

Opportunity is available each year for four 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. Normally the "majors" of these students are in the fields of government, history, international relations, economics, sociology, and related social sciences and humanities.

### FRESHMAN SEMINARS

Interdisciplinary problem-centered Freshman Seminars (FS) are offered each semester on an experimental basis 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 the study of contemporary cultural problems as it relates 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. The faculty is increasing course offerings in Afro-American studies and is exploring the organization of a comprehensive Afro-American studies program which might supplement existing major programs.

## COMPREHENSIVE HONORS PROGRAM

The Comprehensive Honors Program provides superior students with unusual opportunities for intellectual and scholarly development.

### Freshman-Sophomore Years

These are the years in which a student normally completes his exploration of possible major fields and lays the groundwork in the chosen major and in its collateral fields. Thus, honors opportunities are limited.

Honors opportunities for freshmen consist of (1) voluntary enrollment in Honors sections of certain multi-section courses, and (2) acceleration through the attainment of advanced standing. Freshmen who qualify for enrollment in Honors sections will be notified before registration. Advanced standing may be obtained through:

a) The CEEB Advanced Placement Program.

b) Certification by the Office of Admission and the Registrar of college credit for certain secondary school special courses.

c) Anticipatory Examinations during freshman week when there is substantial evidence of special achievement not covered in (a) and (b) above.

In the post-freshman summer the opportunity is offered to engage in guided but truly independent study in preparation for special examinations at the beginning of the sophomore year.

Sophomore opportunities are (1) continuation of enrollment in Honors sections and (2) automatic waiver of the junior-standing prerequisite for courses numbered "100" to "399", if the student has the course prerequisites.

Freshmen and sophomores interested in pursuing these opportunities should consult the Dean of the College in which they are registered.

### Junior-Senior Years

Honor students are those students with a cumulative average of 3.0 or higher. During the junior and senior years, an honor student may choose to work for either Departmental Honors or Interdepartmental 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 be permitted to work for Departmental Honors.

#### DEPARTMENTAL HONORS

Departmental Honors 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* (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*

A candidate for Departmental Honors must announce to his major advisor, not later than the end of his junior year, his intention to work for Departmental Honors. Each major advisor shall send 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. Awards are based on grades obtained in the subject chosen, the results in extra work assigned, and the general proficiency of the candidate as evidenced by either a final examination or a thesis, as the chairman of the department involved may direct.

## INTERDEPARTMENTAL HONORS

The Interdepartmental Honors Program is open to undergraduates from all three Colleges. It offers to students who have demonstrated outstanding ability the opportunity to devote part of their junior and senior years to independent study through a series of limited enrollment seminars and the writing of a thesis. The seminars, one in each of the four large areas of human knowledge, combine breadth, which balances the concentration in a major, with the depth which is possible in small classes of students carefully selected from all majors. The seminars and the thesis also 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:

(1) Completed three of the four Honors Seminars with an average grade of at least 3.33. (University Scholars are permitted to take all four Honors Seminars in which case the required average grade for graduation with Interdepartmental Honors is 3.25.)

(2) Completed an Honors Thesis with a grade of "A".

(A University Scholar who has met all the requirements for graduation in his college but who fails to achieve the specified levels will receive his degree without Interdepartmental Honors.)

## ADMISSION

Each sophomore eligible for admission to the College Honors Program will be notified of his eligibility early 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, or in unusual cases, has had an outstanding record in his second and third semesters.

Admission requires the approval of the chairman of the department in which an applicant is majoring and of the Honors Council.

Each applicant will be notified of the decision on his application far enough in advance of preregistration for the ensuing fall semester to make appropriate plans.

In unusual situations, an outstanding student may, with the approval of the Honors Council, schedule one or more Honors Seminars without committing himself to the whole program. Such special permission will be granted, however, only when the Council feels certain that his admission will not interfere with the maximum effectiveness of the program for those regularly enrolled.

## THE PROGRAM

A student admitted to the Interdepartmental Honors Program will:

(1) Continue with his departmental major.

(2) Schedule one Creative Concepts seminar (see course offerings, page 127) each semester of his junior year and at least one seminar during his senior year. (Those University Scholars who elect to schedule only three seminars are urged to schedule those which are farthest from their major field.)

(3) Schedule Creative Concepts 190, Honors Thesis (3 to 6 credits), during one or both of the semesters of his senior year or during the preceding summer. The work in this course will be directed by an approved member of the faculty and will culminate in the writing of an honors thesis.

University Scholars must file with the Chairman of Honors Programs a thesis proposal approved by

their thesis advisor, department chairman, and the Interdepartmental Honors Council at least one week prior to the last day of registration for the semester during which Creative Concepts 190, Honors Thesis, is first scheduled.

The Interdepartmental Honors Program is administered by the Chairman of Honors Programs. The organization and conduct of the Honors Seminars will be directed by the Honors Council, which shall consist of (a) all faculty members currently teaching in the program or designated to teach in it, (b) the teacher or teachers who have conducted seminars during the preceding semester, and (c) the dean of the College, ex officio. Seminar teachers may be members of the faculty of any of the three colleges. The writing of the thesis will be directed by a member of the faculty with professorial rank.

University Scholars in the College of Arts and Science may, with the approval of the dean, substitute Creative Concepts seminars for distribution courses other than foreign languages.

## 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 male 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.

## GENERAL INFORMATION

### ACADEMIC REGULATIONS

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

To be eligible for a degree from Lehigh University, a student not only must have completed all of the scholastic requirements for the degree, but also he must have paid all University fees, and in addition all bills for the rental of rooms in the residence halls, or for damage to University property or equipment, or for any other indebtedness to the University. It is understood, however, that this regulation does not apply to any 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.

Unless exempted by the faculty for some special reason, such as poor health, a student must satisfy all physical education requirements in order to qualify for graduation.

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.

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; D**—Unsatisfactory, but passing; F—Failure. Physical education is marked P (passing) or F (failure) without hour credit.

A student who withdraws from a course during the first seven weeks of instruction will receive a grade of "W." A student who withdraws from a course after the first seven 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 seventh 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 also 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 restrictions on the use of the system are:
1. Before a student can take a course pass-fail, he must have achieved sophomore standing, have declared a major, and he must be in

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*Continuation Competency ("C") is 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.

**Unsatisfactory but passing ("D") is 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.

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.

3. 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

GENERAL. The scholastic requirements for each student are expressed in terms of his cumulative scholastic average (the weighted point average of all grades received in residence). The cumulative scholastic average will be computed at the end of each semester (and full summer session, i.e., one in which 12 or more semester hours have been rostered). Grades are weighted as follows: A, 4; B, 3; C, 2; D, 1; F, WF, Abs.F., Inc.F., 0.

GRADUATION REQUIREMENT. A student must have a cumulative scholastic average of 1.70 or better in order to be eligible for graduation. This cumulative scholastic average includes all courses passed or failed while in residence.

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, however, all students have the right of 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 interdepartmental honors, see page 22.)

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 faculty to those students who have attained an average of not less than 3.00 in their last two years' work at the University.

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

Degrees "with highest honors" are awarded by vote of the faculty to those students who have attained 3.75 in their last two years' work at the University.

Candidates for graduation who have been in residence at the University for less than two years are not eligible for graduation honors.

Graduation honors are announced at the graduation exercises.

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.

DEPARTMENTAL HONORS. Special honors are awarded at the end of the senior year, on recommendation of the chairman of the department concerned and by vote of the faculty, to students who have done advanced work of unusual merit in some chosen field. Candidates for departmental honors must indicate to the chairman of the department concerned and to the Registrar during the junior year their intention to work for such honors. Awards are based on grades obtained in the subject chosen, the results in extra work as-

signed and the general proficiency of the candidate as evidenced either by a final examination or a thesis, as the chairman of the department involved may direct. Departmental honors are announced at the graduation exercises.

LATEST DATE FOR REGISTRATION. No registration is accepted later than the tenth day of instruction in any semester.

## 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 take cognizance of the off-campus behavior of students only insofar as such behavior is relevant to membership in the academic com-

munity. 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.

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 to 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.

Recently there has been considerable publicity regarding the illegal traffic in *drugs* and increased activity of enforcement agencies involving college students. In June, 1967, the University faculty made its position quite clear when it approved a regulation stating that "the use or distribution of illegal or dangerous drugs by any student without prescription is regarded as a threat to the social community and necessary disciplinary action up to and including dismissal will be taken against the offender." It is obvious therefore, that the University will not condone the illicit use of dangerous drugs (including LSD) and marijuana. In addition to the University regulation, there is also Pennsylvania or Federal laws, or both, which prohibit, use, possession, sale and traffic in marijuana and dangerous drugs. It should be noted that some of the penalties are very severe.

Recent liberalization of visiting regulations for *women guests* is to be understood in terms of the University's essential character and some fundamental educational principles. As an all-male 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 should 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.

Students at Lehigh University are permitted under certain conditions to have *motor vehicles* while attending the University. This privilege will be revoked whenever it appears that the possession of a motor vehicle is interfering with a student's academic work, that he 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.

The University faculty has recently endorsed a *policy on dissent* which emphasizes the responsibility of all members of the University community. The guidelines adopted broadly set forth acceptable and unacceptable 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.

# COLLEGE OF ARTS AND SCIENCE

W. Ross Yates, *Dean*
G. Mark Ellis, *Assistant Dean*

The College of Arts and Science of Lehigh University comprises the departments of biology, classics, English, fine arts, geological sciences, German and Russian, government, history, international relations, mathematics, music, philosophy, psychology, religion, romance languages and literatures, and social relations. Students in Arts and Science may also major in economics, accounting, finance, physics, and chemistry.

The degree of Bachelor of Arts is conferred upon graduates of the College.

## PURPOSES

Under the name "School of General Literature," the College of Arts and Science was a part of the original plan of the University, and its aims have remained constant, although the means employed have been adapted to the changing times.

The purpose of the College is to prepare a man for the exercise of his individual responsibility in the affairs of mature life. This purpose recognizes three distinguishing characteristics of an educated man: the ability to think in a disciplined manner, the ability and willingness to make discriminating judgments, and the capacity to apply his creative imagination.

In order to achieve this purpose the faculty shares with the student the range of human knowledge: the world of fact, and its counterpart, the world of ideas. The fundamentals of this experience remain what they have been for generations: a comprehensive study of all the broad areas of knowledge — the humanities, the natural and physical sciences, and the social sciences — and a rigorous training in one of them.

## COUNSELING

Each student in the College of Arts and Science is considered from the beginning as an individual. The College expects every student to have a well-defined purpose at entrance, but recognizes the student's right to change his objectives and for that reason gives him time in which to find himself and

establish the direction of his future career. To help the student in his decision, the College provides an advisory staff consisting of the dean of the College, the assistant dean, his faculty assistants, and the directors of the major sequences. The individual program for each entering student is reviewed by the dean of the College or his assistant, at or before the beginning of the first semester of the freshman year. This preliminary program is determined by the nature and quality of the student's preparation and by his personal interests. The final program, which is made out in detail no later than the end of the sophomore year, takes into account, in addition, demonstrated aptitudes and pre-professional or vocational needs.

## PREPARATION FOR GRADUATE AND PROFESSIONAL SCHOOLS

A large proportion of the graduates of the College of Arts and Science continue their work in graduate or professional schools. Students preparing for graduate or professional studies will work out a suitable program with the appropriate advisors.

PRE-MEDICAL AND PRE-DENTAL. Students preparing for medical or dental school will plan a program of studies in cooperation with the advisor of their major program, and the pre-medical advisors, namely Dean Ellis in the Arts College office and Dr. Hayden Pritchard of the Department of Biology. A Pre-Medical Advisory Committee assists in helping students prepare applications for medical or dental school.

PRE-LEGAL. Students interested in preparing for law school will work out a program of studies in cooperation with their major advisor. Information on requirements for entry into law school is available from Dean Ellis in the College Office or from Mr. Whitcomb in the Department of Government.

PRE-THEOLOGICAL. Students will select an appropriate major field and work out a program in connection with the major and spiritual advisors.

PRE-ARCHITECTURAL. The University offers no curriculum in architecture but can assist students in preparing for professional education in architectur-

al schools. Associate Professor Carlos Alvare, Department of Fine Arts, is advisor to pre-architectural students.

GRADUATE SCHOOL. Students interested in preparing for graduate school will plan their program in collaboration with the department in which their major is located.

TEACHING. Students planning teaching careers in primary or secondary schools are encouraged to select a major in the field in which they intend to teach and to postpone their professional courses in education to the graduate level. The School of Education provides information on graduate programs in education and requirements for certification in the several states.

## THE CURRICULA

The College of Arts and Science offers two curricula: the four-year curriculum with a major in one of the arts or sciences, and the five-year curriculum in Arts-Engineering. Both are based on the principles of distribution and concentration. Distribution requirements are the same for both curricula. In the Arts-Engineering program, the Engineering general studies requirements are met by completing the Arts College distribution requirements.

This reciprocal arrangement makes it impossible for an Arts-Engineer to qualify for a B.S. in engineering before he has met all requirements for the B.A.

## 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.

The distribution requirements are administered by the dean of the College of Arts and Science in accord with the group regulations given below. The subjects required of the individual student depend in part upon the field in which he expects to major, in part upon his personal preference, and in part upon the subjects he has taken in secondary school.

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

### I. Required Courses

A. FRESHMAN ENGLISH. The normal requirement is Engl. 1 and 2, Composition and Literature. Students who demonstrate satisfactory ability in written composition in the freshman placement tests will meet this distribution requirement by passing Engl. 11 and 12, Types of World Literature.

When a freshman completes Engl. 11 and 12 with a grade of B or better, he is given, in addition to the 6 hours of credit for those courses, 6 hours of advance standing credit for Engl. 1 and 2.

B. MATH. 21, 31, 41 or PHIL. 14. The course selected cannot also be used to satisfy the requirements enumerated under subheads III, IV, or V.

### II. Foreign Language

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, as determined by the appropriate language department. Number of hours varies depending on previous language study. Students who present at entrance three or four years of foreign language normally are able to meet this requirement with one year of advanced college work. Eighteen hours of course work are normally taken by students who begin a new language in college.

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

two years (12 hours) of one foreign language and one year (6 hours) of 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. (Please see page 21.)

## III. Humanities

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

A. 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).

B. FINE ARTS, MUSIC, OR ARCHAEOLOGY (if not used for social science requirement).

C. PHILOSOPHY.

D. RELIGION.

## IV. Natural Sciences and Mathematics

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

A. ASTRONOMY.

B. BIOLOGY.

C. CHEMISTRY.

D. GEOLOGICAL SCIENCES.

E. MATHEMATICS.

F. PHYSICS.

G. PSYCHOLOGY.

## V. Social Sciences

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

A. SOCIOLOGY, CULTURAL ANTHROPOLOGY, SOCIAL PSYCHOLOGY.

B. ANCIENT CIVILIZATION, HISTORY, ARCHAEOLOGY.

C. GOVERNMENT, INTERNATIONAL RELATIONS, ECONOMICS.

D. URBAN STUDIES.

## CONCENTRATION REQUIREMENTS

*Concentration Requirements in Arts and Science*

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 four-year Arts and Science curriculum must select some sequence of studies as his major field. *A major consists of at least twelve semester hours of advanced work in the field chosen.* Including preliminary college work, the minimum number of hours constituting a major is twenty-four. The actual major requirements are those stated under "Details of Major Sequences," pages 34-49.

The major work is designed to enable a student to master his chosen field so far as that is possible during 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 read widely in his subject and will prepare himself largely through his own reading.

When a student selects a major, the chairman of the department offering the major or the official director of a non-departmental major becomes the 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.

*Concentration Requirements in Arts-Engineering*

The standard major for students enrolled in the five-year Arts-Engineering curriculum is Applied Science (page 49). This major is normally completed during the first four years, during which the dean of the College of Arts and Science is the student's official advisor. At the end of the fourth year it is expected that Arts-Engineering students will have taken their B.A. degree and will transfer to the appropriate engineering curriculum for their final year. The chairman of the appropriate engineering department, who has meanwhile been acting as advisor of the major sequence, becomes official advisor for the fifth year.

Pattern rosters which show the normal combination of courses for the first four years of the Arts-

Engineering curriculum are given on pages 49-53.

Arts-Engineering students are encouraged to take one of the other majors offered in the College of Arts and Science. This program must have the approval of both the dean of the College of Arts and Science and the department chairman under whom work for the B.S. will be completed. In some instances it may be advisable to take the two degrees at the end of the fifth year.

To qualify for both the B.A. and the B.S. in Engineering, a student must submit for the second degree thirty credit hours in addition to the number required for the B.S. alone.

## 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 the B.A. 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.

## SPECIAL INTERDISCIPLINARY MAJORS

In addition to the Interdisciplinary Major Programs of Foreign Careers, Natural Science, American Studies, and Natural Resources, which are described later in this section, other 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 a member of the faculty acting as his advisor, work out an interdisciplinary major program to include not less than 24 hours of related course work, of which at least 12 hours shall consist of advanced courses. The program must be approved by the major advisor, at least one other faculty member from another department represented in the major program, and the dean of the College.

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

## REQUIREMENTS FOR GRADUATION

Graduation requirements for the degree of Bachelor of Arts include:

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. Physical education and 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 for students in the curriculum of Arts and Science (but not in the curriculum of Arts-Engineering).

3. Completion of all general requirements applying to all candidates for baccalaureate degrees. (Please see page 24.)

In addition, 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 toward graduation.

### 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 for students in the curriculum of Arts and Science is five regular academic courses with one or two-credit hour laboratory courses, other one-credit hour courses, and courses in military or air science being carried in addition. Normal semester course loads for Arts-Engineering students are detailed in the pattern rosters for Arts-Engineers on page 49.

### Comprehensive Examination or Senior Thesis

A 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 section "Details of Major Sequences", pages 34-49 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.

## 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 are listed on page 58, together with additional information concerning the M.B.A. program.

## HONORS AND UNSCHEDULED WORK

Qualified students in both curricula in the College of Arts and Science may choose to work for either Departmental or Interdepartmental Honors. Particularly well-qualified students sometimes work for both.

### Departmental Honors

Departmental honors are awarded at the end of the senior year, on recommendation of the chairman of the department concerned and by vote of the faculty, to students who have done advanced work of unusual merit in some chosen field. A candidate

for departmental honors must announce to his major advisor, not later than the end of his junior year, his intention to work for Departmental Honors. Each major advisor shall send the registrar and the College Office, no later than the close of registration of each fall semester, the names of seniors who are working for Departmental Honors in his major. Awards are based on grades obtained in the subject chosen, the results in extra work assigned, and the general proficiency of the candidate as evidenced by a thesis.

A student in Departmental Honors is granted a waiver of graduate standing to take courses numbered 400 and above if the student has the course prerequisites and if his semester schedule does not exceed fifteen hours.

### Interdepartmental Honors

The Interdepartmental Honors Program offers students who have demonstrated outstanding ability the opportunity to devote part of their junior and senior years to independent study through a series of limited enrollment seminars and the writing of a thesis. For a description of the program see p. 22.

### Unscheduled Work

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.

## DETAILS OF MAJOR SEQUENCES

## 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**

| | | |
|---|---|---|
| ENGL | 321 20TH CENTURY AMERICAN LITERATURE | |
| ENGL | 341 CONTEMPORARY AMERICAN LITERATURE | 6 |
| ENGL | 343 AMERICAN ROMANTICISM | |
| ENGL | 344 AMERICAN REALISM | |
| HIST | 319 17TH CENTURY AMERICA | |
| HIST | 320 18TH CENTURY AMERICA | 6 |
| HIST | 327 AMERICAN INTELLECTUAL HISTORY | |
| HIST | 328 AMERICAN INTELLECTUAL HISTORY | |

**Options***

| | | |
|---|---|---|
| HIST | EUROPEAN HISTORY | 6 |
| ENGL | EUROPEAN LITERATURE | 6 |
| ELECTIVES | | 6 |

*Choice of electives 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.

## BIOLOGY

The biology major serves several purposes. It provides training for students aiming for graduate study in any of the biological sciences. The program also exceeds the minimum science requirements for admission to medical, dental and allied professional colleges. Finally, the major offers a terminal B.A. degree for students interested in the science of life yet aiming for a career in the business world, teaching at the pre-college level, or some other profession.

To fulfill all of these functions the biology major combines a maximum choice of biology elective courses with a strong requirement in chemistry, physics and mathematics. This enables students to channel their biology training along paths suitable to their interests, aims and competence while, at the same time, it ensures adequate training in other sciences upon which much of contemporary biology is based.

**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 | 313 GENERAL HISTOLOGY | 3 |
| BIOL | 314 VERTEBRATE EMBRYOLOGY | 3 |
| BIOL | 317 EVOLUTION | 3 |
| BIOL | 320 PHYSIOLOGY | 3 |
| BIOL | 333 SYMBIOSIS | |
| 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 |

For students interested in applying to medical, dental or veterinary colleges, Biol. 34, Comparative Vertebrate Anatomy, and Biol. 314, Vertebrate Embryology, are recommended electives.

For students interested in graduate study, Chem. 90, Physical Chemistry, is a suitable elective that may be substituted for biology elective or Chem 39. For these students substitution of Physics 3 & 4 for Physics 16 & 17 and addition of Math. 44 should be considered.

### Additional Required Courses

| | | |
|---|---|---|
| MATH | 41 | BMSS CALCULUS |
| MATH | 42 | BMSS PROBABILITY |
| MATH | 43 | BMSS LINEAR ALGEBRA |
| CHEM | 1 & 11 | CHEMISTRY PRINCIPLES I & LABORATORY |
| CHEM | 3 & 13 | CHEMISTRY PRINCIPLES II & LABORATORY |
| CHEM | 51, 52, 53 | |
| | or 55 | ORGANIC CHEMISTRY & LABORATORY |
| CHEM | 39 | ANALYTICAL CHEMISTRY |
| | | or |
| CHEM | 90 | PHYSICAL CHEMISTRY |
| PHYS | 1, 16 & 17 | MECHANICS OF MASS POINTS, GENERAL PHYSICS AND PHYSICS LABORATORY |

### Recommended Sequence of Courses

#### Freshman Year

| | | | |
|---|---|---|---|
| BIOL | 21 | PRINCIPLES OF BIOLOGY | 3 |
| BIOL | 22 | INTRODUCTION TO BIOLOGY LABORATORY | 1 |
| CHEM | 1 | CHEMICAL PRINCIPLES I | 3 |
| CHEM | 11 | CHEMICAL PRINCIPLES I LABORATORY | 1 |
| MATH | 41 | BMSS CALCULUS | 3 |
| BIOL | 28 | GENETICS | 3 |
| CHEM | 3 | CHEMICAL PRINCIPLES II | 3 |
| CHEM | 13 | CHEMICAL PRINCIPLES II LABORATORY | 1 |
| MATH | 42 | BMSS PROBABILITY | 3 |

#### Sophomore Year

| | | | |
|---|---|---|---|
| CHEM | 51 | ORGANIC CHEMISTRY | 3 |
| CHEM | 52 | ORGANIC CHEMISTRY | 3 |
| CHEM | 53 or 55 | ORGANIC CHEMISTRY LABORATORY | 2 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| MATH | 43 | BMSS LINEAR ALGEBRA | 3 |
| BIOL | | ELECTIVES | 3 OR 6 |

#### Junior Year

| | | | |
|---|---|---|---|
| CHEM | 39 | ANALYTICAL CHEMISTRY | 3 |
| | | OR | |
| CHEM | 90 | PHYSICAL CHEMISTRY | 3 |
| PHYS | 16 | GENERAL PHYSICS | 3 |
| PHYS | 17 | GENERAL PHYSICS LABORATORY | 2 |
| BIOL | | ELECTIVES | 3, 6 OR 9 |

#### Senior Year

| | | | |
|---|---|---|---|
| BIOL | 272 | SENIOR SEMINAR | 3 |
| BIOL | | ELECTIVES | 3, 6 OR 9 |

Biology: Natural Resources Option. Students interested in natural resources and their conservation may take the major in biology, slightly modified to permit taking collateral courses in geology and other pertinent fields.

## CHEMISTRY

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 (pages 65 and 66), for these differ in two respects. The B.A. curriculum requires fewer credits for graduation (120 vs. 127 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 nine hours of German. 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 | 1, 11; 3, 13 | CHEMICAL PRINCIPLES | 8 |
| MATH | 21, 22 | ANALYTICAL GEOMETRY AND CALCULUS I AND II | 8 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |

### Required Major Courses

#### Sophomore Year

| | | | |
|---|---|---|---|
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| PHYS | 4 | ELECTRIC LIGHT & ATOMIC PHYSICS | 4 |
| CHEM | 51, 52 | ORGANIC CHEMISTRY | 6 |
| CHEM | 53, 54 | ORGANIC CHEMISTRY LABORATORY | 4 |
| CHEM | 190 | PHYSICAL CHEMISTRY | 3 |

#### Junior Year

| | | | |
|---|---|---|---|
| CHEM | 191 | PHYSICAL CHEMISTRY | 3 |
| CHEM | 192 | PHYSICAL CHEMISTRY LABORATORY | 1 |
| CHEM | 193 | PHYSICAL CHEMISTRY LABORATORY | 1 |
| CHEM | 332 | ANALYTICAL CHEMISTRY | 3 |
| CHEM | 234 | ANALYTICAL CHEMISTRY LABORATORY | 2 |
| CHEM | 302 | PRINCIPLES OF INORGANIC CHEMISTRY | 3 |
| CHEM | 308 | COORDINATION CHEMISTRY | 3 |
| CHEM | 352 | HETEROCYCLIC COMPOUNDS | 3 |
| CHEM | 358 | ADVANCED ORGANIC CHEMISTRY | 3 |

#### Senior Year

| | | | |
|---|---|---|---|
| CHEM | 381 | RADIATION AND STRUCTURE | 4 |
| CHEM | 382 | STRUCTURE, ELECTROCHEM & KINETICS | 3 |

## CLASSICS

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.

## I. 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.

## II. 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 12 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.

## III. 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 his 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 | 331 ANCIENT PHILOSOPHY | 3 |
| SR | 31 CULTURAL ANTHROPOLOGY | 3 |

## CONSERVATION

See Natural Resources, page 45.

## ECONOMICS AND BUSINESS ADMINISTRATION

Three majors are offered in the field of economics and business administration: economics, finance, and accounting. See also the Arts-M.B.A. Program, page 58.

### Economics.

**Required Preliminary Courses**

*Freshman Year*

| | | | |
|---|---|---|---|
| ECO | 3, 4 | PRINCIPLES OF ECONOMICS | 6 |
| 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 |
| | | | 37 |

A senior comprehensive examination is required.

### Finance.

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| ECO | 3, 4 | ECONOMICS | 6 |
| MATH | 41 | BMSS CALCULUS I | 3 |
| MATH | 42 | BMSS PROBABILITY | 3 |
| MATH | 43 | BMSS LINEAR ALGEBRA | 3 |
| FIN | 125 | 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 |
| FIN | 326 | PROBLEMS IN FINANCIAL MANAGEMENT | 3 |
| ECO | 351 | PUBLIC FINANCE: FEDERAL | 3 |
| ECO | 316 | INTERMEDIATE MACRO-ECONOMIC THEORY | 3 |
| | | *or* | |
| ECO | 332 | MONETARY-FISCAL POLICY | 3 |

*plus six semester hours selected from the following:*

| | | | |
|---|---|---|---|
| FIN | 324 | INVESTMENTS | 3 |
| ECO | 316 | INTERMEDIATE MACRO-ECONOMIC THEORY | 3 |

| | | *or* | |
|---|---|---|---|
| ECO | 332 | MONETARY-FISCAL POLICY | 3 |
| ECO | 337 | INTERNATIONAL ECONOMICS | 3 |
| FIN | 331 | BANK MANAGEMENT | 3 |

### Accounting*

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| ACCTG | 51, 52 | ESSENTIALS OF ACCOUNTING | 6 |
| ECO | 3, 4 | ECONOMICS | 6 |
| 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 |
| ACCTG | 307 | FEDERAL TAX ACCOUNTING | 3 |
| ECO | 129 | MONEY AND BANKING | 3 |
| LAW | 1 | BUSINESS LAW | 3 |
| ECO | 45 | STATISTICAL METHODS | 3 |
| MGMT | 302 | SURVEY OF MGMT. SCI. APPLICATIONS | |
| | | *or* | |
| MGMT | 314 | OPERATIONS ANALYSIS | 3 |

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

*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.

## ENGLISH

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

### English Literature.

Literature is a representation of life at the level of man's individual, human dealings with his fellow men. It is man's response to the physical, emotional, intellectual, and moral conditions of his existence. A literary work is one author's ordering and interpretation of his experience, revealing whatever wisdom and beauty his vision of the universe affords him. It both illuminates human experience and is a joy forever.

When these works are seen as the diverse and yet unified expressions of an epoch, they provide insight into the human problem and solution at a particular moment in time. Put together epoch after epoch, they thus become, in a peculiarly rich and inward sense, a form of history. Among world literatures English is perhaps the most varied and splendid and, together with American literature,

presents in today's international setting an unusual breadth of national, racial, regional, and cultural subjects.

The English major student will come to know the varied richness of this literature. So that he may learn how to read thoughtfully and sensitively, he will be taught how to analyze the basic processes of the literary art. His own skill in using the written word will grow as he studies intensively the writings of those who have shown themselves to be the supreme masters of the skill. Above all, he will be challenged to formulate honest reactions to his reading just as writers originally did when confronted by experience; and so, by integrating his own experience with what Matthew Arnold called "the best that has been thought and said," he will come to perceive whatever wisdom and beauty his own enriched vision will afford him. The resulting enlargement of mind and spirit not only should produce a flexible, yet well-integrated, personality but also can be put at the service of society in whatever profession or enterprise the student may undertake.

**Required Preliminary Courses**

| ENGL | 1, 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 |

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

Collateral courses are recommended in history, philosophy, 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, maga-

zine, 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 |

*(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.

## FINE ARTS

The Department of Fine Arts offers two major programs, each designed to develop the creative potential of the individual both on the personal and social level.

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.

Both programs prepare the student for acceptance into graduate studies.

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.

An intercollegiate exchange with the art department of Moravian College permits students to take art courses offered on both campuses.

### General Art Major

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| FA | 5 | FUNDAMENTALS OF ART | 3 |
| FA | 35 | DRAWING AND GRAPHICS | 3 |
| FA | 36 | COLOR AND DESIGN | 3 |
| | | | 9 |

**Required Major Courses**

| | | | |
|---|---|---|---|
| FA | 3 OR 4 | HISTORY OF ARCHITECTURE | 3 |
| FA | 33 *or* 34 | PAINTING PRINCIPLES | 3 |
| FA | 37 *or* 38 | PRINTMAKING | 3 |
| FA | 15 *or* 17 | ITALIAN RENAISSANCE OR BAROQUE ART | 3 |
| FA | 219 *or* 216 | 19TH CENTURY OR AMERICAN ART | 3 |
| FA | 220 | FORM AND MILIEU IN THE 20TH CENTURY | 3 |
| FA | 131, 132 | ADVANCED STUDIO PRACTICE | 6 |
| FA | 273 | SPECIAL TOPICS IN STUDIO PRACTICE | 1 TO 4 |
| | | | 28 |

An additional six hours outside the department in related courses are required after consultation with the faculty advisor.

| | |
|---|---|
| HOURS OUTSIDE THE DEPARTMENT | 6 |
| HOURS OF ART HISTORY | 15 |
| HOURS OF STUDIO ART | 22 |
| | 43 |

### Pre-Architecture Major

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| PHYSICS I | | | 3 |
| MATH | 21 | ANALYTICAL GEOMETRY AND CALCULUS I | 4 |
| MATH | 22 | ANALYTICAL GEOMETRY AND CALCULUS II | 4 |
| FA | 3, 4 | HISTORY OF ARCHITECTURE | 6 |
| FA | 35 OR 36 | DRAWING AND GRAPHICS OR COLOR AND DESIGN | 3 |
| | | | 20 |

**Required Major Courses**

| | | | |
|---|---|---|---|
| MECH | 1 | STATICS | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| CE | 106 | STRUCTURAL DESIGN | 3 |
| FA | 43, 44 | ENVIRONMENTAL DESIGN | 6 |
| FA | 5 | FUNDAMENTALS OF ART | 3 |
| FA | 143 | PROJECT | 3 |
| FA | 251, 252 | ARCHITECTURAL DESIGN | 6 |
| FA | 220 | FORM AND MILIEU IN 20TH CENTURY | 3 |
| FA | 51 | URBAN DESIGN | 3 |
| | | | 37 |

Collateral courses are recommended, and in some instances may be substituted for the above in civil engineering, mechanics, government and social relations—for example, S.R. 368, C.E. 150, Govt. 357.

A senior comprehensive examination is required and will include both oral and written sections. Qualified seniors will have the opportunity for one-man shows.

## FOREIGN CAREERS

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. The program is under the direction of Professor Finn B. Jensen of the department of economics.

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 are encouraged to investigate the opportunity for taking a second major in the appropriate language. 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 | 3, 4 | ECONOMICS | 6 |
| 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 |

*Required courses for 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 |

*Required courses for concentration in the European area. area.*

| | | | |
|---|---|---|---|
| ECO | 309 | COMPARATIVE ECONOMIC SYSTEMS | 3 |
| ECO | 343 | EUROPEAN ECONOMIC INTEGRATION | 3 |
| HIST | | SIX HOURS OF EUROPEAN HISTORY | 6 |

*Required courses for 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 ECONOMICS | 6 |
| ECO | | IN CONSULTATION WITH THE ADVISER | 6 |

### 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 THOUGHT | 3 |
| | | *or* | |
| GOVT | 364 | CONTEMPORARY POLITICAL THOUGHT | 3 |
| GOVT | 361 | COMPARATIVE ADMINISTRATIVE SYSTEMS | 3 |
| | | *or* | |
| GOVT | 322 | DEVELOPING COUNTRIES | 3 |

A senior comprehensive examination in the appropriate language is required.

### Open Option

In place of any of the three preceding options, a student may take an Open Option by meeting the advanced course requirements for one of the other Arts College majors. The Open Option is most feasible with humanities and social science majors but will require a careful combining of distribution courses and free electives with the eighteen hours normally given to the option. Students interested in the Open Option should consult the director of the Foreign Careers major as early as possible.

## GEOLOGICAL SCIENCES

Geology, and related sciences such as geochemistry, geophysics, and oceanography, 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 geo-

logical sciences must combine study in geology with a broad understanding of physical, chemical, and biological principles.

The undergraduate program in geological sciences at Lehigh emphasizes this relationship. All students are required to take a common core consisting of a few courses in geology and certain basic courses in mathematics, physics, chemistry, and biology. The balance of the program consists of 12 credit hours in approved electives. This permits each student to arrange an informal option in geochemistry, geophysics, general geology, environmental geology, etc.

Attendance at an approved summer field camp is required for all majors. 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.

An extended field trip is held each year for advanced undergraduates in conjunction with work in advanced required major courses.

Geological training may be utilized in industry (especially in the petroleum, mining, highway construction, ceramics, and metallurgical industries), government service and in secondary school and college teaching.

**Required Preliminary Courses**

*Freshman Year*

| | | | |
|---|---|---|---|
| GEOL | 1 | PRINCIPLES OF GEOLOGY | 3 |
| GEOL | 12 | HISTORICAL GEOLOGY | 3 |
| CHEM 1, 11; 3, 13 | | PRINCIPLES OF CHEMISTRY | 8 |
| MATH | 21 | ANALYTICAL GEOMETRY AND CALCULUS | 4 |
| MATH | 22 | ANALYTICAL GEOMETRY AND CALCULUS | 4 |
| | | *or* | |
| MATH | 42 | BMSS PROBABILITY | 3 |

**Required Major Courses**

*Sophomore Year*

| | | | |
|---|---|---|---|
| GEOL | 10 | COMPUTER APPLICATIONS | 1 |
| GEOL | 23 | STRUCTURAL GEOLOGY | 3 |
| GEOL | 33 | INTRODUCTORY MINERALOGY AND PETROLOGY | 3 |
| CHEM | 39 | ANALYTICAL CHEMISTRY | 3 |
| BIOL | 21, 22 | PRINCIPLES OF BIOLOGY | 4 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS | 4 |
| | | *or* | |
| MATH | 43 | BMSS LINEAR ALGEBRA | 3 |

*Junior and Senior Years*

| | | | |
|---|---|---|---|
| GEOL | | APPROVED ELECTIVES | 12 |
| GEOL | | FIELD CAMP* (OR APPROVED SUBSTITUTE) | 6 |
| PHYS | 16, 17 | GENERAL PHYSICS | 5 |
| | | *or* | |
| PHYS | 3 | HEAT AND ELECTRICITY AND | 4 |
| PHYS | 4 | ELECTRICITY, LIGHT, AND ATOMIC PHYSICS | 4 |

*Students normally attend the field camp during the summer between the junior and senior years.*

## GERMAN & RUSSIAN

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 literatures 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 | 205 | TWENTIETH CENTURY GERMAN LITERATURE | 3 |
| GER | 250 | SPECIAL TOPICS | 3 |
| GER | 344 | THE AGE OF GOETHE | 6 |

A senior comprehensive examination is required.

## GOVERNMENT

The major in government is designed to promote understanding of political ideas, 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.

**Required 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 |

*Six elective courses with at least two courses from each of the following two fields:*

American Politics—Public Law

| GOVT 302 COMPARATIVE STATE POLITICS | 3 |
| GOVT 304 POLITICAL PARTIES | 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 308 CLASSICAL POLITICAL HERITAGE | 3 |
| GOVT 310 ASIAN POLITICAL SYSTEMS | 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 THOUGHT | 3 |
| GOVT 364 CONTEMPORARY POLITICAL THOUGHT | 3 |

*One course in a cognate field:*

One 300-level course in a cognate field, such as economics, history, international relations, philosophy, psychology, or social relations, to be determined in consultation with the faculty advisor.

## HISTORY

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 judgments, as well as in writing. History majors have the foundation for law school, government service, journalism, teaching, and graduate study.

A major in history consists of thirty-six hours distributed in three of four areas: American, British, European, and Latin American history. No more than eighteen of these hours may be in one field. 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**

| | | | |
|---|---|---|---|
| HIST | 199 | SENIOR SEMINAR | 3 |

*Twenty-one hours chosen from the following:*

| | | | |
|---|---|---|---|
| HIST | 21, 22 | ANCIENT HISTORY | 6 |
| HIST | 319, 320 | COLONIAL AMERICA | 6 |
| 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 | 3 |
| HIST | 336 | UNITED STATES, 1840-1877 | 3 |
| HIST | 337 | UNITED STATES, 1877-1920 | 3 |
| HIST | 338 | UNITED STATES, 1920 TO THE PRESENT | 3 |
| HIST | 343 | ENGLISH HISTORY, 1471-1660 | 3 |
| HIST | 344 | ENGLISH HISTORY, 1660-1789 | 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 | 365 | COLONIAL LATIN AMERICA, 1492-1825 | |
| 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.

## INTERNATIONAL RELATIONS

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 who possess a clear appreciation of the factors which influence the policies of nations.

Students will approach the study of state behavior through courses in the theory and techniques of diplomacy, the history of modern international relations, and special seminars in international law, international organization, and world politics. The ultimate objective is to shape and develop well-informed and independent observers and participants in the field of international affairs. The flexibility of the program permits added study in history, government, economics and other social sciences.

The broad knowledge and understanding acquired can be utilized in careers in teaching, the Foreign Service of the United States and other government agencies, international business, and the legal profession.

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| IR | 1, 2 | WORLD POLITICS | 6 |

**Required Major Courses**

| | | | |
|---|---|---|---|
| IR | 341, 342 | INTERNATIONAL RELATIONS | 6 |
| IR | 351, 352 | INTERNATIONAL INSTITUTIONS | 6 |
| IR | 361, 362 | INTERNATIONAL LAW | 6 |
| IR | 371, 372 | READINGS IN INTERNATIONAL RELATIONS | 6 |

*and twelve semester hours to be selected, with the approval of the chairman of the department, from international relations, history, and government. A senior essay is required.*

## MATHEMATICS

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** 3

| | | | |
|---|---|---|---|
| MATH | 205 | LINEAR METHODS | 3 |
| MATH | 219 | PRINCIPLES OF ANALYSIS | 3 |
| MATH | 220 | PRINCIPLES OF ANALYSIS | 3 |
| MATH | 226 | COMPLEX ANALYSIS | 3 |
| MATH | 243 | ALGEBRA | 3 |
| MATH | 244 | ALGEBRA | 3 |
| | | APPROVED ELECTIVES | 12 |

*The elective courses must include Math. 307 and 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.

## MUSIC

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 at Moravian College. Courses which are taught on the Moravian campus are so indicated in the course descriptions.

A major concentration in music consists of thirty credit-hours, twenty-four of which shall be advanced courses. Music 21 and 22 are required preliminary courses for students who have not mastered the rudiments of music.

Students must demonstrate their ability at the keyboard 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.

Credit may be earned for private instruction which will be graded pass or fail. Fees must be borne by the students.

## NATURAL RESOURCES

This is an interdepartmental major designed to give the student basic preparation for a career in management and conservation of natural resources and for research and graduate work in these fields. Integrated work in biology and geology with adequate background in chemistry and physics provides the best approach to an understanding of the environment, its influence on man and man's influence upon it.

**Required Preliminary Courses**

*Freshman Year*

| | | | |
|---|---|---|---|
| BIOL | 21 | GENERAL BIOLOGY | 3 |
| BIOL | 22 | INTRODUCTION TO BIOLOGY LABORATORY | 1 |
| BIOL | 28 | GENETICS | 3 |
| CHEM | 1 | CHEMICAL PRINCIPLES I | 3 |
| CHEM | 11 | CHEMICAL PRINCIPLES I LABORATORY | 1 |
| CHEM | 3 | CHEMICAL PRINCIPLES II | 3 |
| CHEM | 13 | CHEMICAL PRINCIPLES II LABORATORY | 1 |
| MATH | 41 | BMSS CALCULUS | 3 |
| MATH | 42 | BMSS PROBABILITY | 3 |

*Sophomore Year*

| | | | |
|---|---|---|---|
| CHEM | 39 | ANALYTICAL CHEMISTRY | 3 |
| GEOL | 1 | PRINCIPLES OF GEOLOGY | 3 |
| BIOL | 306 | ECOLOGY | 3 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| GEOL | 12 | HISTORICAL GEOLOGY | 3 |
| BIOL | 35 | MICROBIOLOGY | 3 |
| BIOL | 361 | SANITARY MICROBIOLOGY | 3 |

*Junior Year*

| | | | |
|---|---|---|---|
| CHEM | 51 | ORGANIC CHEMISTRY | 3 |
| CHEM | 53 | ORGANIC CHEMISTRY LABORATORY | 2 |
| GEOL | 33 | INTRODUCTION TO MINERALOGY AND PETROLOGY | 3 |
| PHYS | 16 | GENERAL PHYSICS | 3 |
| PHYS | 17 | GENERAL PHYSICS LABORATORY | 2 |
| GEOL | 23 | STRUCTURAL GEOLOGY | 3 |

*Senior Year*

| | | | |
|---|---|---|---|
| BIOL | 303 | ADVANCED INVERTEBRATE ZOOLOGY | 3 |
| ECO | 311 | ECONOMICS RESOURCE USE | 3 |
| | | ELECTIVES | 6 *or* 9 |

*Suggested Electives:*

| | | | |
|---|---|---|---|
| BIOL | 34 | COMPARATIVE ANATOMY | 4 |
| BIOL | 320 | PHYSIOLOGY | 3 |
| GEOL | 211 | ENVIRONMENTAL PLANNING | 3 |
| GEOL | 311 | PALEONTOLOGY | 3 |
| GEOL | 313 | SEDIMENTOLOGY | 3 |
| GEOL | 315 | STRATIGRAPHY | 3 |
| GEOL | 357 | ECONOMIC GEOLOGY | 3 |
| GEOL | 363 | INTRODUCTION TO OCEANOGRAPHY | 3 |
| PHIL | 341 | EVOLUTION OF SCIENTIFIC IDEAS | 3 |
| ENGL | 142 | TECHNICAL WRITING | 3 |

A student who is taking a major in biology, geology, or journalism, and who is interested in natural resources and their conservation, should consult with his major advisor. His program can be so arranged as to provide an adequate major concentration combined with appropriate collateral work so selected as to develop his knowledge of natural resources and the problems of their management.

## NATURAL SCIENCE

This major provides students with a broad background in the fundamentals of mathematics and science and the opportunity to concentrate to a reasonable degree in one area of science. The program is designed especially for (1) those students who desire preparation for graduate work or careers in certain of the derivative or interdisciplinary sciences or related professional fields (oceanography, astronomy, psychophysiology, geophysics, information science, medicine or dentistry, conservation, etc.), (2) those students who plan to teach science 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 committee, of which Professor Ryan is chairman, administers the program.

A special program leading to a B.A. in Natural Science and an M.S. in Materials is available for interested students. See page 67 for prerequisites and typical program.

**Required Preliminary Courses**

| | | | |
|---|---|---|---|
| MATH | 21, 22, 23 | ANALYTICAL GEOMETRY AND CALCULUS | 12 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| PHYS | 4 | ELECTRICITY, LIGHT, AND ATOMIC PHYSICS | 4 |
| CHEM | 1, 11; 3, 13 | CHEMICAL PRINCIPLES | 8 |
| GEOL | 1 | PRINCIPLES OF GEOLOGY | 3 |
| | | 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 | 6-10 |
| | | or | |
| CHEM | 91, 190 | PHYSICAL CHEMISTRY | |
| *MATH | | ELECTIVE | 3 |
| *OPTION | | | 24 |

*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

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 this emancipation only to the extent that they 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 capability, a 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 | 331 | ANCIENT PHILOSOPHY | 3 |
| PHIL | 335 | 17TH AND 18TH CENTURY PHILOSOPHY | 3 |
| PHIL | 337 | NINETEENTH CENTURY PHILOSOPHY | 3 |
| PHIL | 339 | TWENTIETH CENTURY PHILOSOPHY | 3 |

*And fifteen additional hours to be selected with the counsel and approval of the departmental advisor from other courses in philosophy and approved from other curricula.*

## PHYSICS

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 1, 11; 3, 13 | | PRINCIPLES OF CHEMISTRY | 8 |
| MATH 21, 22; 23 | | ANALYTICAL GEOMETRY AND CALCULUS | 12 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |

**Required Major Courses**

| | | | |
|---|---|---|---|
| PHYS | 62 | CONTEMPORARY PHYSICS | 3 |
| 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 |

## PSYCHOLOGY

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 | PHILOSOPHY OF NATURAL 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; Physics 1, 16, 17. Additional course work in mathematics, computer programming, and biology is also recommended to be chosen from Mathematics 43, 44, 334, 105 or Accounting 111; Biology 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 courses chosen 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 |

*Two additional courses chosen from departmental offerings with approval of department chairman.*
A senior comprehensive examination is required.

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 encouraged to exercise this choice with the student's interests as the principal guide.

## ROMANCE LANGUAGES & LITERATURES

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 | 11, 12 | INTERMEDIATE FRENCH | 6 |

**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 | 6 |
| 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 |

The student will be expected to complete supplementary reading, the list of which he will receive at the beginning of his major work, and to correlate the knowledge gained in courses and readings through the use of some recommended history of French literature.

A senior comprehensive examination is required.

### Spanish.

**Required Preliminary Courses**

| SPAN | 1, 2 | ELEMENTARY SPANISH | 6 |
|---|---|---|---|
| SPAN | 11, 12 | INTERMEDIATE SPANISH | 6 |

**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 | 231, 232 | SPANISH-AMERICAN LITERATURE | 6 |
| 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 |

In addition to the outside reading and reports required in connection with these courses, the student will be expected to acquire a knowledge of the history of Spanish literature as a whole.

A senior comprehensive examination is required.

## SOCIAL RELATIONS

There are three major sequences combined in the department of Social Relations: Social Psychology, Cultural Anthropology and Sociology. Students majoring in the department select one option given below to fulfill requirements.

With the 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 | 3 |
| PSYCH | 3 *or* 4 | INTRODUCTION TO PSYCHOLOGY | 3 |
| MATH | 41 | BMSS CALCULUS I | 3 |
| | | *or* | |
| PHIL | 14 | INTRODUCTION TO LOGIC | 3 |

*Six hours in the following:*

| | | | |
|---|---|---|---|
| SR | 3-4 | INTRODUCTION TO SOCIAL RELATIONS | 6 |
| SR | 11 | PRINCIPLES OF SOCIOLOGY | 3 |
| SR | 21 | SOCIAL PSYCHOLOGY | 3 |
| SR | 31 | CULTURAL ANTHROPOLOGY | 3 |

### Recommended Courses

| | | | |
|---|---|---|---|
| ECO | 3, 4 | ECONOMICS | 6 |
| IS | 302 | PSYCHOLINGUISTICS | 3 |
| PHIL | 14 | LOGIC | 3 |
| MATH | 42 | BMSS PROBABILITY | 3 |
| MATH | 105 | COMPUTER PROGRAMMING | 3 |
| PSYCH | 9 | STATISTICAL ANALYSIS | 3 |

### Required Major Courses

| | | | |
|---|---|---|---|
| SR | 394 | THE INDIVIDUAL, SOCIETY, AND CULTURE | **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 |
| PSYCH | 302 | THEORIES OF PERSONALITY | 3 |
| | | *and* | |
| PSYCH | | APPROVED COURSES | 6 |

*One course from SR 331, 332, 333, 335, or 339* — 3

*One course from SR 364, 366, 367, 368, 369, 370, 373, 375 or 384*

### Option in Cultural Anthropology

*Twelve hours from the following:*

| | | | |
|---|---|---|---|
| SR | 332 | PEASANT SOCIETIES | 3 |
| SR | 333 | PRIMITIVE POLITICAL SYSTEMS | 3 |
| SR | 335 | CULTURAL DYNAMICS | 3 |
| SR | 336 | RELIGION AND MAGIC | 3 |
| SR | 337 | NATIVE PEOPLES OF LATIN AMERICA | 3 |
| SR | 339 | SEMINAR IN ANTHROPOLOGY | 3 |
| | | *and* | |
| IS | 301 | DESCRIPTIVE LINGUISTICS | 3 |
| BIOL | 13 | HUMAN BIOLOGY | 3 |

*One course from SR 301, 303, 304 or 308* — 3
*One course from SR 364, 366, 367, 368, 369, 370, 373, 375, 381 or 384* — 3

### Option in Sociology

*Twelve 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 | 375 | MINORITY GROUPS | 3 |
| SR | 381 | DEVELOPMENT OF SOCIOLOGICAL THEORY | 3 |
| SR | 384 | SOCIAL STRUCTURE | 3 |
| | | *and* | |
| HIST | 331, 333 334 | THE NEGRO IN AMERICA OR AMERICAN URBAN HISTORY | 3 |
| | | APPROVED ELECTIVES | 3 |

*One course from SR 301, 303, 304, or 308* — 3
*One course from SR 331, 332, 333, 335, 336, or 339* — 3

## MAJOR SEQUENCES IN ARTS-ENGINEERING

The standard major for students in the five-year Arts-Engineering curriculum is Applied Science. This major is open only to Arts-Engineers.

### Applied Science
### Required Preliminary Courses

| | | | |
|---|---|---|---|
| CHEM | 1, 11; 3, 13 | PRINCIPLES OF CHEMISTRY | 8 |
| MATH | 21, 22 | ANALYTIC GEOMETRY AND CALCULUS I AND II | 8 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |

### Required Courses in Major

| | | | |
|---|---|---|---|
| MATH | 23 | ANALYTIC GEOMETRY AND CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |

A student must also complete the following requirements:

(1) A minimum of twenty-four hours of the advanced work in the mathematical, physical, or engineering sciences required for the B.S. degree to be conferred on completion of the fifth year.

(2) All courses in mathematics, science, and engineering required in the first three years of the chosen engineering curriculum.

(3) Any additional courses necessary to prepare for the appropriate B.S. degree in one additional year.

### Other Arts or Science Major

Able Arts-Engineers with special interests outside engineering frequently can combine another arts or science major with their engineering program. Interested students should consult the dean of the arts college and the head of their engineering department.

## RECOMMENDED FRESHMAN YEAR

Arts-Engineering freshmen have the same roster of courses as do engineering freshmen with the exceptions that Arts-Engineering freshmen may choose an elective in place of Economics 3 and must take a foreign language in place of a social science sequence. The recommended freshman year program for all Arts-Engineering freshmen is as follows:

### Freshman Year, First Semester

| | | |
|---|---|---:|
| ENGL | 1 COMPOSITION AND LITERATURE | 3 |
| CHEM | 1 CHEMICAL PRINCIPLES I | 3 |
| CHEM | 11 CHEMICAL PRINCIPLES I LABORATORY | 1 |
| MATH | 21 ANALYTICAL GEOMETRY & CALCULUS I | 4 |
| PHYS | 1 MECHANICS OF MASS POINTS | 3 |
| | *or* | |
| DIST | ELECTIVE | |
| LANG | | 3 |
| PE | 1 PHYSICAL EDUCATION | 0 |
| | | 17 |

### Freshman Year, Second Semester

| | | |
|---|---|---:|
| ENGL | 2 COMPOSITION AND LITERATURE | 3 |
| CHEM | 3 CHEMICAL PRINCIPLES II | 3 |
| CHEM | 13 CHEMICAL PRINCIPLES II LABORATORY | 1 |
| MATH | 22 ANALYTICAL GEOMETRY & CALCULUS II | 4 |
| PHYS | 1 MECHANICS OF MASS POINTS | 3 |
| | *or* | |
| DIST | ELECTIVE | |
| LANG | | 3 |
| PE | 2 PHYSICAL EDUCATION | 0 |
| | | 17 |

### Arts-Engineering Sequences

Beginning with his sophomore year, the Arts-Engineering student will be guided by one of the following pattern rosters in his chosen field of study. These pattern rosters, prepared with the help of the chairman of the several engineering departments, show the most effective way to combine arts and engineering courses to prepare for the last year in the branch of engineering chosen. (For descriptions of the engineering curricula, see pages 68-80.)

Although the minimum number of credit hours needed for the B.A. in Applied Science is 120, the student in Arts-Engineering is expected to earn more than this in order to qualify for the B.S. degree at the end of the fifth year. The number needed for both degrees is shown for each pattern roster.

## ARTS—CHEMICAL ENGINEERING

### Credit Hours Needed for B.A. and B.S.: 167

#### Sophomore Year, First Semester

| | | |
|---|---|---:|
| LANG | | 3 |
| DIST | ELECTIVE | 3 |
| MATH | 23 ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 HEAT AND ELECTRICITY | 4 |
| CHE | 51 CHEMICAL ENGINEERING COMPUTATION | 4 |
| | | 18 |

#### Sophomore Year, Second Semester

| | | |
|---|---|---:|
| LANG | | 3 |
| MATH | 205 LINEAR METHODS | 3 |
| PHYS | 4 ELECTRICITY, LIGHT, AND ATOMIC PHYSICS | 4 |
| CHE | 52 TRANSFORMATIONS PHENOMENA | 4 |
| CHEM | 90 PHYSICAL CHEMISTRY | 3 |
| | | 17 |

#### Junior Year, First Semester

| | | |
|---|---|---:|
| LANG | | 3 |
| ECO | 3 ECONOMICS | 3 |
| CHEM | 191 PHYSICAL CHEMISTRY | 3 |
| CHEM | 192 PHYSICAL CHEMISTRY LABORATORY | 1 |
| DIST | ELECTIVES | 6 |
| | | 16 |

#### Junior Year, Second Semester

| | | |
|---|---|---:|
| ECO | 4 ECONOMICS | 3 |
| LANG | | 3 |
| CHEM | 51 ORGANIC CHEMISTRY | 3 |
| CHEM | 55 ORGANIC CHEMISTRY LABORATORY | 2 |
| DIST | ELECTIVE | 3 |
| | ELECTIVE FOR ENGINEERING MAJOR* | 3 |
| | | 17 |

#### Senior Year, First Semester

| | | |
|---|---|---:|
| DIST | ELECTIVE | 3 |
| CHE | 165 UNIT OPERATIONS I | 4 |
| | ELECTIVES FOR ENGINEERING MAJOR* | 9 |
| | | 16 |

*Senior Year, Second Semester*

| | | | |
|---|---|---|---|
| DIST | | ELECTIVES | 6 |
| CHE | 166 | UNIT OPERATIONS II | 4 |
| CHE | 200 | THERMODYNAMICS | 3 |
| | | ELECTIVES FOR ENGINEERING MAJOR* | 3 |
| | | | 16 |

*The electives indicated must be distributed as indicated for the Chemical Engineering curriculum of the Engineering College.*

# ARTS—CIVIL ENGINEERING

## Credit Hours Needed for B.A. and B.S.: 166

*Sophomore Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| ECO | 3 | ECONOMICS | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| DIST | | ELECTIVE | 3 |
| | | | 17 |

*Sophomore Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| DIST | | ELECTIVES | 6 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |
| | | | 16 |

*Junior Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MECH | 1 | STATICS | 3 |
| CE | 11 | ENGINEERING GRAPHICS | 2 |
| DIST | | ELECTIVES | 9 |
| CE | 10 | PROBLEM COMPUTATION LABORATORY | 1 |
| | | | 18 |

*Junior Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| | | ELECTIVE | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| MECH | 13 | MATERIALS TESTING LABORATORY | 1 |
| CE | 12 | APPLIED ENGINEERING GRAPHICS | 2 |
| CE | 40 | PRINCIPLES OF SURVEYING | 3 |
| | | | 15 |

*Summer*

| | | | |
|---|---|---|---|
| CE | 41 | ENGINEERING SURVEYS | 3 |

*Senior Year, First Semester*

| | | | |
|---|---|---|---|
| CE | 121 | MECHANICS OF FLUIDS | 3 |
| CE | 239 | SOIL MECHANICS | 3 |
| CE | 150 | STRUCTURAL ANALYSIS I | 3 |
| MECH | 102 | DYNAMICS | 3 |
| GEOL | 101 | EARTH MATERIALS AND PROCESSES | 3 |
| MET | 63 | ENGINEERING MATERIALS AND PROCESSES | 3 |
| | | *or* | |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| | | | 18 |

*Senior Year, Second Semester*

| | | | |
|---|---|---|---|
| CE | 222 | HYDRAULICS ENGINEERING | 3 |
| EC | 162 | SANITARY ENGINEERING | 3 |
| CE | 154 | STRUCTURAL ANALYSIS II | 3 |

| | | | |
|---|---|---|---|
| CE | 123 | MECHANICS OF FLUIDS LABORATORY | 1 |
| | | APPROVED ELECTIVE | 3 |
| | | ELECTIVE | 3 |
| | | | 16 |

*Summer*

| | | | |
|---|---|---|---|
| CE | 100 | Eight weeks of industrial employment should precede fifth year. Consult department chairman. | |

# ARTS — ELECTRICAL ENGINEERING

## Credit Hours Needed for B.A. and B.S.: 164

*Sophomore Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| MET | 63 | ENGINEERING MATERIALS & PROCESSES | 3 |
| | | *or* | |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| DIST | | ELECTIVE | 3 |
| | | | 17 |

*Sophomore Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| ECO | 3 | ECONOMICS | 3 |
| MECH | 1 | STATICS | 3 |
| | | | 16 |

*Junior Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| EE | 15 | CIRCUIT THEORY I | 3 |
| MATH | 208 | COMPLEX VARIABLES | 3 |
| MECH | 102 | DYNAMICS | 3 |
| DIST | | ELECTIVE | 3 |
| | | | 15 |

*Junior Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| EE | 16 | CIRCUIT THEORY II | 4 |
| MATH | 231 | STATISTICAL INFERENCE | |
| | | *or* | |
| MATH | 309 | THEORY OF PROBABILITY | 3 |
| DIST | | ELECTIVE | 3 |
| | | ELECTIVES | 3 |
| | | | 16 |

*Senior Year, First Semester*

| | | | |
|---|---|---|---|
| EE | 103 | SEMI-CONDUCTOR DIODE THEORY | 3 |
| EE | 104 | LINEAR SYSTEMS ANALYSIS | 3 |
| EE | 106 | MACHINE THEORY | 4 |
| | | ELECTIVES | 6 |
| | | | 16 |

*Senior Year, Second Semester*

| | | | |
|---|---|---|---|
| EE | 105 | INTRODUCTION TO TRANSISTOR THEORY & CIRCUITS | 4 |
| EE | 231 | ELECTRIC AND MAGNETIC FIELDS | 3 |
| | | ELECTIVES | 9 |
| | | | 16 |

*Summer*

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

## ARTS—ENGINEERING PHYSICS

**Credit Hours Needed for B.A. and B.S.: 162**

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

**Credit Hours Needed for B.A. and B.S.: 170**

*Sophomore Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| ECO | 3 | ECONOMICS | 3 |
| IE | 17 | INTRODUCTION TO COMPUTING | 3 |
| | | | 17 |

*Sophomore Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| MET | 63 | ENGINEERING MATERIALS AND PROCESSES | 3 |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT, AND ATOMIC PHYSICS | 4 |
| IE | 11 | APPLIED PROBABILITY LABORATORY | 1 |
| IE | 18 | INFORMATION PROCESSING THEORY | 3 |
| | | | 17 |

*Junior Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| IE | 221 | INDUSTRIAL STATISTICS | 4 |
| ECO | 4 | ECONOMICS | 3 |
| DIST | | ELECTIVE | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| MECH | 1 | STATICS | 3 |
| | | | 19 |

*Junior Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| DIST | | ELECTIVES | 9 |
| IE | 222 | OPERATIONS ANALYSIS | 4 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| | | | 19 |

*Senior Year, First Semester*

| | | | |
|---|---|---|---|
| IE | 121 | ANALYSIS AND DESIGN I | 5 |
| DIST | | ELECTIVE | 3 |
| PSYCH | 3 | PSYCHOLOGY AS A NATURAL SCIENCE | 3 |
| MECH | 102 | DYNAMICS | 3 |
| IE | 241 | FUNDAMENTALS OF PRODUCTION ENGINEERING | 3 |
| | | | 17 |

*Senior Year, Second Semester*

| | | | |
|---|---|---|---|
| IE | 122 | ANALYSIS AND DESIGN II | 4 |
| ME | 168 | ELEMENTS OF MECHANICAL DESIGN | 2 |
| | | ELECTIVES | 9 |
| ACCTG | 108 | FUNDAMENTALS OF ACCOUNTING | 3 |
| | | | 18 |

*Summer*

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

## ARTS—MECHANICAL ENGINEERING AND ENGINEERING MECHANICS

**Credit Hours Needed for B.A. and B.S.: 165**

*Sophomore Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| DIST | | ELECTIVE | 3 |
| ECO | 3 | ECONOMICS | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| ME | 10 | ANALYSIS OF ENGINEERING PROBLEMS | 1 |
| | | | 18 |

*Sophomore Year, Second Semester*

| | | | |
|---|---|---|---|
| DIST | | ELECTIVE | 3 |
| LANG | | | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |
| CE | 11 | ENGINEERING GRAPHICS | 2 |
| | | | 15 |

*Junior Year, First Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| DIST | | ELECTIVES | 6 |
| MECH | 1 | STATICS | 3 |
| MET | 63 | ENGINEERING MATERIALS AND PROCESSES | 3 |
| | | *or* | |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| | | | 15 |

*Junior Year, Second Semester*

| | | | |
|---|---|---|---|
| LANG | | | 3 |
| DIST | | ELECTIVE | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| MECH | 13 | MATERIALS TESTING LABORATORY | 1 |
| MATH | 208 | COMPLEX VARIABLES | 3 |
| | | *or* | |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS | 3 |
| EE | 161 | ELECTRICAL PROBLEMS | 1 |
| EE | 162 | DYNAMO LABORATORY | 1 |
| | | | 18 |

*Senior Year, First Semester*

| | | | |
|---|---|---|---|
| ME | 101 | MECHANICAL ENGINEERING DESIGN I | 3 |
| ME | 104 | THERMODYNAMICS I | 3 |
| MECH | 102 | DYNAMICS | 3 |
| MECH | 201 | ADVANCED MECHANICALS OF MATERIALS | 3 |
| | | ELECTIVES | 6 |
| | | | 18 |

*Senior Year, Second Semester*

| ME | 105 | THERMODYNAMICS II | 3 |
|----|-----|-------------------|---|
| ME | 231 | FLUID MECHANICS | 3 |
| | | *or* | |
| CE | 121 | MECHANICS OF FLUIDS | 3 |
| CE | 123 | FLUID MECHANICS LABORATORY | 1 |
| ME | 242 | MECHANICAL VIBRATIONS | 3 |
| | | ELECTIVES | 6 |
| | | | 16 |

*Summer*

| ME | 100 | Summer Employment should precede fifth year. Consult department chairman. |
|----|-----|---|

## ARTS—METALLURGY AND MATERIALS SCIENCE

**Credit Hours Needed for B.A. and B.S.: 165-168**

**(depending on options selected)**

*Sophomore Year, First Semester*

| LANG | | | 3 |
|------|-----|---|---|
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS II | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| ECO | 3 | ECONOMICS | 3 |
| | | | 17 |

*Sophomore Year, Second Semester*

| LANG | | | 3 |
|------|-----|---|---|
| DIST | | ELECTIVE | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |
| MET | 10 | METALLURGY LABORATORY | 2 |
| MECH | 1 | STATICS | 3 |
| ECO | 4 | ECONOMICS | 3 |
| | | | 18 |

*Junior Year, First Semester*

| LANG | | | 3 |
|------|-----|---|---|
| DIST | | ELECTIVE | 3 |
| MET | 207 | ELECTRON AND CRYSTAL STRUCTURE | 3 |
| | | ELECTIVE | 3-5 |
| | | *or* | |
| *EE | 103 | SEMICONDUCTOR DIODE THEORY | 3 |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS & APPARATUS | 3 |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS | 1 |
| MET | 210 | METALLURGICAL THERMODYNAMICS | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| | | | 18 |

*Students are required to take either EE 103, or EE 160, 161, or Phys 62 for graduation.*

*Junior Year, Second Semester*

| LANG | | | 3 |
|------|-----|---|---|
| DIST | | ELECTIVE | 3 |
| MET | 208 | PHASE DIAGRAM AND TRANSFORMATIONS | 3 |
| CHEM | 196 | PHYSICAL CHEMISTRY | 3 |
| CHE | 60 | ENGINEERING IN CHEMICAL MANUFACTURING | 3 |
| MET | 218 | MECHANICAL BEHAVIOR OF MATERIALS | 3 |
| | | | 18 |

*Senior Year, First Semester*

| | | ELECTIVES | 9 |
|------|-----|-----------|---|
| MECH | 102 | DYNAMICS | 3 |
| MET | 307 | STRUCTURE AND BEHAVIOR OF MATERIALS | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| | | *or* | |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| | | | 18 |

*Senior Year, Second Semester**

| | | ELECTIVES | 8-9 |
|-----|-----|-----------|-----|
| ME | 166 | PROCEDURES FOR MECHANICAL DESIGN | 2 |
| MET | 304 | EXTRACTIVE METALLURGY I | 4 |
| MET | 101 | PROFESSIONAL DEVELOPMENT | 1 |
| | | | 15-16 |

*Summer*

| MET | 100 | Industrial Employment should precede fifth year. Consult chairman of department. |
|-----|-----|---|

*Students selecting Research Option should elect Met. 240, Research Techniques, in the second semester of the senior year.*

# COLLEGE OF BUSINESS AND ECONOMICS

L. Reed Tripp, *Dean*
Max D. Snider, *Assistant Dean*

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 thorough and systematic training in the fundamentals of business. The College aims to develop in the student an intelligent understanding of business principles, an ability to analyze industrial facts, and habits of thought which will enable him to cope with the problems that increasing executive responsibilities will bring him in later life. Stress is on building a sound foundation, since it is the firm belief of the College that no substitute can be furnished for the training and experience provided by actual contact with the complex problems of modern business. Accordingly, the student's interests are best served by equipping him with those fundamental principles and insights which will make it possible for him to profit more readily from practical experience after graduation.

In accordance with this plan of training in fundamentals, the student is required to learn the basic principles that underlie business. No student may omit basic work in the principles and problems of economics, accounting, corporation finance, money and banking, marketing, business law, management, and statistical method, which are essential for a career in all types of business enterprise. Acquaintance with the fundamentals of the broad field not only equips the student with the elementary requisites for a career in a variety of commercial and industrial enterprises but also gives him an invaluable means of discovering his real abilities and making a sound choice of a profession. A major function of the curriculum in business and economics is to aid students in their efforts to discover their best talents, not only students who enter college uncertain of their ultimate objectives but also those whose choice of a future profession or field of business may have been determined already but predicated upon inadequate grounds.

No student may devote himself exclusively to business subjects. He must acquire at least a rudimentary acquaintance with the cultural and humanitarian aspects of the world around him, and at least a brief contact with science. Consequently, a large part of the curriculum is devoted to work in liberal and scientific subjects. Throughout the entire four years' work there is emphasis on the social aspects of the subjects considered. If a student develops alongside his business work a special interest in some such field as languages, mathematics, or science, he is given opportunity through electives to pursue his special line. The College regards as important the principle that the training as a whole shall offer an education commensurate with the standards of a university.

An increasing number of bachelor graduates are not going directly into business but go on to law school, to graduate study in economics, or graduate schools of business, and many of the latter go on to research and analytical studies of management or economics. They become staff researchers in business or government or foundations or become college and university teachers. And increasingly today, competent and qualified individuals move back and forth, as previously in the natural sciences and engineering, between staff research in business, government or independent consulting and university teaching.

Perhaps the most distinctive feature of the work in business and economics at Lehigh is the character of the class work. Much of the work of the curriculum is taken in the College of Arts and Science, while students of this division and of the College of Engineering avail themselves of the courses given in the College of Business and Economics. There is no segregation of students by colleges, and students in business and economics take their courses in competition with students trained in liberal arts and in the exact sciences. This condition has a marked influence on the standards of work and the quality of the student. Qualified students in Business and Economics are eligible for the Interdepartmental Honors Program (see page 22). Also, on the advice of the chairman of the department in which the major work is being done, and with the consent of the Dean of the College, a junior or senior of unusual merit in the College of Business and Economics who wishes to concentrate in his

chosen field may be allowed to substitute not more than four hours (if a junior) or six hours (if a senior) of unscheduled work per semester for an equivalent number of hours of *elective* work otherwise required for graduation.

Although emphasis is upon broad training, rather than specialization, the College recognizes that some degree of concentration is desirable after the student's interests may reasonably be expected to have crystallized. Accordingly, in the junior and senior years, every student is required to pursue a series of related courses in some more restricted field. Seven fields of concentration are offered, viz: accounting, economics, economic statistics, finance, foreign careers, management, and marketing. The detailed programs of study in each of the above fields are set forth on the following pages.

In times of normal business activity, students who have made creditable records may reasonably expect to receive one or more offers of positions before the date of their graduation. The College of Business and Economics enjoys happy relations with many of the country's leading industries. Representatives regularly visit the campus to engage the services of students graduating in business and economics. The University assumes no responsibility for finding positions for its graduates, but every effort is made by the College and by the University placement service to put its graduating students in touch with desirable opportunities for employment.

Graduates of this curriculum receive the degree of Bachelor of Science in Business and Economics. A five-year curriculum with a bachelor's degree in industrial engineering and a bachelor's degree in business and economics is outlined on page 58.

Many students in the several branches of engineering and various majors in the College of Arts and Science will seek graduate or professional business training through pursuit of the Master of Business Administration degree. If they are eligible for admission to Lehigh's Graduate School, they may plan business electives during their bachelors work in engineering and arts to meet at least part of the background year requirements for Lehigh's MBA degree.

Graduate programs leading to the degrees of Master of Business Administration, Master of Arts in Economics, Master of Science in various business fields (Accounting, Business Economics, Management Science) are outlined on pages 59-62.

The Ph.D. degree in Business and Industrial Economics is described on page 61.

## CURRICULUM FOR B. S. IN BUSINESS AND ECONOMICS

*120 hours required for degree plus physical education for two semesters.*

### I. COLLEGE CORE REQUIREMENTS (54 credits)

*A. 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 |

*B. Business and Economics Core Requirements (39 credits)*

| | | | |
|---|---|---|---|
| ECO | 3 | ECONOMICS | 3 |
| ECO | 4 | ECONOMICS | 3 |
| 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 | 1 | BUSINESS LAW | 3 |
| MKT | 111 | MARKETING | 3 |
| FIN | 125 | CORPORATION FINANCE | 3 |
| MGT S | 302 | SURVEY OF MANAGEMENT SCIENCE APPLICATIONS | 3 |
| | | *or* | |
| MGT S | 321 | BUSINESS AND ORGANIZATIONAL BEHAVIOR | 3 |

*Biological, Management and Social Sciences students

### II. 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 set forth below.

### III. 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 students, 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—See IV below.

## 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 under IV below.

## 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.

## IV. Electives

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 (see 1A above), each freshman enrolled in the College of Business and Economics will register for Economics 3 and 4 his freshman year. For his fourth and fifth courses, he will take optional courses toward the science and arts option requirements each semester of his freshman year, in addition to the two semesters of physical education. 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. See majors below.

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.

## ACCOUNTING MAJOR

**Requirement: 16 credits beyond the Core, including:**

| | | | |
|---|---|---|---:|
| ACCTG | 215 | INTERMEDIATE ACCOUNTING | 4 |
| ACCTG | 307 | FEDERAL TAX ACCOUNTING | 3 |
| MGT | 302 | SURVEY OF MGMT SCIENCE | 3 |
| | | *or* | |
| MGT | 314 | OPERATIONS ANALYSIS | 3 |
| | | ACCOUNTING ELECTIVES (EXCEPT ACCTG 390) | 6 |

Students interested in qualifying for the C.P.A. Certificate at either the bachelor or M.B.A. level should consult the chairman of the department.

## ECONOMICS MAJOR

**Requirement: 15 credits of Economics beyond the Core.**

## ECONOMICS STATISTICS MAJOR

Requirement: 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 11 | 3 |
| ECO | | 300-LEVEL COURSE | 3 |

## FINANCE MAJOR

Requirement: 15 credits beyond the Core, including:

| | | | |
|---|---|---|---|
| FIN | 323 | INVESTMENTS | 3 |
| FIN | 326 | PROBLEMS IN FINANCIAL MANAGEMENT | 3 |
| ECO | 353 | PUBLIC FINANCE: FEDERAL | 3 |
| | | *and 6 credits from the following:* | |
| FIN | 324 | SECURITY ANALYSIS | 3 |
| FIN | 331 | BANK CREDIT MANAGEMENT | 3 |
| ECO | 332 | MONETARY-FISCAL POLICY | 3 |
| ECO | 339 | INTERNATIONAL ECONOMICS | 3 |

## FOREIGN CAREERS MAJOR

Requirement: 15 credits beyond the Core as follows:

| | | | |
|---|---|---|---|
| ECO | 303 | ECONOMIC DEVELOPMENT | 3 |
| ECO | 309 | COMPARATIVE ECONOMIC SYSTEMS | 3 |
| ECO | 339 | INTERNATIONAL ECONOMICS | 3 |
| ECO | 340 | INTERNATIONAL ECONOMICS | 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.

## MANAGEMENT MAJOR

Requirement: 15 credits beyond the Core as follows:

| | | | |
|---|---|---|---|
| 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* | |
| | | A COURSE IN SOCIAL RELATIONS AS APPROVED BY ADVISOR | 3 |

## MARKETING MAJOR

Requirement: 15 credits beyond the Core as follows:

| | | | |
|---|---|---|---|
| MKT | 113 | ADVERTISING | 3 |
| MKT | 214 | SALES MANAGEMENT | 3 |
| | | *or* | |
| MKT | 217 | INDUSTRIAL MARKETING | 3 |
| MKT | 312 | MARKETING RESEARCH | 3 |
| MKT | 315 | CONSUMER BEHAVIOR | 3 |

*One of the following (not taken in the Core)*

| | | | |
|---|---|---|---|
| MGT S | 302 | SURVEY OF MANAGEMENT SCIENCE APPLICATIONS | 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 |

## *FIVE YEAR PROGRAMS*

## ENGINEERING - M.B.A. PROGRAM and ENGINEERING - M.S. IN MANAGEMENT SCIENCE PROGRAM

These programs are 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 over-all time involved in each program is five years, but a certain amount of summer session work would be necessary to attain both a bachelor's degree in engineering and a master's degree in business administration or management science within that period. 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 both the M.S. in Management Science and the M.B.A. degrees. 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 M B.A. candidates, see page 59.

The background required for the M.S. in Management Science is preparation in mathematics embracing a thorough knowledge of calculus (at least six credit hours) and linear algebra (at least 3 credit hours) plus basic courses in accounting, finance computers, economics (basic level in Macro and intermediate Micro), marketing, and statistics. Candidates for this program will also be required to take the Admission Test for Graduate Study in Business (ATGSB), or GRE exam.

Transfer credits from a reputable accredited college or university will be accepted for background courses. Students wishing to take some of their background work elsewhere should consult Professor M. D. Snider, Office of the Dean, College of Business and Economics, to obtain approval of the proposed course or courses and of the institution at which they are to be taken.

It is suggested that engineering students who are interested in these programs confer with Professor Snider for additional information. The graduate programs leading to the degrees of Master of Business Administration and M.S. in Management Science are outlined on pages 60-61. The Ph.D. in Business and Industrial Economics is described on pages 61-62.

## ARTS—M.B.A. PROGRAM

This program is designed to meet the needs of competent students in any of the Arts and Science Majors who wish to add to their Arts studies training in business management at an advanced level.

The over-all time involved in the program is five years, but a certain amount of summer session work may be necessary for majors in the sciences to attain both a B.A. and a master's degree in business administration within that period. In addition to a year's work in economics, which can be counted as part of the undergraduate social science distribution requirements, thirty hours of basic business must complete the fifteen to eighteen hours requirements for the M.B.A. degree.

For background courses required for the M.B.A., see p. 59.

Transfer credits from a reputable accredited college or university will be accepted for background courses. Students wishing to take some of their background work elsewhere should consult Professor M. D. Snider, Office of the Dean, College of Business and Economics, to obtain approval of the proposed course or courses and of the institution at which they are to be taken.

It is suggested that Arts and Science students who are interested in this program confer with Professor Snider for additional information. The graduate program leading to the degree of Master of Business Administration is outlined on page 59. The Ph.D. in Business and Industrial Economics is described on page 61.

## 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. It is necessary that a student be enrolled in the curriculum in industrial engineering for the first four years and that he complete the requirements in the curriculum as outlined on page 75. At the beginning of the fifth year the student transfers to the curriculum in business and economics and is required to complete thirty-three semester hours as follows:

Majors in Accounting, Economics, Economic Statistics, Finance, Management, and Marketing must complete the hours required for his major in the regular four-year program in Business and Economics as listed on page 55. The balance of his program to complete the required thirty-three hours of the fifth year will be selected in consultation with his advisor from those college core requirements listed on page 55, which he has not already taken for the B.S. in Industrial Engineering.

Majors in personnel and industrial relations must pursue the following program for the fifth year:

**Required Courses**

*Fifth Year, First Semester*

LAW       1 BUSINESS LAW                                3

| ECO | 129 | MONEY AND BANKING | 3 |
| PSYCH | 201 | INDUSTRIAL PSYCHOLOGY | 3 |
| | | | 9 |

*Fifth Year, Second Semester*

| ECO | 206 | INTERMEDIATE MICRO-ECONOMIC THEORY | 3 |
| ECO | 338 | LABOR MARKET INSTITUTIONS | 3 |
| SR | 11 | SOCIOLOGY | 3 |
| ECO | 346 | BUSINESS CYCLES | 3 |
| | | | 12 |

*and twelve semester hours to be selected from the following in consultation with the advisor:*

| FIN | 323 | INVESTMENTS | 3 |
| FIN | 351 | PUBLIC FINANCE: FEDERAL | 3 |
| FIN | 337 | INTERNATIONAL ECONOMICS | 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 |
| | | | 39 |

## 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.S. (Accounting, Business Economics or Management Science) and the Master of Arts in Economics. On a more advanced level, the College offers a Ph.D. in Business and Industrial Economics.

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 the candidate a working knowledge of the managerial problems involved in the various facets of business activity—marketing, finance, pricing, etc., with the integration of the various fields into generalized professional business training.

A candidate who has had basic courses in accounting, business law, corporation finance, economics, marketing, money and banking, and statistics and management in his undergraduate edu-

cation will usually have sufficient background work to enable him to complete the requirements for the degree in one year. For other candidates an additional semester or year devoted to prerequisite and basic courses is necessary as indicated in the program outlined below.

All candidates for this program will be required to take the Admission Test for Graduate Study in Business.

The background and advanced 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. Equivalent background courses taken at other approved institutions will be accepted in lieu of those indicated. A comprehensive examination will be required of all candidates for the M.B.A. degree.

**Background Courses (30 hours)**

| FIN | 125 | PRINCIPLES OF CORPORATION FINANCE | 3 |
| LAW | 1 | BUSINESS LAW | 3 |
| ECO | 45 | STATISTICAL METHOD | 3 |
| ECO | 206 | INTERMEDIATE MICRO-ECONOMIC THEORY | 3 |
| ECO | 129 | MONEY AND BANKING | 3 |
| ACCTG | 108 | FUNDAMENTALS OF ACCOUNTING* | 3 |
| MKT | 111 | MARKETING | 3 |
| ACCTG | 111 | BUSINESS DATA PROCESSING | 3 |
| MGT S | 302 | SURVEY OF MANAGEMENT SCIENCE APPLICATIONS | 3 |
| MGT S | 321 | BUSINESS AND ORGANIZATIONAL BEHAVIOR | 3 |

**Required Courses (15 hours)**

| ACCTG | 422 | MANAGERIAL ACCOUNTING | 3 |
| | | *or* | |
| ACCTG | 431 | ACCOUNTING THEORY AND THOUGHT (for Accounting majors) | 3 |
| ECO | 431 | MANAGERIAL ECONOMICS | 3 |
| FIN | 421 | FINANCIAL MANAGEMENT | 3 |
| LAW | 401 | LEGAL PROBLEMS IN BUSINESS | 3 |
| MGT S | 451 | MANAGERIAL POLICY AND DECISION-MAKING** | 3 |

*If students have had Accounting 51 and 52 or equivalent as undergraduates, they are not required to take Accounting 108.

**It is recommended that this course be taken the last semester before graduation.

**Elective Courses (15 hours)**

Elective credit hours may be selected from desired combinations of 300- and 400-level courses offered in the College of Business and Economics, as described under the various departmental listings in this Catalog. However, each candidate is urged to take 6-9 credits of electives in one of the following fields:

MANAGEMENT SCIENCE
FORECASTING

Finance
Labor Relations
Transportation
International Trade and Finance
Accounting
Marketing

## Master of Arts in Economics

Candidates for the degree may qualify by completing thirty hours of approved course work or by completing twenty-four hours in approved courses and submitting a satisfactory thesis for six hours credit. Every candidate will be required to pass a comprehensive examination covering general economics and one major field selected from his graduate studies.

The program of study will include:

(1) six hours of required courses—Economics 432, Micro-Economics and Economics 436, Macro-Economics

(2) at least twelve hours of credit selected from the offerings of the department of Economics.

(3) up to twelve credit hours of optional courses may be elected from related fields in any department in the university with the consent of the director of the program.

## Master of Science in Accounting, Business Economics, or Management Science

The Master of Science degree is offered with a concentration in Accounting or Business Economics or Management Science. Each candidate for the degree must take the following core courses, in addition to making up any background deficiencies for his particular field, and will then complete the degree in accordance with the concentration requirements listed in each subsection below.

### Common M.S. Core (12 credits)

| | |
|---|---|
| ACCTG 422, ACCTG 424 or ACCTG 431 | 3 |
| ECO 431 or ECO 432 | 3 |
| MGT S 321 or MGT S 412 | 3 |
| ECO 352* | 3 |

*Mgt S 302 may be substituted for Eco. 352 for M.S. (Accountancy)*

## M.S. (Accountancy)

Candidates should consult the Chairman of the Accounting Department for any background deficiencies required.

**Accounting Electives (9 to 12 additional credits from the following courses)**

One 300 level Accounting Course

| | | | |
|---|---|---|---|
| ACCTG | 406 | ADVANCED TAX PLANNING AND RESEARCH | 3 |
| ACCTG (I.E.) | 408 | MANAGEMENT INFORMATION SYSTEMS | 3 |
| ACCTG | 424 | ADVANCED MANAGEMENT ACCOUNTING | 3 |
| ACCTG | 431 | ACCOUNTING THEORY AND THOUGHT | 3 |
| ACCTG | 442 | PROFESSIONAL ACCOUNTING SEMINAR | 3 |

**Other Electives (6 to 9 additional credits from non-accounting courses to be approved by director of program)**

Qualifying exam: A comprehensive examination for the M.S. degree would be required.

## M.S. (Business Economics)

Advanced work in economics is offered in a Business Economics curriculum in recognition of the rapidly growing need for professionally trained economists with applied research aptitude and interests. The objective of the program is to provide the training necessary to conduct independent economic research in a business environment. To this end, the curriculum includes advanced economic theory and quantitative methods courses to provide an understanding of the basic units of measurement; courses on economic and research methodology to provide an understanding of research objectives and procedures; and a seminar at the end of the program to provide a concentrated exposure to research under close faculty supervision.

Although it is possible for the student with a strong background to complete the program in one year, extending the program to engage in research is encouraged. Many opportunities exist for students to work as research assistants in the Center for Business Economics and Urban Studies. This opportunity to conduct joint and independent research in concert with faculty and undergraduates is considered a valuable aspect of the program.

Although the basic objective requires that all students take a considerable number of specified courses, a limited number of elective hours is permitted to allow the student to gain added insight in a particular field. Listed below are the courses which comprise the program.

**Required Course Work (18 additional credits)**

| | | |
|---|---|---|
| ECO 316 | INTERMEDIATE MACRO-ECONOMIC THEORY | 3 |
| | *or* | |
| ECO 436 | MACRO-ECONOMICS | 3 |
| ECO 347 | NATIONAL INCOME ANALYSIS | 3 |
| | *or* | |
| ECO 447 | SYSTEMS OF NATIONAL ACCOUNTS | 3 |
| ECO 454 | FORECASTING | 3 |
| ECO 455 | ECONOMETRIC METHODS | 3 |
| | *or* | |
| ECO 461 | METHODOLOGY IN THEORY AND RESEARCH | 3 |
| ECO 475 | BUSINESS ECONOMICS SEMINAR | 3 |
| | ELECTIVES (TO BE APPROVED BY ADVISOR) | 3 |

The following courses have been selected as providing the minimum background for the program and may be taken without credit to remove any deficiences.

| | | |
|---|---|---|
| ECO | 4 | ECONOMICS PRINCIPLES |
| ECO | 45 | STATISTICAL METHOD |
| ECO | 129 | MONEY AND BANKING |
| ECO | 206 | INTERMEDIATE MICRO-ECONOMIC |
| ACCTG 51-52 | | ESSENTIALS OF ACCOUNTING |
| ACCTG | 111 | BUSINESS DATA PROCESSING |
| FIN | 125 | CORPORATION FINANCE |
| MATH | 9 hours of college mathematics (equivalent to Lehigh Math 41-43) | |

A final degree requirement is the successful completion of a written comprehensive examination to be administered during the last semester of course work.

## M.S. (MANAGEMENT SCIENCE)

This program is designed to provide a rigorous analytical preparation in business education emphasizing certain applied and behavioral aspects of economic theory. Management Science is an interdisciplinary program and is given in cooperation with the departments of Industrial Engineering and Mathematics.

To be eligible for this program, the applicant must have had background preparation in mathematics embracing a thorough knowledge of calculus (at least 6 credit hours) and linear algebra (at least 3 credit hours) plus basic courses in accounting, finance, computers, economics, marketing* and statistics.

**Required Course Work (18 additional credits)**

| | | |
|---|---|---|
| MGT S 412 | SEMINAR IN ORGANIZATION BEHAVIOR | 3 |
| | *or* | |
| MGT S | 451 MANAGERIAL POLICY AND DECISION-MAKING | 3 |
| MGT S | 417 ADVANCED MATHEMATICAL PROGRAMMING | 3 |
| MGT S | 418 SEMINAR IN MANAGEMENT SCIENCE | 3 |
| ACCTG. (I.E.) | 408 MANAGEMENT INFORMATION SYSTEMS | 3 |

*In addition the candidates must take 6 credit hours from the following:*

MGT S 451 or 412
ECO 316, 437, 454
IE 308, 326, 410, 416, 418, 420, 425, 426, 427, 440
MATH 251, 309, 334, 362
EE 411, 412
SR 305, 381, 402, 465
LAW 401
FIN 421
MKT 450

*\*This requirement may be waived if student is taking Mkt. 450 as part of his program.*

## THE PH.D. IN BUSINESS AND INDUSTRIAL ECONOMICS

The college offers Ph.D. work in various fields of economics and business. Students normally present on admission economics or business background or some combination of these with good mathematics preparation, though some come with engineering or other social sciences preparation. They must have superior graduate study prospects, normally including the Graduate Record Exam advanced test in business or economics. A commitment to full time resident graduate study for at least one year is required for anyone wishing to be considered for this program. Letters of inquiry or applications should be addressed to the Chairman, doctoral program committee of the College.

A student in the program applies to the graduate committee for candidacy after he has presented an approved dissertation plan and has successfully passed general examinations as follows:

1. A general examination in economic theory.
2. General examinations in three fields, one of which may be outside the College of Business and Economics. Fields which may be chosen include the following:

ACCOUNTING
BUSINESS FINANCE
ECONOMIC DEVELOPMENT
ECONOMIC SYSTEMS
FORECASTING AND BUSINESS CONDITIONS
INTERNATIONAL ECONOMICS
LABOR ECONOMICS
MACRO-ECONOMICS
MANAGEMENT SCIENCE AND MANAGEMENT
MICRO-ECONOMIC THEORY
MONEY, CREDIT, AND BANKING
PUBLIC FINANCE
REGIONAL ECONOMICS

3. Quantitative Analysis and Research Methodology, demonstrating competence in:

(1) Statistics
(2) Accounting
(3) Operations Analysis

A dissertation committee comprised of at least four faculty members including the candidate's major professor as chairman and two other members as readers is established for each candidate passing the general examinations. At least one member of the committee shall be appointed from outside the College of Business and Economics, and at least two departments within the college shall be represented on the committee.

# COLLEGE OF ENGINEERING

John J. Karakash, *Dean*

Robert Gallagher, *Associate Dean*

The College of Engineering offers curricula in chemical engineering, chemistry, civil engineering, electrical engineering, engineering physics, fundamental sciences, industrial engineering, mechanical engineering and engineering mechanics, and metallurgical engineering and materials science.

The engineering curricula were formulated on the basis of study by the faculty of Lehigh University of the problems of technical education and the changing needs of modern society. This study led to the conclusion that greater emphasis than heretofore should be placed upon the fundamentals of engineering, including mathematics, physics, chemistry, and theoretical and applied mechanics and less emphasis upon the highly specialized details of engineering practice; and that the engineer must know something of the social sciences and humanities, that is, the sciences which deal with human relations. The various engineering curricula accordingly emphasize the fundamental sciences and those subjects from the social sciences and the humanities which are expected of every well-educated man. These latter are now recognized as essential to the education of engineers, not only because of their practical applications in industrial, business, and civic life, but also because they enrich the whole of a man's private life.

Engineering undergraduates with interests related to problems in the areas of aerospace, environmental control, biomedical instrumentation and management can pursue such interests through use of upper level electives provided in the curricula. Effective graduate work in such areas can best be effected by mastering engineering fundamentals and combining these with appropriate electives related to the areas.

Recommendation is made for a uniform freshman year in the College of Engineering. The student's tentative choice of a specific engineering curriculum, as recorded at the time of entrance, may be changed (within the limitations of enrollment in the various curricula) prior to his entering upon the sophomore year without loss of time. Engineering freshmen are admitted with "open" curriculum choice. Within a year of college experience, and on the basis of conferences with members of the faculty, it is hoped that any student who is uncertain as to his curriculum choice may choose wisely. In the second semester of his freshman year, just prior to preregistration for the sophomore year, each engineering student selects a particular engineering curriculum. The sophomore year for many of the engineering curricula are sufficiently alike so as to be 'tradeable" between these curricula, and it is thus possible for a student to transfer from one curriculum to another without loss of credit or having to make up courses at the end of his sophomore year.

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. The successful completion of one year of full-time graduate study leads to the degree of Master of Science.

Students pursuing studies leading to a specific engineering degree have opportunities for elective sequences which provide the foundation for graduate work in special areas of interest. Even though elective opportunities in some curricula do not appear until the Senior year, students are urged to become aware of such opportunities as early as their Sophomore year and consult with their curriculum advisors for optimal planning of their programs.

Five-year courses 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 baccalaureate degree is awarded upon the successful completion of four years of study, and a second baccalaureate degree is awarded at the end of the fifth year. Similar programs may be worked out leading to an M.S. in Materials, or an M.B.A.

## 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 three: the humanities, the natural sciences, and the social sciences. Since all engineers receive extensive training in the physical sciences, their general studies are 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, six hours of social sciences, and three hours of economics. During the following six semesters, fifteen additional hours (five courses) are elected so that by the end of the senior year, a student will have completed a total of thirty credit hours—the minimum requirement in General Studies.

All courses must be on the approved list of courses for General Studies. The distribution requirements of General Studies are as follows:

**General Studies** (*Thirty total hours required*)

GROUP 1: HUMANITIES (*9 hours minimum required*)
Freshman English. Six semester hours (University-wide 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.

GROUP 2: LIFE AND EARTH SCIENCES
(*No required minimum*)

GROUP 3: SOCIAL SCIENCES
(*9 hours minimum required*)

ECO 3 ECONOMICS (3 *hours*)

ELECTIVES: Not more than 12 hours General Studies (GS) credit is allowed in any one department. Registration into any of the elective courses may be limited by the maximum class size.

The objective of the study of the humanities and social sciences in technical schools has been stated by the American Society for Engineering Education

to be the development of an "understanding of the evolution of the social organism within which we live . . .; and the development of moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude." We conceive it to be the duty of the engineer to be a professional man in the broadest sense of the term, a member of a group whose primary aim is to advance human well-being.

Several of these courses (notably History 1 and 2, Course of Civilizations; Biology 13, Human Biology; and Philosophy 100, Philosophy of Contemporary Civilization) have been developed particularly to satisfy the objectives of general studies. They are designed to acquaint the student with some broad segment of the heritage of our civilization, thereby opening intellectual doors for the student to facilitate the self-education which will continue throughout his life. The requirements in various fields are planned to encourage the student to study as broadly as is possible yet retain the possibility that the student who has a strong interest in a field may pursue that interest to as great an extent as is reasonable within the time available. Since election of History 1 and 2 is encouraged in the freshman year, it is scheduled to fit with the normal freshman courses, whereas difficulty of schedules and conflicts may be expected in later years.

**General Studies Courses**

GROUP I: HUMANITIES

*Literature (English or American)*
ENGL    1, 2; 11, 12 COMPOSITION AND LITERATURE
             (Required)

ENGL    4, 5, 7, 8, 9,
    11, 12, 18, 19,
    20, 21, 35, 36, OR ANY ENGLISH LITERATURE COURSE
             ABOVE 100.

*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)
SPCH    61 (Dramatics)

*Philosophy and Religion*

PHIL    (any course)
RELIGION (any course)

GROUP 2: LIFE AND EARTH SCIENCES

| | | | |
|---|---|---|---|
| ASTRON | 1 | DESCRIPTIVE ASTRONOMY | 3 |
| ASTRON | 2 | GENERAL ASTRONOMY | 3 |
| ASTRON | 104 | STELLAR ASTRONOMY AND ASTROPHYSICS | 3 |
| BIOL | 13 | HUMAN BIOLOGY | 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 | PSYCH AS A NATURAL SCIENCE | 3 |
| PSYCH | 4 | PSYCH AS A SOCIAL SCIENCE | 3 |
| PSYCH | 111 | HISTORY AND SYSTEMS | 3 |

GROUP 3: SOCIAL SCIENCES

| | | | |
|---|---|---|---|
| ECO | 3 | ECONOMICS (*Required*) | 3 |
| ECO | 4 | ECONOMICS | 3 |
| 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 ECONOMICS | 3 |
| ECO | 340 | INTERNATIONAL ECONOMICS | 3 |
| ECO | 353 | PUBLIC FINANCE, FEDERAL | 3 |
| GOVT | | Any Course | |
| HIST | | Any Course | |
| IR | | Any Course | |

*or the following*

| | | | |
|---|---|---|---|
| GK | 21 | ANCIENT HISTORY | 3 |
| GK | 202 | GREEK ARCHAEOLOGY | 3 |
| LAT | 22 | ANCIENT HISTORY | 3 |
| LAT | 203 | ARCHAEOLOGY OF ITALY | 3 |
| SR | | Any Course | |

## 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 upper three years, please refer to the several specialized curricula which follows.

**Freshman Year (First Semester)**

| | | | |
|---|---|---|---|
| ENGL | 1, 11 | COMPOSITION AND LITERATURE* | 3 |
| CHEM | 1 | CHEMICAL PRINCIPLES I | 3 |
| CHEM | 11 | CHEMICAL PRINCIPLES I LABORATORY | 1 |
| HIST | 1 | COURSE OF CIVILIZATIONS | 3 |
| MATH | 21 | ANALYTICAL GEOMETRY & CALCULUS I | 4 |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| | | *or* | |
| ECO | 3 | ECONOMICS | 3 |
| ENGR | | INTRODUCTION TO SCIENCE AND ENGINEERING | 0 |
| PE | 1 | PHYSICAL EDUCATION | 0 |
| | | | 17 |

**Freshman Year (Second Semester)**

| | | | |
|---|---|---|---|
| ENGL | 2, 12 | COMPOSITION & LITERATURE* | 3 |
| CHEM | 3 | CHEMICAL PRINCIPLES II | 3 |
| CHEM | 13 | CHEMICAL PRINCIPLES II LABORATORY | 1 |
| HIST | 2 | COURSE OF CIVILIZATIONS | 3 |
| MATH | 22 | ANALYTICAL GEOMETRY & CALCULUS II | 4 |
| ECO | 3 | ECONOMICS | 3 |
| | | *or* | |
| PHYS | 1 | MECHANICS OF MASS POINTS | 3 |
| ENGR | | INTRODUCTION TO SCIENCE AND ENGINEERING | 0 |
| PE | 2 | PHYSICAL EDUCATION | 0 |
| | | | 17 |

*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.

## 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.

## HONORS PROGRAMS

Outstanding students in the college may participate in the 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.

During the first two years, the student who contemplates independent study should consult his department chairman to determine desirable accelerations or rearrangements in his standard program. Normally, the unscheduled work is begun in the junior year, but under conditions which vary slightly among departments.

Outstanding students are urged to consult their department chairmen concerning the requirements for independent study and the thesis which must be submitted. Within the limits of facilities and staff available special programs will be arranged for those accepted for Honors work. Students who successfully complete the program and submit an outstanding thesis are awarded Departmental Honors at graduation.

Students of the college are also eligible for Interdepartmental honors, award of which is based on a series of very broad Creative Concepts Seminars and the submission of a thesis. (See page 22).

## 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. Sequences in Arts— Engineering begin on page 49.

## ENGINEERING-M.B.A. PROGRAM

Qualified engineering students who wish to obtain supplementary training in business management may be interested in the Engineering—M.B.A. program described on page 57 of this Catalog. By attending one or two summer sessions, both the bachelor's degree in engineering and the master's degree in business administration may be attained in a period of five years.

## 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

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.

## B.S. ENGINEERING—M.S. MATERIALS

A special program leading to an M.S. degree in Materials is offered for engineering graduates who complete prerequisite courses in physical chemistry, metallurgy, mechanics, etc. Careful selection of technical electives by interested 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.

### A. Prerequisite Courses

*Science Orientation*

| | | | |
|---|---|---|---|
| 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 |
| | | | 21 |

*Engineering Orientation*

| | | | |
|---|---|---|---|
| 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 |
| | | | 21 |

*Alternately Chem 91 and Chem 190.

### B. Recommended Electives for Preparatory Program

(1) *Structure of Solids Group*

| | | | |
|---|---|---|---|
| MET | 315 | 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 | |
| MET | 343 | PHYSICAL POLYMER SCIENCE | 3 |
| EE | 304 | SEMICONDUCTOR ELECTRONICS | 3 |
| EE | 306 | SOLID STATE MAGNETIC & DIELECTRIC DEVICES | 3 |
| GEOL | 333 | CRYSTALLOGRAPHY | 3 |
| PHYS | 362 | ATOMIC AND MOLECULAR STRUCTURE | 3 |
| PHYS | 363 | PHYSICS OF SOLIDS | 3 |
| MATH | | APPROVED ELECTIVE | 3 |

(2) *Physical Metallurgy Group*

| | | | |
|---|---|---|---|
| MET | 307 | STRUCTURE & BEHAVIOR OF MATERIALS | 3 |

| | | | |
|---|---|---|---|
| MET | 315 | 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 |

(3) *Mechanics & Mechanical Behavior Group*

| | | | |
|---|---|---|---|
| ME | 166 | PROCEDURES FOR MECHANICAL DESIGN | 2 |
| MECH | 201 | ADVANCED MECHANICS OF MATERIALS | 3 |
| MECH | 303 | MECHANICS OF CONTINUA I | 3 |
| MECH | 304 | MECHANICS OF CONTINUA II | 3 |
| MECH | 313 | FRACTURE MECHANICS | 3 |
| MET | 313 | MATERIALS FABRICATION | 3 |
| MET | 317 | IMPERFECTIONS IN CRYSTALS | 3 |
| MATH | | APPROVED ELECTIVE | 3 |

(4) *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 | |

## C. 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 |
| ME | 441 | STRESS ANALYSIS & DESIGN | 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 SCIENCE | 3 |
| MET | 418 | DEFORMATION & FRACTURE | 3 |
| | | *or* | |
| | | 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 | TOPIC SIN POLYMER SCIENCE | 3 |
| CHEM | 443 | SOLID STATE CHEMISTRY | 3 |
| CHEM | 497 | 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 MINERALOGY | 3 |
| IE | 344 | METAL CUTTING THEORY | 3 |
| ME | 441 | APPLIED STRESS ANALYSIS | 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 |
| MECH | 451 | NON-LINEAR CONTINUUM MECHANICS *same as* , | 1-3 |
| PHYS | 471 | NON-LINEAR CONTINUUM MECHANICS | 1-3 |
| MET | 319 | CURRENT TOPICS IN MAT SCI | 3 |
| MET | 320 | ANALYTICAL METHODS IN MAT SCI | 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 | PHYSICS 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 | 3 |

## *UNDERGRADUATE CURRICULA*

## CHEMICAL ENGINEERING

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 in engineering principles and intensive 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.

**Freshman Year** (*See page 65*)
**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| MATH | 23 | ANALYTIC GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| ECO | 4 | ECONOMICS | 3 |
| CHE | 51 | CHEMICAL ENGINEERING COMPUTATION | 4 |
| | | ELECTIVE* | 3 |
| | | | 18 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| MATH | 205 | LINEAR METHODS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| CHEM | 90 | PHYSICAL CHEMISTRY | 3 |
| CHE | 52 | TRANSPORT PHENOMENA | 4 |
| | | ELECTIVE* | 3 |
| | | | 17 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| CHEM | 191 | PHYSICAL CHEMISTRY | 3 |
| CHEM | 192 | PHYSICAL CHEMISTRY LABORATORY | 1 |
| CHEM | 51 | ORGANIC CHEMISTRY | 3 |
| CHEM | 53 | ORGANIC CHEMISTRY LABORATORY | 2 |
| CHE | 165 | UNIT OPERATIONS I | 4 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| CHE | 166 | UNIT OPERATIONS II | 4 |
| CHE | 200 | THERMODYNAMICS | 3 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVES* | 6 |
| | | | 16 |

**Senior Year (First Semester)**

| | | |
|---|---|---|
| GS | REQUIREMENT | 3 |
| | ELECTIVES* | 15 |
| | | 18 |

**Senior Year (Second Semester)**

| | | |
|---|---|---|
| GS | REQUIREMENT | 3 |
| | ELECTIVES* | 15 |
| | | 18 |

*The electives indicated above must be distributed as follows:

| | |
|---|---|
| CHEMISTRY, PHYSICS, MATHEMATICS | 9 hours |
| ADVANCED CHEMICAL ENGINEERING | 9 hours |
| EXTRA-DEPARTMENTAL ENGINEERING AND SCIENCE | 12 hours |
| FREE ELECTIVES | 12 hours |

## CHEMISTRY

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 110,000. 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 to 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. The tabulation below indicates some of the possibilities of this guided selection of elective courses.

IN PREPARATION FOR CAREERS IN:

Graduate study or research in chemistry,
    take physics and mathematics
Medicine, take biology and biochemistry
Pharmaceutical or food industries,
    take biochemistry
Materials, producing or using industries,
    take polymer chemistry and metallurgy
City Management, take Social Relations
Executive or sales departments of chemical
    industries, take business management
Plant management in chemical industries,
    take chemical engineering

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 page 67.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| MATH | 23 | ANALYTICAL GEOMETRY AND CALCULUS III | 4 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| CHEM | 51 | ORGANIC CHEMISTRY | 3 |
| CHEM | 53 | ORGANIC CHEMISTRY LABORATORY | 2 |
| GER | 1 | GERMAN | 3 |
| | | | 16 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| CHEM | 52 | ORGANIC CHEMISTRY | 3 |
| CHEM | 54 | ORGANIC CHEMISTRY LABORATORY | 2 |
| CHEM | 90 | PHYSICAL CHEMISTRY | 3 |
| GER | 4 | GERMAN | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT, & ATOMIC PHYSICS | 4 |
| | | | 15 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| CHEM | 191 | PHYSICAL CHEMISTRY | 3 |
| CHEM | 192 | PHYSICAL CHEMISTRY LABORATORY | 1 |

| | | | |
|---|---|---|---|
| CHEM | 302 | INORGANIC CHEMISTRY | 3 |
| CHEM | 358 | ADVANCED ORGANIC CHEMISTRY | 3 |
| GER | 27 | SCIENTIFIC GERMAN | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| CHEM | 193 | PHYSICAL CHEMISTRY LABORATORY | 1 |
| CHEM | 234 | ANALYTICAL CHEMISTRY LABORATORY | 2 |
| CHEM | 332 | ANALYTICAL CHEMISTRY | 3 |
| CHEM | 352 | ORGANIC CHEMISTRY, HETEROCYCLIC COMPOUNDS | 3 |
| CHEM | 308 | COORDINATION CHEMISTRY | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 15 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| CHEM | 381 | RADIATION AND STRUCTURE | 4 |
| GS | | REQUIREMENT | 6 |
| | | ELECTIVES | 6 |
| | | | 16 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| CHEM | 382 | STRUCTURE, ELECTROCHEMISTRY & KINETICS | 3 |
| CHEM | 375 | RESEARCH CHEMISTRY (OPTIONAL) | 3 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVES | 6 |
| | | | 15 |

# CIVIL ENGINEERING

Civil engineering, the original 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.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| CE | 10 | PROBLEM COMPUTATION LABORATORY | 1 |
| CE | 11 | ENGINEERING GRAPHICS | 2 |
| MATH | 23 | ANALYTIC GEOMETRY & CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| CE | 12 | APPLIED ENGINEERING GRAPHICS | 2 |
| CE | 40 | PRINCIPLES OF SURVEYING | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| MECH | 13 | MATERIALS TESTING LABORATORY | 1 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| | | | 16 |

**Summer**

| | | | |
|---|---|---|---|
| CE | 41 | ENGINEERING SURVEYS | 3 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| CE | 121 | MECHANICS OF FLUIDS | 3 |
| CE | 150 | STRUCTURAL ANALYSIS I | 3 |
| CE | 239 | SOIL MECHANICS | 3 |
| MECH | 102 | DYNAMICS | 3 |
| GEOL | 101 | EARTH MATERIALS AND PROCESSES | 3 |
| MET | 63 | ENGINEERING MATERIALS & PROCESSES | 3 |
| | | *or* | |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| | | | 18 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| CE | 123 | FLUID MECHANICS LABORATORY | 1 |
| CE | 154 | STRUCTURAL ANALYSIS II | 3 |
| CE | 162 | SANITARY ENGINEERING | 3 |
| CE | 222 | HYDRAULIC ENGINEERING | 3 |

| | | | |
|---|---|---|---|
| | | APPROVED ELECTIVE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Summer**

| | | | |
|---|---|---|---|
| CE | 100 | INDUSTRIAL EMPLOYMENT | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| CE | 102 | CIVIL ENGINEERING PROSEMINAR | 1 |
| CE | 145 | TRANSPORTATION ENGINEERING I | 3 |
| CE | 151 | STRUCTURAL THEORY | 3 |
| CE | 153 | REINFORCED CONCRETE THEORY | 3 |
| CE | 157 | CONCRETE LABORATORY | 1 |
| | | APPROVED ELECTIVE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| ME | 160 | THERMODYNAMICS | 3 |
| | | APPROVED ELECTIVES | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 15 |

## ELECTRICAL ENGINEERING

The 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. Irrespective of his decision, his ultimate success will depend upon the depth and breadth of his background, the effectiveness with which he can utilize his knowledge, and the keenness with which he can analyze and solve problems. This is one basic assumption upon which the four-year curriculum is based.

The other basic assumption is that the variety of activities in which modern electrical engineers are engaged will continue to remain large, and so an appropriate curriculum must provide opportunity for mobility of the individual. Finally, the undergraduate curriculum reflects the awareness that it should concentrate on broad fundamentals and not on the details of current engineering practice.

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. Subjects in physics and mathematics form one block of courses in the electrical engineering curriculum.

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 programming, physical electronics, electromagnetic theory, and energy conversion. Some of these courses contain laboratory work and together they constitute 25 per cent of the curriculum following the freshman year, which is common to all engineering students.

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.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 15 | CIRCUIT THEORY I | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| MET | 63 | ENGINEERING MATERIALS & PROCESSES | |
| | | *or* | |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| EE | 16 | CIRCUIT THEORY II | 4 |
| MATH | 205 | LINEAR METHODS | 3 |
| MECH | 1 | STATICS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMICS PHYSICS | 4 |
| | | APPROVED ELECTIVE | 2 OR 3 |
| | | | 16 or 17 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 103 | SEMICONDUCTOR DIODE THEORY | 3 |
| EE | 104 | LINEAR SYSTEMS ANALYSIS | 3 |
| EE | 106 | MACHINE THEORY | 4 |
| MATH | 208 | COMPLEX VARIABLES | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| EE | 105 | INTRODUCTION TO TRANSISTOR THEORY AND CIRCUITS | 4 |
| EE | 231 | ELECTRIC & MAGNETIC FIELDS | 3 |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| | | *or* | |
| MATH | 309 | THEORY OF PROBABILITY | 3 |
| MECH | 102 | DYNAMICS | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Summer**

| | | |
|---|---|---|
| EE | 100 | INDUSTRIAL EMPLOYMENT |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 111 | PROSEMINAR | 1 |
| EE | 151 | SENIOR LABORATORY I | 2 |
| EE | 245 | ELECTROMAGNETIC THEORY | 3 |
| | | APPROVED ELECTIVES | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 18 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| ME | 220 | THERMODYNAMICS | 3 |
| | | APPROVED ELECTIVES | 11 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

## INDUSTRIAL ENGINEERING

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 a 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 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| IE | 17 | INTRODUCTION TO COMPUTING | 3 |
| MATH | 23 | ANALYTIC GEOMETRY AND CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| MET | 63 | ENGINEERING MATERIALS AND PROCESSES | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| IE | 11 | APPLIED PROBABILITY LABORATORY | 1 |
| IE | 18 | INFORMATION PROCESSING THEORY | 3 |
| ECO | 4 | ECONOMICS | 3 |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT AND ATOMIC PHYSICS | 4 |
| | | | 18 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| IE | 121 | ANALYSIS & DESIGN I | 5 |
| IE | 221 | INDUSTRIAL STATISTICS | 4 |
| IE | 241 | FUNDAMENTALS OF PRODUCTION ENGINEERING | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| PSYCH | 3 | PSYCHOLOGY AS A NATURAL SCIENCE | 3 |
| | | | 18 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| IE | 122 | ANALYSIS & DESIGN II | 4 |
| IE | 222 | OPERATIONS ANALYSIS & DESIGN | 4 |
| ACCTG | 108 | FUNDAMENTALS OF ACCOUNTING | 3 |
| ME | 168 | ELEMENTS OF MECHANICAL DESIGN | 2 |
| MECH | 102 | DYNAMICS | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 19 |

**Summer**

| | | |
|---|---|---|
| IE | 100 | INDUSTRIAL EMPLOYMENT |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 160 | ELECTRICAL CIRCUITS & APPARATUS | 3 |
| EE | 161 | ELECTRICAL PROBLEMS | 1 |
| EE | 162 | ELECTRICAL LABORATORY | 1 |
| ME | 160 | THERMODYNAMICS | 3 |
| | | APPROVED TECHNICAL ELECTIVES | 6 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| IE | 152 | INDUSTRIAL ENGINEERING PROJECT | 2 |
| CHE | 60 | UNIT OPERATIONS SURVEY | 3 |
| ME | 161 | ENGINEERING LABORATORY | 1 |
| | | APPROVED TECHNICAL ELECTIVE | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 18 |

## FUNDAMENTAL SCIENCES

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 the 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 an option 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 option 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 chairmen concerned with the major field of his option.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| BIOL | 21 | PRINCIPLES OF BIOLOGY | 3 |
| | | *and* | |
| BIOL | 22 | BIOLOGY LABORATORY | 1 |
| | | *or* | |
| GEOL | 1 | PRINCIPLES OF GEOLOGY | 3 |
| CHEM | 51 | ORGANIC CHEMISTRY | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| | | | 15 or 14 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| ECO | 4 | ECONOMICS | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| BIOL | 28 | GENETICS | 3 |
| | | *or* | |
| GEOL | 12 | HISTORICAL GEOLOGY | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| | | ELECTIVE | 3 |
| | | | 16 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| ASTR | 104 | STELLAR ASTRONOMY | 3 |
| GEOL | 1 | PRINCIPLES OF GEOLOGY | 3 |
| | | *or* | |
| BIOL | 21 | PRINCIPLES OF BIOLOGY | 3 |
| | | *and* | |
| BIOL | 22 | BIOLOGY LABORATORY | 1 |
| PSYCH | 3 | PSYCHOLOGY AS A NATURAL SCIENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | OPTION | 3 |
| | | ELECTIVE | 3 |
| | | | 18 or 19 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| GEOL | 12 | HISTORICAL GEOLOGY | 3 |
| | | *or* | |
| BIOL | 28 | GENETICS | 3 |
| PSYCH | 4 | PSYCHOLOGY AS A SOCIAL SCIENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVES | 6 |
| | | OPTION | 3 |
| | | | 18 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVES | 6 |
| | | OPTION | 6 |
| | | | 18 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| PHIL | 261 | PHILOSOPHY OF NATURAL SCIENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVES | 6 |
| | | OPTION | 6 |
| | | | 18 |

## MECHANICAL ENGINEERING AND ENGINEERING MECHANICS

The curriculum in Mechanical Engineering and Engineering Mechanics consists of a 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.

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 mechanics option of the curriculum. This option emphasizes the analytical approach to engineering problems and the application to their solution of the basic methods and principles of mechanics.

Graduates in either 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 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| CE | 11 | ENGINEERING GRAPHICS | 2 |
| ME | 10 | ANALYSIS OF ENGINEERING PROBLEMS | 1 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| MATH | 205 | LINEAR METHODS | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| MECH | 13 | MATERIALS TESTING LABORATORY | 1 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| | | *or* | |
| MET | 63 | ENGINEERING MATERIALS | |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| ME | 101 | MECHANICAL ENGINEERING DESIGN | 3 |
| ME | 104 | THERMODYNAMICS I | 3 |
| MECH | 102 | DYNAMICS | 3 |
| MECH | 201 | ADVANCED MECHANICS OF MATERIALS | 3 |
| EE | 160 | ELECTRICAL CIRCUITS & APPARATUS | 3 |
| EE | 161 | ELECTRICAL PROBLEMS | 1 |
| EE | 162 | ELECTRICAL LABORATORY | 1 |
| | | | 17 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| ME | 105 | THERMODYNAMICS II* | 3 |
| | | *or* | |
| | | APPROVED ELECTIVE | |
| ME | 231 | FLUID MECHANICS | 3 |
| CE | 123 | FLUID MECHANICS LABORATORY | 1 |
| ME | 242 | MECHANICAL VIBRATIONS | 3 |
| MATH | 208 | COMPLEX VARIABLES** | 3 |
| | | *or* | |
| MATH | 231 | STATISTICAL INFERENCE | |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

*Candidates for the B.S. in ME will take M.E. 105.
**Candidates for the B.S. in Eng. Mech. will take Math. 208.

**Summer**

| | | | |
|---|---|---|---|
| ME | 100 | INDUSTRIAL EMPLOYMENT | 0 |

*Candidates for B.S. in Mechanical Engineering*
**Senior Year (First Semester)**

| ME | 108 | LABORATORY I | 2 |
|----|-----|--------------|---|
| ME | | ELECTIVE | 3 |
| | | APPROVED ELECTIVES* | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| ME | 109 | LABORATORY II | 2 |
|----|-----|---------------|---|
| ME | | ELECTIVE | 3 |
| | | APPROVED ELECTIVES* | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

*Candidates for B.S. in Engineering Mechanics*
**Senior Year (First Semester)**

| ME | 108 | LABORATORY I | 2 |
|------|-----|--------------|---|
| MECH | 302 | ADVANCED DYNAMICS | 3 |
| MECH | 303 | MECHANICS OF CONTINUA I | 3 |
| | | APPROVED ELECTIVES* | 6 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| ME | 109 | LABORATORY II | 2 |
|------|-----|---------------|---|
| MATH | 322 | METHODS OF APPLIED ANALYSIS I | 3 |
| MECH | 304 | MECHANICS OF CONTINUA II | 3 |
| | | APPROVED ELECTIVES* | 6 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

*The Approved Electives must represent a coherent group of approved courses such as 200 and 300-level courses in Mathematics, Mechanical Engineering, Mechanics, Physics and Chemistry, and a limited number of other approved electives.

## ENGINEERING PHYSICS

The curriculum in engineering physics is designed to prepare men for careers in scientific work. The first two years of work are similar to those in the other engineering curricula, and some further engineering study in circuits is included. Physics 62 in the fourth semester provides the student with a perspective of the subject matter of contemporary physics 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 unified 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 in 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, Introduction to 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 in the senior year 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 65*)

**Sophomore Year (First Semester)**

| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
|------|----|----------------------|---|
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVE | 3 |
| | | APPROVED ELECTIVE* | 3 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
|------|----|--------------------------------------|---|
| MATH | 205 | LINEAR METHODS | 3 |
| PHYS | 62 | CONTEMPORARY PHYSICS | 3 |
| PHYS | 90 | ELECTRICAL PHENOMENA | 1 |
| GS | | REQUIREMENT | 3 |
| | | APPROVED ELECTIVE* | 2 or 3** |
| | | | 16 or 17 |

*2 semesters of German are recommended for students planning graduate study.

**2 hours if C.E. 11, otherwise 3 hours

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| PHYS | 191 | LABORATORY TECHNIQUES | 2 |
| PHYS | 212 | ELECTROSTATICS | 3 |
| PHYS | 215 | PARTICLES & FIELDS I | 3 |
| MATH | 322 | METHODS OF APPLIED ANALYSIS I | 3 |
| GS | | REQUIREMENT | 3 |
| | | APPROVED ELECTIVE* | 3 |
| | | | 17 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| PHYS | 254 | OPTICS LABORATORY | 2 |
| PHYS | 213 | ELECTROMAGNETISM | 3 |
| PHYS | 216 | PARTICLES & FIELDS II | 3 |
| | | ELECTIVE | 3 |
| | | APPROVED ELECTIVES | 4 |
| | | | 15 |

*Suggested: EE 15, 16; Chem 302

**Summer**

| | | | |
|---|---|---|---|
| PHYS | 100 | INDUSTRIAL EMPLOYMENT | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| PHYS | 192 | ADVANCED LABORATORY | 2 |
| PHYS | 340 | HEAT, THERMODYNAMICS & PYROMETRY | 3 |
| PHYS | 362 | ATOMIC AND MOLECULAR STRUCTURE | 3 |
| | | APPROVED ELECTIVE* | 3 |
| | | ELECTIVE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| PHYS | 171 | PROSEMINAR | 1 |
| | | APPROVED ELECTIVE** | 3 |
| | | ELECTIVES | 9 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Two of Phys. 363, 364, 365, 369 and Met. 362 are to be elected.

## METALLURGY AND MATERIALS SCIENCE

Progress in many fields of engineering depends upon discovery of new materials and a better understanding of the behavior of existing materials. Interest in new materials for solid-state devices, for application of nuclear energy and for space technology, as well as a better understanding of the behavior of materials in the design of structures, automobiles and aircraft, plant processing equipment, electrical machinery, etc., have increased the need for men trained in the science and technology of metals and other materials. The curriculum in metallurgy and materials sciences is designed to train graduates for research, development, operations, management and sales careers in industry or for graduate study in metallurgy and materials science.

Training for this field of engineering requires basic studies in mathematics, chemistry, physics, and mechanics, plus a general background in engineering principles, followed by intensive training in the application of scientific and engineering principles to the development and use of materials in a technological society. In addition, the curriculum offers an introduction to humanistic and social studies which broaden the student's outlook and enhance his professional development after graduation.

The objective of the program is to combine a fundamental understanding of the behavior of materials from the electronic, atomic, crystallographic, microstructural and macrostructural viewpoints with knowledge of the technology of materials preparation and processing. The student will thus receive a broad education with emphasis on the factors which govern the mechanical, physical and chemical properties of materials to aid him in the analysis, development, selection and use of materials for all types of industries. While some graduates go directly into metal producing companies, a 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.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| ECO | 4 | ECONOMICS | 3 |
| MATH | 23 | ANALYTICAL GEOMETRY & CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| PHYS | 3 | HEAT AND ELECTRICITY | 4 |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| CHE | 60 | UNIT OPERATIONS | 3 |
| MECH | 11 | MECHANICS OF MATERIALS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| MET | 10 | METALLURGY LABORATORY | 2 |
| GS | | REQUIREMENT | 3 |
| | | ELECTIVE | 2 or 3 |
| | | | 17 or 18 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| MET | 207 | ELECTRONIC AND CRYSTAL STRUCTURE | 3 |
| MET | 210 | METALLURGICAL THERMODYNAMICS | 3 |

| | | | |
|---|---|---|---|
| | | ELECTIVE* | 3 or 4 |
| | | *or* | |
| EE | 103 | SEMICONDUCTOR DIODE THEORY* | |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS* | |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS* | |
| MECH | 102 | DYNAMICS | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| | | *or* | |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 18 or 19 |

*Student is required to take either EE 103, or EE 160 and 161, or Phys 62 during his program.

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| MET | 101 | PROFESSIONAL DEVELOPMENT | 1 |
| MET | 208 | PHASE DIAGRAMS & TRANSFORMATIONS | 3 |
| MET | 218 | MECHANICAL BEHAVIOR OF MATERIALS | 3 |
| MET | 304 | EXTRACTIVE METALLURGY I | 4 |
| CHEM | 196 | PHYSICAL CHEMISTRY | 3 |
| ME | 166 | PROCEDURES FOR MECHANICAL DESIGN | 2 |
| | | | 16 |

**Summer**

| | | | |
|---|---|---|---|
| MET | 100 | SUMMER EMPLOYMENT | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| MET | 305 | EXTRACTIVE METALLURGY II | 3 |
| MET | 307 | STRUCTURE AND BEHAVIOR OF MATERIALS | 3 |
| MET | 313 | MATERIALS FABRICATION | 3 |
| | | APPROVED ELECTIVES | 6 |
| GS | | REQUIREMENT | 3 |
| | | | 18 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| MET | 278 | METALLURGICAL REPORTS | 3 |
| MET | 358 | SELECTION OF MATERIALS | 3 |
| | | ELECTIVE* | 3 or 4 |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS* | |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS* | |
| | | *or* | |
| PHYS | 62 | CONTEMPORARY PHYSICS* | |
| | | APPROVED ELECTIVE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 15 or 16 |

*Student is required to take either EE 103, or EE 160 and 161, or Phys 62 during his program.

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 men in a four-year program as a plant metallurgist or materials engineer. To assist in this objective, students electing the option take a special course, Met. 325, Industrial Metallurgy (8), in the first semester of the senior year in place of an equivalent number of other specified courses. The emphasis in this course is a team approach to 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 among those who apply. Summer employment is provided for those students who elect to initiate the program during the summer preceding the senior year.

**Junior Year** (*Same as Regular Program*)

**Summer**

| | | | |
|---|---|---|---|
| MET | 100 | SUMMER EMPLOYMENT | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| MET | 305 | EXTRACTIVE METALLURGY II | 3 |
| MET | 307 | STRUCTURE AND BEHAVIOR OF MATERIALS | 3 |
| MET | 313 | MATERIALS FABRICATION | 3 |
| MET | 325 | INDUSTRIAL METALLURGY | 8 |
| | | | 17 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| MET | 338 | METALLURGY COLLOQUIUM | 2 |
| MET | 358 | SELECTION OF MATERIALS | 3 |
| | | ELECTIVE* | 3 or 4 |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS* | |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS* | |
| | | *or* | |
| PHYS | 62 | CONTEMPORARY PHYSICS* | |
| GS | | REQUIREMENT | 6 |
| | | APPROVED ELECTIVE | 3 |
| | | | 17 or 18 |

*Student is required to take either EE 103 or EE 160 and 161, or Phys 62 during his program.

### RESEARCH OPTION

For those students whose interests lie in the fields of theoretical metallurgy or materials science, and who intend to pursue graduate work, a Research Option is offered. In this option, students are required to take Met 340, Research Techniques (2-3); and Met. 191, Experimental Metallurgy (3). 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.

*Research Option*

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| MET | 207 | ELECTRONIC AND CRYSTAL STRUCTURE | 3 |
| MET | 210 | METALLURGICAL THERMODYNAMICS | 3 |
| | | ELECTIVE* | 3 or 4 |
| | | *or* | |
| EE | 103 | SEMICONDUCTOR DIODE THEORY* | |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS* | |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS* | |
| MECH | 102 | DYNAMICS | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| | | *or* | |
| MATH | 231 | STATISTICAL INFERENCE | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 18 or 19 |

*Student is required to take either EE 103 or EE 160 and 161, or Phys. 62 during his program.*

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| MET | 101 | PROFESSIONAL DEVELOPMENT | 1 |
| MET | 208 | PHASE DIAGRAMS & TRANSFORMATIONS | 3 |
| MET | 218 | MECHANICAL BEHAVIOR OF MATERIALS | 3 |
| MET | 240 | RESEARCH TECHNIQUES | 2 |
| MET | 340 | RESEARCH TECHNIQUES | 2 |
| CHEM | 196 | PHYSICAL CHEMISTRY | 3 |
| ME | 166 | PROCEDURES FOR MECHANICAL DESIGN | 2 |
| | | | 18 |

**Summer**

| | | | |
|---|---|---|---|
| MET | 100 | SUMMER EMPLOYMENT OR RESEARCH | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| MET | 291 | EXPERIMENTAL METALLURGY | 3 |
| MET | 305 | EXTRACTIVE METALLURGY II | 3 |
| MET | 307 | STRUCTURE AND BEHAVIOR OF MATERIALS | 3 |
| MET | 313 | MATERIALS FABRICATION | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 15 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| MET | 338 | METALLURGICAL COLLOQUIUM | 2 |
| MET | 358 | SELECTION OF MATERIALS | 3 |
| | | ELECTIVE* | 3 or 4 |
| | | *or* | |
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS* | |
| | | *and* | |
| EE | 161 | ELECTRICAL PROBLEMS* | |
| | | *or* | |
| PHYS | 62 | CONTEMPORARY PHYSICS | |
| GS | | REQUIREMENT | 3 |
| | | APPROVED ELECTIVE | 3 |
| | | ELECTIVE | 3 |
| | | | 17 or 18 |

*Student is required to take either EE 103 or EE 160 and 161, or Phys 62 during his program.*

## THE COMBINED FIVE-YEAR CURRICULA

## 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 dialectric, magnetic and semiconductor materials along with a study of circuits in modern communications and control systems.

The E.E. degree is conferred on the successful completion of the fourth year, and the E.P. degree at the end of the fifth year.

**Freshman Year** (*See page 65*)

**Sophomore Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 15 | CIRCUIT THEORY I | 3 |
| MATH | 23 | ANALYTIC GEOMETRY & CALCULUS III | 4 |
| MECH | 1 | STATICS | 3 |
| MET | 91 | ELEMENTS OF MATERIALS SCIENCE | 3 |
| PHYS | 3 | HEAT & ELECTRICITY | 4 |
| | | | 17 |

**Sophomore Year (Second Semester)**

| | | | |
|---|---|---|---|
| EE | 16 | CIRCUIT THEORY II | 4 |
| MATH | 205 | LINEAR METHODS | 3 |
| PHYS | 4 | ELECTRICITY, LIGHT & ATOMIC PHYSICS | 4 |
| PHYS | 62 | CONTEMPORARY PHYSICS | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 103 | SEMICONDUCTOR DIODE THEORY | 3 |
| EE | 104 | LINEAR SYSTEMS ANALYSIS | 3 |
| EE | 106 | MACHINE THEORY | 4 |
| MATH | 208 | COMPLEX VARIABLES | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| EE | 105 | INTRODUCTION TO TRANSISTOR THEORY AND CIRCUITS | 4 |
| EE | 231 | ELECTRIC & MAGNETIC FIELDS | 3 |
| MECH | 102 | DYNAMICS | 3 |
| MATH | 302 | METHODS OF APPLIED ANALYSIS | 3 |
| GS | | REQUIREMENT | 3 |
| | | | 16 |

**Summer**

| | | | |
|---|---|---|---|
| EE | 100 | INDUSTRIAL EMPLOYMENT | |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 111 | PROSEMINAR | 1 |
| EE | 151 | SENIOR LABORATORY I | 2 |
| EE | 245 | ELECTROMAGNETIC THEORY | 3 |
| PHYS | 215 | PARTICLES & FIELDS I | 3 |
| EE | | DEPARTMENTAL ELECTIVES | 6 |
| GS | | REQUIREMENT | 3 |
| | | | 18 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| PHYS | 213 | ELECTROMAGNETISM | 3 |
| PHYS | 216 | PARTICLES & FIELDS II | 3 |

| | | | |
|---|---|---|---|
| EE | | DEPARTMENTAL ELECTIVES | 8 |
| GS | | REQUIREMENT | 3 |
| | | | 17 |

**Fifth Year (First Semester)**

| | | | |
|---|---|---|---|
| PHYS | 192 | ADVANCED LABORATORY | 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 |
| | | | 17 |

**Fifth Year (Second Semester)**

| | | | |
|---|---|---|---|
| PHYS | 254 | OPTICS LABORATORY | 2 |
| PHYS | 363 | PHYSICS OF SOLIDS | 3 |
| PHYS | 171 | PROSEMINAR | 1 |
| | | APPROVED ELECTIVE* | 3 |
| | | ELECTIVES** | 6 |
| | | | 15 |

*Two courses selected from Phys. 364, 365, 369; Mech. 302; and Met. 362.
**Students planning graduate study should elect two semesters of German.

## INDUSTRIAL ENGINEERING AND BUSINESS

Students with definite objectives in mind which require more concentration in business administration may elect to pursue a five-year program which combines the two curricula of industrial engineering and business. This combined curriculum will lead to the degree B.S. in Industrial Engineering at the end of the fourth year and B.S. in Business and Economics at the end of the fifth year. The first four years are essentially the standard industrial engineering curriculum. For the fifth year please see page 68 under Business and Economics.

**Freshman Year** (*See page 65*)

**Sophomore Year** (*same as Industrial Engineering*)

**Junior Year (First Semester)**

| | | | |
|---|---|---|---|
| IE | 121 | ANALYSIS AND DESIGN I | 5 |
| IE | 221 | INDUSTRIAL STATISTICS | 4 |
| IE | 241 | FUNDAMENTALS OF PRODUCTION ENGINEERING | 3 |
| MATH | 205 | LINEAR METHODS | 3 |
| PSYCH | 3 | PSYCHOLOGY AS A NATURAL SCIENCE | 3 |
| | | | 18 |

**Junior Year (Second Semester)**

| | | | |
|---|---|---|---|
| IE | 122 | ANALYSIS AND DESIGN II | 4 |
| IE | 222 | OPERATIONS ANALYSIS AND DESIGN | 4 |
| ACCTG | 108 | FUNDAMENTALS OF ACCOUNTING | 3 |
| ME | 168 | ELEMENTARY MACHINE DESIGN | 2 |

| | | | |
|---|---|---|---|
| MECH | 102 | DYNAMICS | 3 |
| ECO | 335 | MANPOWER ECONOMICS | 3 |
| | | | 19 |

Those students who will major in Accounting in the fifth year will take Acctg. 51 and 52 in the junior year in place of Eco. 335 and Acctg. 108; and will take Eco. 335 in the senior year in place of Mkt. 11; and Acctg. 215 and 307 will be taken in the senior year in place of Fin. 125 and an Approved Technical Elective; and Mkt. 11 and Fin. 125 will be taken in the fifth year.

**Summer**

| | | | |
|---|---|---|---|
| IE | 100 | INDUSTRIAL EMPLOYMENT | 0 |

**Senior Year (First Semester)**

| | | | |
|---|---|---|---|
| EE | 160 | ELECTRICAL CIRCUITS AND APPARATUS | 3 |
| EE | 161 | ELECTRICAL PROBLEMS | 1 |
| EE | 162 | ELECTRICAL LABORATORY | 1 |
| ME | 160 | THERMODYNAMICS | 3 |
| MKT | 11 | MARKETING | 3 |
| | | APPROVED TECHNICAL ELECTIVE | 3 |
| ENGL | | ELECTIVE | 3 |
| | | | 17 |

**Senior Year (Second Semester)**

| | | | |
|---|---|---|---|
| IE | 152 | INDUSTRIAL ENGINEERING PROJECT | 2 |
| CHE | 60 | UNIT OPERATIONS SURVEY | 3 |
| ME | 161 | ENGINEERING LABORATORY | 1 |
| FIN | 125 | CORPORATION FINANCE | 3 |
| | | APPROVED TECHNICAL ELECTIVE | 6 |
| ENGL | | ELECTIVE | 3 |
| | | | 18 |

# THE GRADUATE SCHOOL

Robert Daniel Stout, *Dean*

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 was 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.

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, 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, history, industrial engineering, 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 $5 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."

Women are admitted as graduate students on the same terms as men. Except during a summer session, however, they are not ordinarily permitted to attend, either as registered students or as listeners, courses intended only for undergraduates.

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 $1000 per semester or $84 per semester hour, whichever amount is lower. The maximum full-time roster of graduate courses is 15 semester hours. No exceptions to this rule are made.

In an effort to help alleviate the existing shortage of fully qualified school teachers in the United States, 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, amount to $400 per semester or $34 per semester hour.

A listener's fee of $84 is charged for each course audited, unless the student is already paying the full tuition fee. (See regulation on page 00.)

Where the major department requires a master's thesis, the student registers for the thesis and pays at the rate of the regular semester hour charge.

The minimum tuition fee for a student in residence at the University is $700 per semester. Candidates for the doctorate who have completed all of their course work and have paid the minimum fees for the doctorate may be excused from these fees as described below.

To qualify for the doctorate, all students must pay tuition fees equivalent to two full academic years beyond the master's degree, or its equivalent of 30 credit hours. These fees amount to $4000. Resident doctoral candidates must pay a minimum registration fee of $700 per semester until these fees are paid. Thereafter the doctoral candidacy can be maintained by a registration fee of $100 per semester. *All students using the resources of the University must be registered.* The Dean of the Graduate School should be consulted in any case where the proper amount of the registration fee is in doubt.

Part-time candidates who have previously met residency requirements should consult the Dean of the Graduate School about completing the payment of the minimum tuition fee.

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 $30. 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 5 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 to 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.

## 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. 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."

## MISCELLANEOUS REGULATIONS

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 or courses 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.

## DEGREES

*In addition to the general regulations set forth below, more detailed instructions for procedures may be obtained from the Office of the Graduate School.*

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.

## 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:

1. 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 chairmen 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.

2. 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 (see page 104 for classification of courses).

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

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

3. 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.

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

5. In order to qualify for the master's degree, candidates will be required (a) to submit a thesis or a report based on a research course of at least 3 credit hours, *or* (b) 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.

6. The master's degree is not granted unless the candidate has earned the grades "A" or "B" in at least eighteen hours of the 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.

7. All work which is to be credited toward a master's degree must be done in actual and regular attendance at Lehigh University.

8. All work on a program for the master's degree 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.

1. 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 work on a program for the Ph.D. degree must be completed within a ten-year period.

2. 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.

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

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

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

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

4. 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.

5. 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 in charge of a committee consisting of representatives of the language department concerned and of the candidate's major department. Fee for each examination is $8.

The E.T.S. examinations in French, Spanish, German and Russian will be held December 19, 1970, February 6, 1971, and May 8, 1971.

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

6. 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 department 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.

7. 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 to 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 the 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.

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 in standard form and binding; (3) three copies of an abstract, not exceeding 600 words, of the dissertation, 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 dollars ($30). 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 fifteen dollars ($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.

8. FINAL EXAMINATION. After the dissertation has been written and revised to the satisfaction of the advisor, the student should submit one copy as approved by the advisor to the Dean of the Graduate School for his inspection. Upon its return, he 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.

9. 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 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, 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 on page 94 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 (1) formal course instruction and (2) a research experience, the University has developed means to enable students to fruitfully 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 largest universal hydraulic testing machine; Whitaker Laboratory, completed in 1965 for the chemical and metallurgical engineering departments; 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 all collections in the humanities and social sciences, including the Rare Book Collection. The Mart Science and Engineering Library 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, and the School of Education has developed a strong rapport with area school systems for the training of teachers.

The University's policy is to make these resources available to all faculty and students, including un-dergraduates, 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, developing a campus awareness of these 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.

There are six interdisciplinary centers, all formed since 1962: Materials Research Center, Center for Marine and Environmental Studies, Center for Information Science, Center for the Application of Mathematics, Center for Surface and Coatings Research, and Center for Business Economics and Urban Studies. Their functions are more fully described on the following pages.

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.

## 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.

Normally Lehigh's athletic schedule includes four or five home football games, six or seven wrestling meets at home (Lehigh's most popular sport), nine or ten home basketball games, nine home baseball games, and four home swimming meets.

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 Foundation, 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, the New York Pro Musica and such solosists as Marian Anderson, Jerome Hines, and Gerard Souzay.

Among the outstanding speakers brought to the Lehigh campus in recent years, in addition to scholars in many academic disciplines, were the historian Mrs. Catherine Drinker Bowen, Dr. Arnold J. Toynbee, Sean O'Faolain, Dick Gregory, Charles V. Hamilton, Senator Barry Goldwater, and James Farmer.

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. Lecture series was established at Lehigh through an endowment gift from the Jacob and Hilda Blaustein Foundation of Baltimore. Mr. Blaustein, Class of 1913, is a pioneer in the petroleum industry and an international statesman of some note.

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. The Globus Series in the avant-garde is an outstanding feature of the special events calendar.

## 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 in the Alumni Memorial Building. No fee is charged for this registration.

## ACCIDENT AND SICKNESS REIMBURSEMENT INSURANCE

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

The summer sessions at Lehigh are open to men and women.

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*

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

Descriptions of Graduate School scholarships and fellowships will be found in Appendix B.

## 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 is fortunate to have received funds from individual donors and corporations which provide for the support of several graduate students on scholarships, fellowships and traineeships. The funds which make these programs possible are listed below. 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. Such funds are described in general below.

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 the 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 remis-

sion 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 Institute 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 $700 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 is taken on the recommendation of departments to the Graduate School. Notices of award are mailed in March. In accordance with a resolution of the Council of Graduate Schools in the United States, to which over 180 graduate schools have signified their assent, a student has until April 15 to decline an award.

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

## ENDOWMENT OF FELLOWSHIPS

A research fellowship, named in honor of an individual or a corporation, offering opportunities for graduate work and training in research in any designated field of study, may be established in perpetuity through the payment to the Board of Trustees of an appropriate fund.

## 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. Among the loan funds available are the following:

### United States Aid Funds Loan Program

Lehigh University is one of more than 600 colleges and universities participating in this national nonprofit loan program for needy and deserving students. Graduate students may borrow as much as $2,000 per year, but no student may borrow more than $4,000. Interest of 6% simple and payments of interest and principal begin the fifth month after graduation and may be anticipated. In case of dropouts, payments are due to begin at once. The financial aid officer recommends the loan, after consultation with the student, and the loan is then negotiated at the student's home town bank on the student's own signature.

### National Defense Student Loan Fund

In order to extend the benefits of low-interest, educational loans to a larger segment of the student body, Lehigh has joined the National Defense Student Loan Program.

"Special consideration" is mandatory for (1) students with superior academic backgrounds who plan to become elementary or secondary school teachers, and (2) students whose academic backgrounds indicate a superior capacity for or preparation in science, mathematics, engineering, or a foreign language. This does not exclude other students.

ELIGIBILITY. Graduate students are eligible to apply for NDEA loans provided they are full-time graduate students who show themselves capable of "maintaining good standing" and show financial need.

AMOUNT OF LOANS. The maximum loan available is $1,000 in an academic year and a total of $5,000.

REPAYMENT. The student's note will be taken for repayment in ten equal installments, beginning one year after the date on which he stops being a full-time student. Interest is charged at the rate of three per cent starting with the first payment. In the case of death or disability, liability for repayment of any balance then due is waived.

TEACHERS. If a graduate becomes a full-time teacher in a public elementary or secondary school, up to one-half of the loan (plus the interest on that portion) will be waived at the rate of ten per cent per annum.

### Short-Term Loans

Short-term loans are emergency loans and must be repaid, according to the schedule agreed upon, 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 for other student needs.

## THE UNIVERSITY LIBRARIES

Two principles underlie the operation of the Lehigh University Libraries. First is the development of sound, balanced collections in support of teaching and research on the campus. Second is the provision of a reference and information service to assist students and faculty in making maximum use of available literature. A policy of open access to the general collections affords the user an opportunity to browse at leisure and to exploit the literature of his special field.

General and special collections now number half a million volumes, with annual accessions in excess of 15,000. Over 4,500 serials and periodicals are currently received, including important newspapers, both foreign and domestic. The Library is a depository for a wide selection of U.S. government documents.

The *Linderman Library* incorporates a part of the original library, built in 1877 by Asa Packer as a memorial to his daughter, Lucy Packer Linderman, with an addition opened in 1929. It houses collections in the humanities and social sciences, the Rare Book Collection and the Uni-

versity Archives as well as the offices of library administration. Collections are particularly strong in the classics, English literature, and British Colonial History.

The *Mart Science and Engineering Library* houses 85,000 volumes in the fields of engineering mathematics and the natural and physical sciences. It includes an all-night study and serves as headquarters for the Center for Information Science. This building was opened in 1969 as a memorial to the late Leon T. Mart, '13 and his son Thomas L. Mart, '51.

# THE SCHOOL OF EDUCATION

John A. Stoops, *Dean*

Natt B. Burbank, *Assistant Dean*

The President and the Board of Trustees announced the establishment of the School of Education February 1, 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, 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 (see page 87). Course offerings and other pertinent data may be found under the list beginning on page 131.

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 School through preparation at the master's and doctorate levels.

One hundred seventy-three doctoral students, 640 students engaged in M.A. and M.Ed. programs, and 346 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.

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 | Physical and Natural |
| International Relations | Sciences |

Lehigh's program of training for advanced professional responsibility is planned in three stages. The first is represented in the M.Ed. or M.A.; 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 Doctorate in Education program at present provides for major work in five areas: (1) administration, (2) reading, (3) educational foundations, (4) counseling, and (5) educational research. Students are screened for admission in the fall and spring of each year and begin doctoral study the following semester. Formal admission to the Ed.D. program usually occurs after the completion of 15-30 hours beyond the master's level. When the student has his proposal accepted by the Graduate School, he becomes a candidate for the Ed.D., and is eligible to take the general examination.

The School is organized in five divisions. Specific information regarding degree programs can be obtained from the director of the appropriate division.

Division of Educational Administration
Charles W. Guditus, *Director*
Elementary School Principalship, Secondary School Principalship, School Business Managership, Curriculum Administration, School Superintendency, Community College Teachers.

Division of Counselor Education
John A. Mierzwa, *Director*
Guidance Counselor, School Psychologist, Counseling Psychologist.

Division of Elementary Education
Alfred J. Castaldi, *Director*
Elementary Teachers (Interns), Elementary Master Teachers, and Reading.

Division of Secondary Education
Robert L. Leight, *Director*
Secondary School Teachers (Interns), and Seconday Master Teachers, and Educational Foundations.

Division of Educational Research
Paul Van Miller, *Director*

# RESEARCH CENTERS and ORGANIZATIONS

Currently, eight interdisciplinary research centers have been established at Lehigh University to assist the academic departments in developing the full research potential of the University in special areas. The Centers represent research trusts 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.

Operationally, the Centers aim to provide an effective interdisciplinary framework for programs involving faculty members and graduate students from many departments working together on a single research program. Thus, Centers offer unique research opportunities for M.S. and Ph.D. students interested in combining traditional course programs with an interdisciplinary research experience relevant to regional and national technological and social progress.

The eight research Centers and related research organizations are listed below and descriptions follow:

- Center for Business Economics and Urban Studies
- Center for Surface and Coatings Research
- Computing Center
- Fritz Engineering Laboratory
- Center for Information Science
- Center for Marine and Environmental Studies
- Materials Research Center
- Center for the Application of Mathematics
- Bureau of Educational Service
- Office of Research

## 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 (1) apply economic analysis to business problems; and (2) carry out research linking business behavior and policy with economic analysis and investigation.

Note: Center personnel are listed under "Administration."

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 to 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 may elect to receive a master degree in a traditional discipline such as economics, history, government, or social relations. An increasing number of students who work in the Center are working toward the Ph.D. degree.

Basic disciplinary and interdisciplinary research in the Center includes plant and equipment forecasting models, housing analyses, urban design, regional transportation systems, political structure, and social processes that take place within the inner core and suburbs of an urban area.

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

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, adhesion to and flow into porous substrates, and the spectral characteristics of colorant layers.

Other research involves the surface properties of ice nucleants, electrodeposition, environmentally induced metal fatigue, pollution of streams by solids and their 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.

## COMPUTING CENTER

In July, 1967, the Computing Center was organized as a separate unit along lines similar to the other graduate research centers on campus. Organizationally the director of the Center reports to the Vice President for Research. A Computing Center Advisory Committee, having both a User's and a computing Instruction Subcommittee, advises the Vice President for Research on matters relevant to Lehigh's computing environment. The Center serves as the laboratory for departmental courses and research in computer theory, programming, information systems, and information retrieval. Also the Center provides computer service to all departments and centers of the University for the solution of instructional and research 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), 167 million characters of disk storage, 4 magnetic tape units, 1200 cards-per-minute card reader, 250 cards-per-minute card punch, two 1200 lines per minute printers, incremental plotter, remote entry displays and teletypes. The principal programming languages are Fortran IV, Fortran Extended, Cobol, Compass (assembler) and a large library of programs.

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

## 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 sanitation.

The Fritz Engineering Laboratory is one of the research organizations of the University un-

der the cognizance of the Vice President for Research. The 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, industrial corporations and associations, private companies, and by state and federal government agencies.

Graduate studies combined with research investigations commenced at Fritz Engineering Laboratory in 1928. A major expansion of the facilities in 1955 has been followed by addition of the necessary equipment to meet the needs of new research opportunities.

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.

Plastic Analysis—Maximum load-carrying capacity of rigid frame structures.

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 operation.

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 response to these needs and ideas, and 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 origination, 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 placed on mathematics, computer programming, computer languages, statistics, electrical engineering, philosophy, linguistics, industrial 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 Department of Philosophy.

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 which is to be 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 being developed 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

An interdepartmental Marine Science Center was established at Lehigh in 1962, consisting of staff and graduate students from the departments of Biology, Chemistry and Geology. In 1968 the scope of the Center was expanded to include ocean engineering and environmental studies, and the name was changed to the Center for Marine and Environmental Studies. As an interdisciplinary research organization, CMES provides opportunities for research on problems of common interest for students and staff from several departments.

The Center is not an academic department of the University: graduate students are enrolled in traditional departments, courses are taught and graduate degrees are granted by these departments. Pertinent courses are offered by the departments of Biology, Chemistry, Geological Sciences, Civil Engineering, Chemical Engineering, and Mechanical Engineering and Mechanics (see course listings for individual departments). Curricula are available upon request.

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 ESSA (Miami), Texas A & M University, Duke University, the Sandy Hook Laboratory of the U.S. Bureau of Fish and Wildlife.

A major Sea Grant Coherent Area Research Program will be initiated in 1970. During the first year, geotechnical probes will be developed for and tested on submersibles, Lockheed's DEEP QUEST and Sun Ship's GUPPY. In subsequent years, the geotechnical properties of the San Diego Trough off California and deep basins in the Gulf of Maine will be investigated, to establish "Sea-Floor Geotechnical Development and Demonstration Areas" for systems testing of instruments and equipment that rely upon the bearing strength or settlement analysis of the sea-floor for their successful operation.

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

pollution studies are active on the Lehigh and Delaware Rivers. CMES is an active member of a multi-institution consortium, the Institute for the Development of Riverine and Estuarine Systems (IDRES), with numerous research projects on the Delaware River and Estuary, funded by the Pennsylvania Science and Engineering Foundation, the National Science Foundation, the Federal Water Pollution Control Administration and other state and federal agencies.

Current research activities of CMES staff and students include: marine microbiology and biochemistry of proteolytic marine bacteria; geotechnical properties of deep-sea 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; regeneration of carbon adsorbents for $SO_2$; mathematical modeling of ecological, chemical and physical systems of streams and lakes; and pollution studies of various local streams.

The facilities of CMES include: a well-equipped laboratory for microbiological and biochemical research; a Marine Biology Laboratory with temperature-controlled circulating artificial salt water aquaria; and a well-equipped Laboratory of Geotechnical Ocean Engineering, including telemetering probes for measuring significant engineering properties of ocean-floor sediments in water depths to 4.5 kilometers. CMES staff and students have access to the Lehigh University Computing Center (CDC-6400 and peripheral equipment) and to many other major items of research equipment located in other centers and departments.

### Marine Science and Ocean Engineering Courses Offered

| | | | |
|---|---|---|---|
| BIOL | 417 | MARINE ECOLOGY | 3 |
| BIOL | 418 | BIOLOGICAL OCEANOGRAPHY | 3 |
| BIOL | 480 | MARINE SCIENCE SEMINAR | 1 |
| CE | 328 | CHANNEL AND OCEANOGRAPHICAL HYDRAULICS | 3 |
| CE | 332 | OCEAN ENGINEERING | 3 |
| CE | 425 | MECHANICS OF SEDIMENT TRANSPORT | 3 |
| CE | 4XX | MARINE GEOTECHNIQUE | 3 |
| GEOL | 363 | INTRODUCTION TO OCEANOGRAPHY | 3 |
| GEOL | 461 | MARINE GEOLOGY | 3 |
| ME | 4XX | FLUID MECHANICS OF OCEAN AND ATMOSPHERE | |

(*additional courses are being developed in oceanography and ocean engineering*)

### Environmental Studies and Water Pollution Control Courses Offered

| | | | |
|---|---|---|---|
| BIOL | 306 | ECOLOGY | 3 |
| BIOL | 361 | SANITARY MICROBIOLOGY | 3 |
| BIOL | 414 | ADVANCED ECOLOGY | 3 |
| CHEM ENG | 320 | WASTE WATER CONTROL | 3 |
| CHEM | 310 & 311 | INSTRUMENTATION PRINCIPLES | 3, 3 |
| CHEM | 397 | COLLOID AND SURFACE CHEMISTRY | 3 |
| CE | 312 | GROUND WATER HYDROLOGY | 3 |
| CE | 360 | SANITATION | 3 |
| CE | 395 | CIVIL ENGINEERING PLANNING | 3 |
| CE | 460 | WATER SUPPLY AND SEWAGE | 3 |
| CE | 461 | TREATMENT OF WATER AND WASTE WATER | 3 |
| CE | 426 | SURFACE WATER HYDROLOGY | 3 |
| ECON | 311 | ECONOMICS RESOURCE USE | 3 |
| GEOL | 3XX | GEOCHEMICAL HYDROLOGY | 3 |
| GEOL | 3XX | ENVIRONMENTAL PLANNING | 3 |
| GOVT | 354 | ADMINISTRATIVE LAW | 3 |
| IND ENG | 210 | DESIGN OF EXPERIMENTS | 3 |

(*additional courses are being developed in environmental studies and water pollution control*)

No undergraduate degrees are offered in marine science or ocean engineering, or environmental studies 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 pollution control. These and other interdisciplinary programs can be arranged.

Current research activities of staff and students include: marine microbiology and biochemistry of proteolytic marine bacteria; systematics and ecology of deep sea Ectoprocts (Bryozoa); shallow water nearshore and estuarine sedimentation; biological effects of thermal pollution; carbonate mineral geochemistry and diagenesis; crustacean physiology; zooplankton dynamics; mathematical modeling of upper Delaware River; coastal salt marsh environmental studies; design and development of tools for submersibles.

## 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:

a. Coordinates and integrates all activities pertaining to materials science and technology at Lehigh University;

b. Seeks to establish a climate in which faculty members, post-doctoral associates, and graduate assistants develop an awareness of materials;

c. Arranges for facilities and space required to conduct interdisciplinary research;

d. Guides the search for new materials by encouraging fundamental research and new approaches to materials problems;

e. Assists in developing educational opportunities in materials, in particular, interdisciplinary graduate programs devoted to training for research in materials; and

f. 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 two service laboratories: Materials clean room and Electron Microscopy Laboratory. Also there are several associated laboratories, physically located within departments, that include special laboratories for: Engineering Structure Analysis, Fracture Mechanics Analysis, Surface Chemistry, Stress Corrosion, Magnetic Materials, Crystal Growing and Zone Processing, Manufacturing Processes, Hydrothermal Synthesis, Solid State

Investigations, and Environmental Science Studies.

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 frequent interaction, achieved by: (1) semi-annual day seminars; (2) special lectures; (3) consultation on materials problems and research; (4) distribution of reprints and papers; (5) distribution of all M.S. and Ph.D. thesis abstracts on materials research; and (6) 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 on page 67.

The Center has available several industrial fellowships and provides for a number of fellowships from its own operating funds. In addition, graduate students are awarded various government traineeships and fellowships as well as being offered positions as research assistants. For details of

Graduate Scholarships and Fellowships please refer to page 90.

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*

* Correlation of microstructure with mechanical behavior of low-alloy high-strength steels, especially fatigue, creep and brittle fracture.
* Electron fractography.
* Fatigue crack propagation studies.
* Friction welding studies.
* High temperature mechanical behavior of sintered carbides.
* Influence of welding on fatigue characteristics of weldments.
* Mechanical behavior of anisotropic materials.
* X-ray measurement of residual stresses.

*Physical Ceramics*

* Ceramic-to-metal bonding.
* Correlation between surface condition and mechanical strength.
* Deformation mechanisms.
* Oxide semiconductors.
* Press forging (compressive deformation).
* Processing behavior of alumino-silicate ceramic materials.

* Reactively sintered polycrystalline garnets.
* Sintering mechanisms.
* Strengthening mechanisms.
* Synergetic press forging.

*Polymers*

* Environmental effects on polymers to protect concrete against corrosion.
* Fatigue behavior of reinforced eposy resins.
* 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.

## CENTER FOR THE APPLICATION OF MATHEMATICS

The Center 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.

*RESEARCH RELATED 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, Bureau of Education Service, 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

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.

HIR courses must have been approved by the department and its chairman, and by the dean of the sponsoring college. A course title and description, using *University Catalog* format, shall have been prepared by the department for incorporation into the preregistration course list in time that the Registrar can fit the course into the semester schedule.

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 prerequisites listed, unless the student's records in the Office of the Registrar show that the proper officers have so evaluated this preparation previously.

English 2 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**

JAMES B. HOBBS, D.B.A.
FENG-SHYANG LUH, PH.D.

**Assistant Professor**

FRANCIS MARIO BRADY, JR., M.B.A.

**Instructor**

ROBERT L. STONE, M.A.
ROBERT A. PFENNING, M.B.A.

### 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. First and second semesters. Staff

### 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. First and second semesters. Staff

### 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. First and second semesters. Staff

### 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. First and second semesters. Mr. Luh

### 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: Accounting 52. First and second semesters.

## For Advanced Undergraduates and Graduates

### 304. Governmental and Institutional Accounting (3)

Study of fund accounting as it applies to municipalities, public school systems and eleemosynary institutions. The course will include such current problems as the financing of urban renewal projects, capital budgeting for governmental units, effect of medicare on hospital cost accounting and cost benefit analysis. Prerequisite: Acctg. 51 or Acctg. 108. Mr. Brady

### 305. Financial Statements and Reports (3)

Study of the features of accounting data essential to the interpretation and evaluation of business operations and financial position. Analysis of financial statements and reports from point of view of management, investors, creditors, and others. Prerequisite: Acctg. 52 or 108. Mr. Trumbull

### 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. Mr. Koch

### 311. Accounting Information Systems (3)

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.

### 315. Advanced Accounting (3)

Problems dealing with business combinations, partnerships, fiduciary accounts, insolvent concerns, national income accounts, etc. Prerequisite: Acctg. 52. First semester.

### 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. Second semester. Mr. Brady

### 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. Staff

### 331. Seminar in Accounting (3)

Advanced readings, cases, oral and written reports, discussion, in various fields of accounting. Prerequisite: Senior standing and consent of instructor.

### 371. Readings (3)

Readings and research in various fields of accounting; designed for superior student who has a special interest in some

topic or topics not covered by the regularly rostered courses. Written term paper or papers required. Prerequisite: Preparation in accounting acceptable to the supervising professor and the department chairman. First or second semester. Staff

### 372. Readings (3)

Continuation of Accounting 371. First or second semester.
Staff

### 390. Internship (3-6)

Designed to give advanced students of accounting, who have maintained a satisfactory standard of scholarship and who show promise in the field of accounting, an opportunity to acquire field experience and training with selected industrial or public accounting firms or governmental agencies as a complement to the academic learning process. Outside readings will be assigned. Written reports will be submitted by employer and students. The amount of credit will be influenced by the length of the training period and the character of the experience afforded to the trainee, but will not exceed six hours for a regular semester or three hours for a summer period of at least eight weeks. Prerequisite: Junior standing and approval of faculty committee on internship.

### For Graduates

The specialized accounting courses at the 300-level are frequently offered in graduate sections in addition to the 400-level courses. These graduate offerings permit 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 masters' 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. Second semester.
Mr. Koch

### 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. 325); uses of accounting data for managerial planning and control; including cost control; capital expenditure planning; product pricing decisions; operations research applications. Prerequisite: Accounting 52 or 108. First semester. Mr. Moore

### 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. Second semester. Mr. Moore

### 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. First semester.
Mr. Trumbull

### 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. Second semester. Mr. Mills

# BIOLOGY

**Professors**

SAUL BENJAMIN BARBER, PH.D. *Chairman*
THOMAS C. CHENG, PH.D.
RICHARD GRIFFITH MALSBERGER, PH.D.
BASIL WALDO PARKER, PH.D.
FRANCIS JOHN TREMBLEY, PH.D.

**Associate Professors**

SIDNEY SAMUEL HERMAN, PH.D.
BRADFORD BRECKENRIDGE OWEN, PH.D.

**Adjunct Professors**

EDWARD JOHN BENZ, M.D.
EUGENE M. LANDIS, M.D., PH.D.
JACK B. PEARCE, PH.D.

**Assistant Professor**

HAYDEN NELSON PRITCHARD, PH.D.

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Students may not take for credit both Biol. 21, Principles of Biology (3), and Biol. 13, Human Biology (3).

**13. Human Biology (3)**

A lecture course in biological principles as illustrated by man. Man in relation to his environment, the organ systems of man, population biology, parasitism, elements of human inheritance, and human evolution. First and second semesters.

**21. Principles of Biology (3)**

Introduction to biology by study of selected principles. Topics covered include cell structure and function, plant and animal structure and function, diversity and evolution of organisms. Three lectures per week. First and second semesters.

**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. First and second semesters. One 3-hour laboratory per week. This course is graded only on a pass-fail basis.

**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. Second semester.

**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. Second semester.

**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 micro-organisms. Recitations, lectures, and laboratory work. Prerequisite: A laboratory course in biology. Second semester.

### 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.                                          Staff

**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. Summer Session.                                          Mr. Trembley

**232. Natural History and Ecology Workshop (3)**

Field and laboratory work in Natural History and Ecology. Must be taken concurrently with Biol. 231. Summer Session.                                          Mr. Trembley

**233. Modern Biology for Teachers (3)**

Lectures, demonstrations, and readings in frontier areas of biology. For secondary school teachers in biology and general science. Not available for undergraduate credit. First semester.

**234. Modern Biology for Teachers (3)**

Continuation of Biology 233. Second semester.

**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. First semester.

**262. Special Topics in Biology (1-3)**

Continuation of Biology 261. Second semester.

**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. Second semester.

**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. Second semester.
                                          Mr. Cheng

**306. Ecology (3)**

The basic principles of ecological interrelationships; training in use of analytical keys and reference collections for the identification of plants and animals; field trips for the study of interrelationships of living organisms. Two lectures and one laboratory period or field trip per week. Prerequisite: Two semesters of Biology, one with laboratory. Second semester.                                          Mr. Herman

### 313. General Histology (3)

The techniques of preservation and preparation of animal and plant tissues for microscopical study; comparative studies of fresh and preserved tissues. One lecture and two laboratory periods per week. Prerequisite. Biol. 21 and 22 or equivalent. Biol. 34 or equivalent recommended. First semester.                                                     Mr. Owen

### 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. Second semester.                          Mr. Owen

### 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. First semester.                    Staff

### 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. First semester.            Mr. Barber

### 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. First semester.

Mr. Cheng

### 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 with laboratory. Two lectures, one laboratory. Second semester.            Mr. Pritchard

### 336. Evolution of Land Plants (3)

A 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: Biology 21 or its equivalent. First semester.            Mr. Pritchard

### 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. First semester.                               Mr. Malsberger

### 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. First or second semester as required.

Mr. Parker

### 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-five 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 areas encompassed by their own research interests. These are: comparative physiology of nerve and muscle, capillary circulation, virology, biological oceanography, histochemistry, aquatic biology, including fisheries biology, biological aspects of water pollution, symbiosis and parasitism. Interdisciplinary programs in biological aspects of marine sciences may also be arranged in cooperation with the Marine and Environmental Studies Center.

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, and Invertebrate Immunobiology.

### 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: Two years of college biology or consent of instructor. Second semester.
Mr. Barber

### 405. Special Topics in Biology (1-3)
Research, conferences, and reports on selected topics not covered in the general graduate offerings. May be taken more than once for credit. Staff

### 406. Biological Seminar (1)
An advanced seminar in current developments including departmental research. Required for candidates for graduate degrees. Second semester. Staff

### 407. Biological Research (3)
Investigations in any phase of the biological sciences according to the student's preparation and interests. First semester. Staff

### 408. Biological Research (3)
Continuation of Biol. 407. Second semester. Staff

### 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. Mr. Owen

### 410. Topics in Modern Biology (3)
A seminar on current developments in biological sciences. Required of all candidates for advanced degrees in the department. First semester. Staff

### 411. General Cytology (3)
Conferences, assigned readings, and laboratory work on the structural features of the cell in relation to cellular function and on modern methods of preparing living and fixed tissues for cytological study. Included are special studies of the cytology of microorganisms. Prerequisite: Biol. 313 or its equivalent. First semester. Mr. Owen

### 412. Field Zoology (3)
Methods of biological survey work; animal censuses; collection, preparation, and care of zoological specimens; use of keys; study of the interrelationships existing between the groups of local animals, especially the vertebrates, and of their habitat preferences. Lectures, laboratory work, and field trips. Offered as required. Staff

### 413. Problems in Field Zoology (3)
Concentrated work in the life history study of one or more local species. To be taken concurrently with or following Biol. 412 depending upon the previous experience and interest of each student. Offered as required. Staff

### 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 Institute of Research. Prerequisite: Consent of the instructor. Offered as required. Staff

### 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. Mr. Pritchard

### 416. Immunology (3)
Consideration of antigen-antibody systems from theoretical and practical aspects. Lectures and reports on the structure and origins of antigens and antibodies and the mechanisms of agglutination, precipitation, complement fixation, anaphylaxis etc. Laboratory work on preparation, standardization, and assay of antigens and antibodies. Prerequisite: Biol. 353, Chem. 371 or equivalent. First semester.
Mr. Malsberger

### 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. First semester. Mr. Herman

### 418. Biological Oceanography (3)
Surveys of marine plant and animal plankton, nekton and benthos. Composition of various groups, productivity, interrelationships of plants and animals and the role of microorganisms in the sea. Three lectures per week. Prerequisite: Consent of chairman of department. First semester. Mr. Herman

### 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. Second semester.
Mr. Malsberger

### 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.
Mr. Parker

**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. Second semester.
Staff

# BUSINESS ADMINISTRATION

The College of Business and Economics offers three degrees at the master's level: the M.B.A., the M.S. (Accounting, Business Economics, or Management), and Master of Arts in Economics. On a more advanced level the College offers a Ph.D. in Business and Industrial Economics, described on page 61.

# 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.

**Associate Professors**

ROBERT WILLIAM COUGHLIN, PH.D.
WILLIAM L. LUYBEN, PH.D.
GARY WAYNE POEHLEIN, PH.D.
FRED P. STEIN, PH.D.

**Assistant Professors**

MARVIN CHARLES, PH.D.
SIDNEY KLEINBERG, PH.D.
LESLIE H. SPERLING, PH.D.

**Lecturers**

JACOB MYER GEIST, PH.D.
CLYDE MCKINLEY, PH.D.

**Research Associates**

JURAJ GEBAUER, PH.D.
MIROSLAV HARTMANN, PH.D.

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**51. Chemical Engineering Computation (4)**
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. First semester.

**52. 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. Second semester.

**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. Second semester.

**100. Summer Employment (0)**
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. First semester.

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

### 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. Second semester.

### 183. Projects (2)
Undergraduate research. Independent study of a problem involving laboratory, design or theoretical studies under the guidance of a senior faculty member. This is the first course in a one year program. First semester.

### 184. Projects (2)
Continuation of Ch.E. 183. Second semester.

#### 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. First semester.

### 301. Process Design (3)
Intensive study of selected or proposed chemical processes with emphasis on optimum order of steps, flow diagrams, energy balances and recycle ratios and their effect on the balance sheet of the operation. Approximation methods of obtaining data. Prerequisite: Ch.E. 200. Second semester.
Messrs. Foust, Poehlein

### 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. First semester.
Mr. Stein

### 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. First semester.
Messrs. Clump, Schiesser

### 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.
Mr. Clump

### 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. Engineering Process Control (3)
Concepts of feedback control. Transfer function representation of linear systems. Closed loop transfer functions and the response of closed loop feedback control to deterministic signals. Mathematical models for discreet and distributed systems. Introduction to cascade, feed-forward and computer control. Analysis of complex systems by digital simulation. Prerequisite: Senior standing in a curriculum of the Engineering College, or consent of the instructor. Second semester.

### 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. Messrs. Manson, Poehlein

### 393. (Chem. 393, Met. 343) Physical Polymer Science (3)
Structural and physical aspects of polymers (organic, inorganic, natural). Molecular and atomic basis for polymer properties and behavior. Characteristics of glassy, crystalline, and paracrystalline states (including viscoelastic and relaxation behavior) for single and multi-component systems. Thermodynamics and kinetics of transition phenomena. Structure, morphology, and behavior. Prerequisite: 1 year phys. chem.

### 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 free-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 fourteen M.S. degrees, and five Ph.D. degrees.

Offerings of the department include courses in thermodynamics, reaction kinetics, transport processes, heat transfer, mass transfer, momentum transfer, process dynamics, and applied mathematics. In addition, more specialized courses in catalysis, cryogenic engineering, and polymer processing are offered on a rotating basis. The individual graduate student builds 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 interests, but usually are consistent with this basic departmental philosophy.

The research facilities of the Department are continuously 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 going on in the following fields:

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 sytems
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, research, calibration standards, process dynamics study, reaction kinetics and thermodynamics research, nuclear engineering, high pressure research, and a wide range of general research space.

In addition to activities that are traditionally chemical engineering, the department cooperates with several other campus groups to offer interdisciplinary programs. At present these include a program in Chemical Metallurgy carried on in cooperation with the Department of Metallurgy and Materials Science, a program in polymer science through cooperation with the Polymers Research Laboratory of the Materials Research Center, a program in water resources through cooperation with the Departments of Civil Engineering and Biology, research in interfacial phenomena through the Center for Surface and Coatings Research, 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 installations are within easy driving distance of the Lehigh campus, and in both places the student would receive experience in the most advanced work being done in the industry. Typically, a student would work 20 hours per week and would receive pay equivalent to that of a teaching assistant. This would allow him to enroll for about 10 hours of graduate course work per semester, and to progress toward the M.S. degree at a rate equivalent to that of a teaching or research assistant. Under this arrangement, the student pays his own tuition which he accumulates from his industrial wage.

There are available within the department several opportunities for financial support for the graduate student. See page 90 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 of the 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. First semester.
Messrs. Wenzel, Stein

### 401. Chemical Engineering Thermodynamics II (3)

A detailed study of the uses of thermodynamics in predicting phase equilibria in solid, liquid, and gaseous systems. The phase rule; solution theories; uses of equations of state. Theoretical basis and development of equations of state. Applications to azeotropic and extractive distillation, multicomponent separations, liquid extraction. Second semester, alternate years.
Mr. Wenzel

### 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. Second semester, alternate years.
Mr. Stein

### 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 bond-structure models. Mechanisms of catalytic reaction of industrial importance. Selection and classification of catalysts.
Mr. Coughlin

### 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. Second semester.
Messrs. Foust, Clump

### 428. Rheology (3)

An intensive study of momentum transfer in elastic viscous liquids. Rheological behavior of solution and bulk phase polymers with emphasis on the effect of molecular weight, molecular weight distribution and branching. Derivation of constitutive equation based on both molecular theories and continuum mechanics principles. Application of the momentum equation and selected constitutive equations to geometries associated with viscometric flows.

### 430. Mass Transfer (3)

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

### 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. First semester, alternate years.
Mr. Clump

### 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. Second semester, alternate years.
Mr. Foust

### 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.
Messrs. Luyben, Schiesser

### 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. Alternate years.
Messrs. Luyben, Schiesser

### 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.

# CHEMISTRY

**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. First semester.

Messrs. Coughlin, Luyben, Schiesser

**462. Mathematical Methods in Chemical Engineering II (3)**

A continuation of Ch.E. 461 with emphasis on applications involving numerical methods. Second semester, alternate years. Messrs. Schiesser, Coughlin, Luyben

**470. Cryogenic Engineering (3)**

Liquefaction and separation of gases, physical and chemical principles. Low temperature thermometry. Insulation. Properties of fluids and of structural materials. The behavior of helium. Ultra-low temperature phenomena and theories. First semester, alternate years.

Messrs. Stein, Wenzel

**471. Low Temperature Processes (3)**

The problems and design of plants operating in the cryogenic temperature range: Refrigeration demands. Distillation and heat exchange at low temperatures. Analysis of processes for thermodynamic and operating efficiency. Problems of safety, non-steady state behavior, and control. Second semester, alternate years. Mr. Wenzel

**480. Research (3-4)**

Investigation of a problem in chemical engineering. First semester.

**481. Research (3-4)**

Continuation of Ch.E. 480. Second semester.

**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.

Messrs. Manson, Poehlein, Sperling

### Professors

FREDERICK MAYHEW FOWKES, PH.D., *Chairman*
ALBERT CHARLES ZETTLEMOYER, PH.D.,
   *Vice President and Provost*
EUGENE MURRAY ALLEN, PH.D.
EDWARD DELBERT AMSTUTZ, PH.D.
HENRY LEIDHEISER, JR., PH.D.
JOSEPH ROBERT MERKEL, PH.D.
ROBERT STEACY SPRAGUE, PH.D.
THOMAS EDWIN YOUNG, PH.D.

### Associate Professors

ALFRED JAMES DIEFENDERFER, PH.D.
NED D. HEINDEL, PH.D.
KAMIL KLIER, PH.D.
CHARLES STEPHEN KRAIHANZEL, PH.D.
ROLAND WILLIAM LOVEJOY, PH.D.
JOHN ALEXANDER MANSON, PH.D.
WILLIAM EDWARD OHNESORGE, PH.D.
JAMES EDWARD STURM, PH.D.

### Assistant Professors

FORTUNATO JOSEPH MICALE, PH.D.
THOMAS RUSSELL ORTOLANO, PH.D.
DANIEL ZEROKA, PH.D.
MATTHEW HAROLD HULBERT, PH.D.

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**1. Chemical Principles I (3)**

An introduction to the important principles of chemistry. Topics include atomic structure and bonding, stoichiometry, kinetic molecular theory, states of matter, solutions, and an introduction to chemical equilibrium. Math. 21 previously or concurrently. Two lecture, one recitation. First and second semesters. Mr. Sprague

**11. Chemical Principles I Lab (1)**

A laboratory course to be taken concurrently with Chemistry 1. Emphasis is on quantitative methods. One three-hour laboratory period per week. First semester. Staff

**3. Chemical Principles II (3)**

A continuation of Chemistry 1. Topics include further 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. First and second semesters. Mr. Sprague

**13. Chemical Principles II Lab (1)**

A laboratory course to be taken concurrently with Chemistry 3. Emphasis is on quantitative physico-chemical experiments. Prerequisite: Chemistry 1. One three hour laboratory period per week. Staff

**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 3. First semester.

Analytical Chemistry Staff

**51. Organic Chemistry (3)**

Systematic survey of the typical compounds of carbon, their classification and general relations; study of synthetic reactions. Prerequisite: Chem. 3. First semester.

Mr. Amstutz

**52. Organic Chemistry (3)**

Continuation of Chem. 51. Prerequisite: Chem. 51. Second semester. Mr. Amstutz

**53. Organic Chemistry Laboratory (2)**

Preparation of pure organic compounds. Prerequisite: Chem. 3. First semester.

Messrs. Amstutz, Young, Heindel

**54. Organic Chemistry Laboratory (2)**

Continuation of Chem. 53 with particular emphasis upon aromatic compounds and qualitative organic analysis. Prerequisite: Chem. 53. Second semester.

Messrs. Amstutz, Young, Heindel

**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. Messrs. Young, Amstutz, Heindel

**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 statistical thermodynamics. Discussion of various states of matter (gases, liquids, solids, interfaces). Prerequisites: Chem. 3; Math 23, previously or concurrently. Second semester. Messrs. Allen, Sturm

**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. Prerequisites: Chem. 3; Math. 23, Phys. 4. First semester. Mr. Zeroka

**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. First semester.

Physical Chemistry Staff

**193. Physical Chemistry Laboratory (1)**

A course in the statistical design of experiments and analysis of data together with the use of the computer in physical chemical calculations. Prerequisite: Chem 90. Second semester. Physical Chemistry Staff

**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. 3. Second semester. Physical Chemistry Staff

**234. Analytical Chemistry Laboratory (2)**

Laboratory course: experiments coordinated with and illustrating methods and principles discussed in Chem. 332. Second semester. Analytical Chemistry Staff

**250. Special Topics (3)**

Selected topics in Chemistry not included in other courses. Prerequisite: Consent of the chairman of department.

Staff

**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. First semester. Mr. Kraihanzel

**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. First semester. Mr. Sturm

**306. Inorganic Laboratory (2)**

A laboratory course illustrating a variety of techniques for the preparation and purification of inorganic compounds. Hours equivalent to two laboratory periods per week will be arranged by the instructor. Prerequisite: Chem. 302, previously or concurrently. Messrs. Kraihanzel, Ortolano

**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. Second semester. Mr. Kraihanzel

**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. First semester. Mr. Diefenderfer

**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. Second semester.

Mr. Diefenderfer

**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, polari-

zation 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. Second semester.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 350.   Special Topics (3)

Selected advanced topics in Chemistry not included in other courses. Prerequisite: Consent of the chairman of department.                                                   Staff

### 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.                        Mr. Young

### 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 method; 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. Second semester.                   Staff

### 358.   Advanced Organic Chemistry (3)

The study of modern theories of reaction mechanisms and their application to the problems of organic chemistry. Prerequisite: One year of organic chemistry. First semester.
Mr. Heindel

### 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. First or second semester.              Messrs. Young, Heindel

### 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. First semester.                        Mr. Merkel

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

Dynamic aspects of biochemistry: Enzyme reactions including energetics, kinetics, and mechanisms; Metabolism of carbohydrates, lipids, proteins, and nucleic acids; Photosynthesis, electron transport mechanism, coupled reactions, phosphorylations, and the synthesis of biological macromolecules. Prerequisite: Chem. 371.      Mr. Merkel

### 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. First and second semesters.                     Staff

### 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. First semester.

### 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. Second semester.            Mr. Merkel

### 381.   Radiation and Structure (3-4)

A study of the method and theory of the development of chemical information from radiation-matter interactions; macroscopic optics, scattering pheonomena, 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. First semester.
Messrs. Ohnesorge, Zeroka

### 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. 381. Second semester.
Messrs. Diefenderfer, Sturm

### 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.
Mr. Micale

### 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 1969-70 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 complete all the requirements for the Ph.D. degree.

During his first year of graduate work a student normally takes basic graduate courses from the fields of analytical, biological, inorganic, organic, and physical chemistry and becomes acquainted with the research interest of the various faculty members. From these contacts the student is able to assess critically his own research interests, 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 the 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 include the following: 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 fluoresence 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. The electronic structures of transition metal complexes as a function of ligand strength and 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 chromic 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.

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, phosphorescence 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 speedcentrifuges, automatic fraction collectors, freeze dryers, high voltage electrophoreses apparatus, electron microscope, laboratory fermentor, walk-in cold room, cell disintegrator, Warburg respirometer, zone and disc electrophoresis apparatus, paper and 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: Center for Information Science, Center for Marine and Environmental Studies, Materials Research Center, Center for the Application of Mathematics, Center for Surface and Coating Research. The Computing Laboratory on campus is equipped with a CDC 6400 computing and information processing facility.

### 400. Inorganic Chemistry Research (1-4)
Investigation of a problem in inorganic chemistry.
Messrs. Kraihanzel, Ortolano, Sprague

### 401. Inorganic Chemistry Research (1-4)
Continuation of Chem. 400. Second semester.
Messrs. Kraihanzel, Ortolano, Sprague

### 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. Second semester.
Mr. Ortolano

### 403. Advanced Topics in Inorganic Chemistry (3)
Subjects of contemporary interest in inorganic chemistry, including quantitative treatment of acid-base chemistry in non-aqueous solvents, mechanisms of inorganic reactions, chemistry of organo-metallic 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. First or second semester.
Messrs. Sprague, Ortolano, Kraihanzel

### 429. Seminar in Inorganic Chemistry (1-6)
Reports and discussions of recent developments in inorganic chemistry.
Messrs. Kraihanzel, Ortolano, Sprague

### 430. Analytical Research (1-4)
Investigation of problems in analytical chemistry. First semester.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 431. Analytical Research (1-4)
Continuation of Chem. 430. Second semester.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 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. Alternate years.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 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. Alternate years.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 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. Alternate years.
Mr. Ohnesorge

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

### 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.
Mr. Sturm

### 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 paint defects in ionic and semi-conducting crystals, surface states and surface fields in crystals. Prerequisite : Chem. 191 or equivalent. First semester.
Messrs. Fowkes, Klier

### 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. First semester.
Messrs. Lovejoy, Sturm

### 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 interpretations. Prerequisite: Chem. 445 or consent of chairman of department. Second semester.
Messrs. Lovejoy, Sturm

### 449. Seminar in Analytical Chemistry (1-6)
Reports and discussions of recent developments in analytical chemistry.
Messrs. Diefenderfer, Hulbert, Ohnesorge

### 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.
Messrs. Young, Heindel

**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.
Mr. Young

**458. Topics in Organic Chemistry (3)**

An intensive study of limited areas in organic chemistry.
Messrs. Young, Heindel

**459. Seminar in Organic Chemistry (1-6)**

Reports and discussions of recent important developments in theoretical and applied organic chemistry.
Messrs. Young, Heindel

**460. Organic Chemistry Research (1-4)**

Investigation of a problem in organic chemistry. First semester.
Messrs. Amstutz, Young, Heindel

**461. Organic Chemistry Research (1-4)**

Continuation of Chem. 460. Second semester.
Messrs. Amstutz, Young, Heindel

**466. Advanced Organic Preparations (2 or 3)**

A laboratory course of instruction in advanced techniques of the preparation of organic compounds. First or second semester.
Messrs. Young, Heindel

**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.
Mr. Heindel

**473. Seminar in Biochemistry (1-4)**

Reports and discussions of current developments in the field of biochemistry.
Mr. Merkel

**474. Biochemistry Research (1-4)**

Investigation of a problem in biochemistry.

**475. Biochemistry Research (1-4)**

Continuation of Chem. 474.

**476. Microbial Biochemistry (3)**

Composition, nutrition and metabolism of micro-organisms; with emphasis on microbial enzyme reactions and products of microbial metabolism. Prerequisites: Chem. 372. and Biol. 35 or their equivalents.

**477. Topics in Biochemistry (3)**

Intensive study of selected areas of biochemistry, such as mechanisms of enzyme action, new developments in the chemistry of lipids, nucleic acids, carbohydrates and proteins. Prerequisite: Consent of the chairman of the department.
Mr. Merkel

**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. First semester.
Mr. Merkel

**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.
Mr. Merkel

**490. Physical Chemistry Research (1-4)**

Investigation of a problem in physical chemistry. First semester.
Physical Chemistry Staff

**491. Physical Chemistry Research (1-4)**

Continuation of Chem. 490. Second semester.
Physical Chemistry Staff

**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.
Messrs. Lovejoy, Zeroka

**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.
Mr. Zeroka

**497. Surface Chemistry (3)**

Applications of colloid chemistry; special topics in surface chemistry. Lectures and seminar. Prerequisites: Chem. 397 and Chem. 441.
Messrs. Fowkes, Micale, Zettlemoyer

**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.
Physical Chemistry Staff

# CIVIL ENGINEERING

**Professors**

DAVID ALAN VANHORN, PH.D., *Chairman*
LYNN SIMPSON BEEDLE, PH.D., *Director, Fritz Laboratory*
GEORGE CLARENCE DRISCOLL, JR., PH.D.
WILLIAM JOSEPH ENEY, M.S., *Joseph T. Stuart Professor*
JOHN WILLIAM FISHER, PH.D.
LE-WU LU, PH.D.
ALEXIS OSTAPENKO, PH.D.
ADRIAN F. RICHARDS, PH.D.

**Associate Professors**

GEORGE ANSON DINSMORE, M.S.
HSAI-YANG FANG, PH.D.
WALTER H. GRAF, PH.D.
TI HUANG, PH.D.
JOHN ORTH LIEBIG, JR., M.S.
ROGER GEORGE SLUTTER, PH.D.
LAMBERT TALL, PH.D.
BUNG-TSENG YEN, PH.D.

**Assistant Professors**

JOHN RODGER ADAMS, PH.D.
ARTHUR WILLIAM BRUNE, PH.D.
WAI-FAH CHEN, PH.D.
JOHN HARTLEY DANIELS, PH.D.
TERENCE JOHN HIRST, PH.D.
ROBERT LEROY JOHNSON, PH.D.
CELAL NIZAMETTIN KOSTEM, PH.D.

**Visiting Assistant Professor**

OSMAN AHMED EL-GHAMRY, PH.D.

**Postdoctoral Research Associate**

PAUL J. MAREK, PH.D.

**Instructors**

JOSEPH A. CORRADO, M.S.
STEPHEN CHIHCHI KO, M.S.
SAMPATH N. S. IYENGAR, M.S.

### 10. Problem Computation Laboratory (1)

Preparation of problems for computer programming with emphasis on problems in civil engineering; technique of programming for computers. First semester.

### 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. First and second semesters.

### 12. Applied Engineering Graphics (2)

Drawings for civil engineering projects; graphical solutions and representation of data. Prerequisite: C.E. 11. Second semester.

### 40. Principles of Surveying (3)

Study of theory of errors and measurements; applications to field procedures in the use of the tape, level, transit, selection of instruments, office procedures in computa-

tions; relation of errors to precision, accuracy, preparation of survey specifications. Astronomical observations, leveling, traversing, stadia and elements of photogrammetry. Prerequisite: C.E. 11. Second semester.

### 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.

### 43. Advanced Surveying (3)

Adjustment of instruments; investigation of systematic and observational errors; elements of least squares with application to surveying; adjustment of level nets and triangulation; celestial observation; precise leveling; photogrammetry. Office work, with some field exercises. Prerequisite: C.E. 40. Second semester.

### 100. Industrial Employment (0)

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.

### 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. First semester.

### 103. Special Problems (1-6)

Supervised individual research problems with report. Prerequisite: Consent of instructor. First and second semesters.

### 104. Readings in Civil Engineering (1-3)

Study of selected technical papers, with abstracts and reports. Prerequisite: Consent of instructor. First and second semesters.

### 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. Second semester.

### 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. First or second semester.

### 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. First and second semesters.

### 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. Second semester.

**145. 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. First semester.

**146. Transportation Engineering II (3)**

Principles of planning for major forms of transportation facilities. Development, operation, coordination, and regulation of highway, rail, air, water, and pipeline transportation. Traffic studies, location analysis, and economic consideration. Mass transportation of freight and passengers. Studies of large transportation terminals. Prerequisite: C.E. 145. Second semester.

**150. Structural Analysis I (3)**

Analysis of statically determinate frames and trusses; influence lines; deflections; statically indeterminate structures by method of deflections. Digital computer applications. Prerequisites: Mech. 11, C.E. 12. First semester.

**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. First semester.

**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. First semester.

**154. Structural Analysis II (3)**

Elastic analysis of statically indeterminate beams, frames, and trusses by methods of energy, moment distribution, and slope deflection; influence lines; introduction to plastic analysis. Prerequisite: C.E. 150. Second semester.

**155. Structural Design (3)**

Design of structures utilizing various structural materials. Prerequisites: C.E. 151, 153. Second semester.

**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. First semester.

**162. Sanitary Engineering (3)**

A systematic study of water and waste-water treatment employing the concept of unit-operations. Laboratory work includes field studies, examination of water and waste-water samples, batch and pilot plant experiments. Prerequisites: Chem. 3, C.E. 121. Second semester.

### For Advanced Undergraduates and Graduates

**201. Foundation Engineering (3)**

Application of soil engineering to foundation design. Site investigations and engineering tests to evaluate subsoil conditions. Procedures for choosing and proportioning foundation elements to meet specific structural requirements. The design and construction of temporary and permanent retaining structures. Prerequisites: C.E. 239; C.E. 153 previously or concurrently; or consent of department chairman. First or second semester.          Mr. Fang

**222. Hydraulic Engineering (3)**

Fluid measuring devices, pipe hydraulics, open channel hydraulics, hydraulics of coast lines, sediment transport, water hammer. Prerequisite: C.E. 121 or equivalent. Second semester.          Messrs. Graf, Brune, Adams

**239. Soil Mechanics (3)**

Fundamental physical and mechanical properties affecting soil action in engineering projects; identification; classification; hydromechanical, deformation, shear and compaction properties. Applications of theories and principles in engineering practice. Prerequisite: Mech. 11; or consent of department chairman. First semester.

Messrs. Fang, Hirst

**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. Second semester.

Messrs. Daniels, Eney

**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. First or second semester.

Messrs. Graf, Adams

**323. Hydraulic Laboratory Practice (1-3)**

Study of theory and method of hydraulic experimentation. First and second semesters.          Staff

**325. Hydrology (3)**

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

**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. Second semester.          Mr. Brune

**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.

Messrs. Graf, Adams

**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. Second semester.                                         Messrs. Graf, Adams

**332. Ocean Engineering (3)**

Background information and identification of the present and probable future ocean industries, emphasizing contributions from the principal engineering disciplines to man's exploration and exploitation of the oceans. Prerequisite: consent of department chairman. First semester.                                         Mr. Richards

**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.            Staff

**341. 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. First or second semester.        Mr. Hirst

**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. Second semester.                    Messrs. Liebig, Eney

**352. Structural Dynamics (3)**

Analysis of linear structural systems to time dependent loads. Free and forced vibration. Classical and numerical methods of solution. Lumped-mass technique, energy methods, and introduction to matrix formulation of dynamic problems. Application to design. Prerequisite: Math. 205 or equivalent.            Messrs. Yen, Kostem

**359. Plastic Analysis and Design (3)**

Plastic analysis and design of steel structures. Strength and behavior of frames and component parts beyond the elastic limit. Methods of predicting strength and deformation in the plastic range. Studies of industrial and multistory frames. Comparison of plastic design techniques with allowable-stress design methods. Current research. Prerequisite: C.E. 154 or equivalent.        Messrs. Lu, Chen

**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. Second semester.                    Messrs. Huang, VanHorn

**371. Sanitation (3)**

Study of those environmental factors having an influence upon public health, including food and milk sanitation; garbage and refuse collection and disposal; insect and rodent control; lighting, heating, and ventilation; plumbing, industrial hygiene, school sanitation; and swimming pools, but excluding water works and sewerage. Prerequisite: C.E. 162 previously or concurrently. First semester.                                         Mr. Johnson

**381. Special Topics (3)**

A study of selected topics in Civil Engineering, not included in other formal courses. First and second semesters.                                         Staff

**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. First semester.                                         Mr. Beedle

### 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, hydraulic engineering, water resources, water pollution, and ocean engineering, leading to the M.S. and Ph.D. degrees. A master's degree can also be earned in sanitary engineering. 38 Ph.D. and 38 M.S. candidates were enrolled in the Department in the 1969-70 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, 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 Department of Mechanical Engineering and Mechanics, the Department of Chemical Engineering, the Department of Metallurgy and Materials Science, the Department of Biology, and the Department of 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 lan-

guage 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. Interative, 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. First semester.                    Messrs. Ostapenko, Lu

### 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. Second semester.
Mr. Kostem

### 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. Second semester.
Mr. Brune

### 425. Mechanics 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. First semester.
Mr. Graf

### 428. Advanced Topics in Hydraulics (1-3)

Recent developments in hydromechanics and hydraulics. Topics to be selected from: wave mechanics, theory of flow through porous media, dispersion, hydrodynamic forces on structures, potential flow, free streamline theory, open channel hydraulics, computer methods. Prerequisites: C.E. 322 and consent of department chairman. May be repeated for credit.                    Staff

### 429. Hydraulic Research (1-6)

Individual research problems with reports. May be repeated for credit. First and second semesters.      Staff

### 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.
Mr. Richards

### 439. Ocean Engineering Research (1-6)

Individual research problems with reports. First and second semesters. May be repeated for credit.      Staff

### 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.      Mr. Hirst

### 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. First semester.
Messrs. Fang, Hirst

**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. Second semester. Messrs. Fang, Hirst

**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. First semester.
Mr. Fang

**447. Advanced Topics in Geotechnical Engineering (1-3)**

Advanced studies in selected subjects related to geotechnical engineering. The general areas in which studies may be taken include: stress-strain-time relationships of soils, colloidal phenomena in soils, ground water flow and seepage, soil dynamics, soil plasticity, numerical methods applied to soil mechanics, earth dam design, theories of layered systems and their application to pavement design, rock mechanics. The studies specifically undertaken in any particular semester depend on the availability of staff and the interest of students. Prerequisite: Consent of department chairman. First or second semester. Offered on sufficient demand only. May be repeated for credit. Staff

**449. Geotechnical Research (1-6)**

Individual research problems relating to soil engineering, with report. Prerequisite: A course in soil mechanics. First and second semesters. Staff

**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. First semester. Messrs. Daniels, Fisher

**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. Second semester.
Messrs. Driscoll, Fisher

**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.
Messrs. Lu, Ostapenko

**454. Plate and Shell Structures (3)**

Analysis and design of plates loaded transversely and in their plane. Shear lag; influence surfaces. Buckling and post-buckling behavior of elastic and inelastic plates. Membrane and bending analysis of cylindrical, rotational and hyperbolic-paraboloidal shells. Exact and approximate engineering methods. Design considerations. Prerequisite: Consent of chairman of department. Mr. Ostapenko

**455. Advanced Structural Dynamics (3)**

Analysis and design of structures to resist wind, earthquake, and blast loading. Matrix methods and computer applications. Non-linear and elasto-plastic response. Damping characteristics of structures and structural components, spectral analysis, dynamic instability. Characteristics of aerodynamic and seismic forces and nuclear blast. Introduction to vibration of 3-dimensional structural systems. Prerequisites: C.E. 403, C.E. 352 or Mech. 406, and C.E. 450 or equivalent. Mr. Kostem

**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. Mr. Fisher

**459. Advanced Topics in Plastic Theory (3)**

Advanced problems in plastic analysis and design: minimum weight design, composite design, deflections, shakedown, and arch analysis. Fundamentals of the mathematical theory of plasticity; the general theorems of limit analysis and their applications to beams under combined loading, space frames, plates and shells. Current developments. Prerequisite: C.E. 359. Messrs. Chen, Lu

**462. Experimental Methods of Structural Analysis (3)**

Analysis of structures using various experimental techniques; use of mechanical devices in investigation of special problems, such as temperature deformations, foundation displacements, and integral action of structures; moire fringe method; theory of similitude and its application to model design; principles of structural analogies. Mr. Lu

**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. Messrs. Slutter, Yen

**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. Messrs. Huang, VanHorn

**466. Concrete Shell Structures (3)**

Analysis and design of various types of concrete shell structures. Folded plates, barrel shells and shells of double

# CLASSICS

curvature. Application of prestressing. Prerequisite: C.E. 403 and C.E. 364 or equivalent. Desirable preparation: C.E. 454 or Mech. 416.          Messrs. Huang, VanHorn

**467.   Advanced Topics in Structural Engineering (1-3)**
Advanced study of selected topics in structural mechanics and engineering, such as: finite element methods, suspension systems; space frames; stability of non-linear systems; cold-formed and lightweight construction; optimization and reliability; second-order phenomena in structures; interaction of structures with environment; structural use of plastics; composite construction, etc. Selection of topics will depend on particular qualifications of the staff, as well as on the interests of the students. Prerequisite: Consent of department chairman. May be repeated for credit.          Staff

**468.   (Mech. 415) Stability of Elastic Structures (3)**
For course description see Mech. 415.

**469.   Structural Research (1-6)**
Individual research problems with reports. First and second semesters. May be repeated for credit.          Staff

**471.   Water Supply and Sewage (3)**
Theory and design of facilities for the supply and distribution of water and for collection of waste water.
                                                        Mr. Johnson

**472.   Treatment of Water and Waste Water (3)**
Theory and design of treatment facilities for water, sewage, and industrial waste; advanced topics of current practices, with reports.          Mr. Johnson

**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. First and second semesters.   Staff

**483.   Graduate Seminar (1-3)**
Study of current topics in the field of civil engineering. First or second semester.          Staff

**491.   Thesis (1-6) Staff**

**Professors**
JOSEPH ABELE MAURER, PH.D., *Chairman*
DOUGLAS DAVID FEAVER, PH.D.

**Assistant Professor**
EDNA SOPHIA DEANGELI, PH.D.

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## Greek

**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. First semester.

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

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

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

**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. First semester.

**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. First or second semester.

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

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

**113.   Greek Historians (3)**
Selections from Herodotus, Thucydides, or Xenophon. A study of Greek historiography. Prerequisite: Gk. 4. First semester.

### 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. First semester.

### 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. First or second semester.

### 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. First or second semester.

### 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. Second semester.

### 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. First semester.

## Latin

### 22. (Hist. 22) Ancient History (3)

Continuation of Gk. 21. The Hellenistic Age. Rome from its origin to 395 A.D. Second semester.

### 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. First or second semester.

### 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. First semester.

### 62. Caesar (3)

Selections from Caesar: *The Gallic War*. Prose composition and syntax. Prerequisite: Lat. 61 or 2 entrance units. Second semester.

### 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. First semester.

### 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. Second semester.

### 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 metres; memorization of stanzas and passages. Prerequisite: Lat. 65 or at least 4 entrance units. First semester.

### 168. Latin Drama (3)

Readings of selected plays of Plautus, Terence, and Seneca. Prerequisite: Lat. 65 or at least 4 entrance units. First semester.

### For Advanced Undergraduates and Graduates

### 203. Archaeology of Italy (3)

Neolithic, Terramara, Villanovan, and Etruscan cultures. Rome the city: its buildings, monuments, and streets, its destruction and rediscovery through excavation; origin and growth of the city; the three periods, empire, republic, and kingdom; methods of identifying and dating monuments. A survey of Pompeii, Herculaneum, and Ostia. Lectures, readings, and reports. First or second semester.

### 211. 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. First semester.

### 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. Second semester.

### 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. First semester.

### 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. Second semester.

### 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. First or second semester.

# Creative Concepts

**304. Latin Historical Grammar (3)**

The development of Latin syntax with survey of early Latin. Syntactical analysis of Caesar, Cicero, and Vergil. The development of classical prosody and metrics with emphasis on changes in the hexameter from Catullus and Lucretius to Vergil. The course is designed primarily for teachers of Latin in secondary schools and for majors in Classics planning to teach. Prerequisites: Six hours of courses at the "100" level and consent of chairman of department. First or second semester.

**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.          Second semester.

**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.          Second semester.

**381. Senior Seminar (3)**

Continuation of Gk. 381. Prerequisite: Consent of chairman of department. Second semester.

**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. First semester.

**412. History of Latin Literature (3)**

Continuation of Lat. 411. The Age of Vergil to the end of Classical Literature. Prerequisite: Lat. 411. Second semester.

Honors Seminars are open to students admitted to the Interdepartmental Honors Program (see page 22), and occasionally to special students approved by the Honors Council. Enrollment is limited.

Seminars are conducted with a combination of lectures, student reports, and discussion. Emphasis is placed on the development of the student's ability to conduct, report on, and defend independent research. In addition to the scheduled seminar hours, there will be personal conferences with the instructor.

Course titles indicate only the general area in which a seminar will be conducted. The particular concepts to be considered and the material to be studied will be determined by the instructor with the concurrence of the Honors Council.

**Creative Concepts 101. The Humanities (3)**

A study of concepts significant in man's attempts to understand himself as an individual, his place in and his relation to the universe, the meaning of his existence, and the way in which he should live. Material is drawn chiefly from literature, philosophy, religion, and the fine arts and music.

**Creative Concepts 102. The Life Sciences (3)**

A study of concepts significant in man's efforts to understand and to control the living world of which he is a part. Material is drawn primarily from biology, psychology, and geology, but also, because of the ultimate inseparability of the natural sciences, from chemistry and physics.

**Creative Concepts 103. The Physical Sciences (3)**

A study of concepts significant in man's efforts to understand and use the physical universe in which he lives. Material is drawn primarily from chemistry, physics, mathematics, and astronomy, but also, because of the ultimate inseparability of the natural sciences, from biology and geology.

**Creative Concepts 104. The Social Sciences (3)**

A study of concepts significant in man's attempts to understand himself as a social being, his beliefs as to how men should live together and the means he has used to achieve social order. Material is drawn, depending on the orientation of individual seminars, from the political and social sciences.

**Creative Concepts 190. Honors Thesis (3-6)**

Independent work and thesis on an approved subject in a form appropriate to the field of study. The work is directed throughout by the thesis adviser.

# ECONOMICS

### 3. Economics (3)

A general course in the principles of economics, covering the organization of production, problems of concentration and efficiency, principles of value and price, income distribution and labor problems. First and second semesters.

### 4. Economics (3)

A continuation of Eco. 3 in which the work deals with the basic institutions of economic life, money and banking, the general price level, national income, income determination, business cycles, monetary policy, and public finance. Prerequisite: Eco. 3. First and second semesters.

### 45. Statistical Method (3)

An introduction to quantitative method: descriptive statistics, elementary probability and sampling, estimation and testing of population parameters, simple correlation and regression. Prerequisite: A course in college-level mathematics.

### 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. Second semester.                Mr. Petrakis

### 130. Money and Banking (3)

A course dealing with specific monetary and banking problems with suggested actions to resolve these problems. Prerequisite: Eco. 129. Second semester.        Mr. Petrakis

## 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. First and second semesters.
                    Messrs. Cohen, Walker, Weintraub

### 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. Prerequisite. Economics 3 and 4 or consent of instructor. Second semester.
                    Mr. Gonce

### 303. Economic Development (3)

The principal determinants of economic development; economic development in advanced and underdeveloped countries. First semester.                Mr. Cohen

### 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. Second semester.
                    Mr. Cohen

### 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. First semester.
                    Mr. Gonce

### 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. Second semester.                Mr. Gonce

### 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. First semester.                Mr. Balabkins

### 310. Economic Evolution (3)

Long term economic growth and social transformation of the United States.                Mr. Balabkins

**311.  Economics Resource Use (3)**

Problems of the economic use and development of human and natural resources, with particular reference to the future and to relationships within and between regions. Prerequisite: Eco. 306 or consent of chairman of department. First semester.                                          Staff

**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. First and second semester.

**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. First semester.        Mr. Jensen

**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. First and second semester.

Mr. Weintraub

**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. Second semester.

Mr. Gonce

**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. First semester.        Mr. Pillsbury

**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. First and second semesters.                                          Staff

**339.  International Economics (3)**

The theory of international trade; the theory of tariffs; United States Commercial policies; the impact of growth and development on the world economy. First semester.

Mr. Jensen

**340.  International Economics (3)**

The balance of payments and the theory of disturbances and adjustment in the international economy; international monetary policies. Second semester.        Mr. Jensen

**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. First or second semester.

Mr. Jensen

**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. First and second semesters.        Messrs. Bratt, Weintraub

**347.  National Income Analysis (3)**

Analysis of income and product aggregates 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. First semester.        Messrs. Innes, Shen

**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. Second semester.

Mr. Bratt

**352.  Advanced Statistical Method (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. First semester.        Messrs. De Rooy, Shen

**353.  Public Finance: Federal (3)**

A course dealing with government expenditures and revenues, the economics of taxation, and government administration. First semester.

Messrs. Aronson, Jensen, Schwartz

**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. Second semester.

Mr. Aronson

**355. Empirical Economic Analysis (3)**

The course provides empirical content to the theoretical concepts developed in intermediate economic theory (micro-and macro-). Prerequisite: Eco. 45, 206, and 361.

Mr. Innes

**371.  Readings in Economics (3)**

Readings in various fields of economics, designed for the student who has a special interest in some field of economics not covered by the regularly rostered courses. Prerequisite: Preparation in economics acceptable to the department chairman. First semester.                         Staff

**372.  Readings in Economics (3)**

Continuation of Eco. 371. Second semester.        Staff

## For Graduates

#### 404. Developmental 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. Second semester. Mr. Cohen

#### 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. Prequisite: Graduate exposure to economic theory.

#### 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. Mr. Schwartz

#### 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: Economics 206 or consent of the instructor. First and second semesters. Mr. Walker

#### 432. Micro-Economics (3)

A survey of methods of decision making at the microeconomic level utilizing concepts developed in price theory and econometrics. Prerequisite: Eco. 206 or equivalent. Messrs. Garb, Walker, Weintraub

#### 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. Prerequisites: Eco. 432 or equivalent and consent of instructor. Mr. Garb

#### 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.
Messrs. Innes, Shen

#### 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. First semester. Mr. Unterberger

#### 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. Second semester. Mr. Unterberger

#### 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. Second semester.
Mr. Pillsbury

#### 441. Foreign Trade Management (3)

Current problems of foreign operations: including channels of export in foreign markets, management of exports at home and abroad, export and import financing, foreign investments, policies of government and international agencies as they affect foreign operations. Second semester.
Mr. Jensen

#### 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.
Mr. Balabkins

#### 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. First and second semesters.
Messrs. Aronson, Jensen, Schwartz

#### 445. International Economic Theory (3)

The theory of international economics, with emphasis on the way in which general economic theory is applied to the problems and issues of international economics. Prerequisite: Eco. 339 and Eco. 340, or consent of the instructor. Mr. Garb

#### 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. First semester. Mr. Innes

#### 453. Time Series Econometrics (3)

Statistical measurement of economic change and its economic significance. Second semester. Mr. Shen

#### 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. Second semester. Mr. Bratt

#### 455. Econometric Methods (3)

The development of economic models. The statistical estimation of economic parameters, and the testing of hypotheses suggested by economic theory. The development of production, cost, demand, and consumption functions; aggregate cyclical and growth models. Prerequisites: Background in statistics and calculus. Second semester.
Mr. Shen

# EDUCATION

## 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. Second semester.                    Mr. Garb

## 461. Methodology in Theory and Research

Foundations of theory construction and empirical research in economics and related subject matter. Theory, hypothesis formation and empirical study in the business firm, organizations, industrial relations, and micro-macro research.                    Mr. Garb

## 471. Special Topics (3)

An extended study of an approved topic in the field of economics.                    Staff

## 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. Second semester.    Staff

## 475. Business Economics Seminar (3)

Independent research for M.S. in Business Economics candidates. Second semester.                    Mr. Bratt

## 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. First and second semesters.    Staff

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# URBAN STUDIES

Students who wish to concentrate on *Urbanization and related problems* have the option of an interdisciplinary major in Urban Studies. They apply for it from within the department of their choice (Economics, Social Relations, Government or History) and work out a course schedule with the advice of faculty members participating in the program of Urban Studies. Courses offered:

*Economics*
212.   Urban Economics (3)
440.   Regional Science; Metropolitan Analysis (3)

*Government*
357.   Urban Politics (3)
358.   Community & Regional Politics (3)
460.   Community Power Structure (3)
461.   Metropolitan Politics (3)

*Fine Arts*
51.   Urban Design (3)

*Social Relations*
312.   Urban Research (3)
368.   Urban Community (3)
468.   Urban Sociology (3) Seminar
472.   Designs of Urban Systems (3) Seminar

*History*
333.   American Urban History (3)
334.   American Urban History (3)
423.   Urban History (3)

## Professors

JOHN A. STOOPS, ED.D., *Dean*
NATT BRYANT BURBANK, M.A. *Assistant Dean*
GLENN JAMES CHRISTENSEN, PH.D.
   *University Distinguished Professor*
LLOYD WILLIAM ASHBY, ED.D.
JOHN S. CARTWRIGHT, M.A.
ANDREW J. EDMISTON, PH.D.
MERLE W. TATE, ED.D

## Associate Professors

ALFRED JOSEPH CASTALDI, ED.D.
CHARLES W. GUDITUS, ED.D.
ROBERT LEWIS LEIGHT, ED.D
JOHN ANTHONY MIERZWA, ED.D
PAUL VAN REED MILLER, PH.D.
ESTOY REDDIN, ED.D
NORMAN HAROLD SAM, E.D.

## Assistant Professors

MARGARET C. GRANDOVIC, ED.D.
JOSEPH KENDER, ED.D.
ETHEL MAY MCCORMICK, D.SC. ED.
ALICE DUFFY RINEHART, ED.D.
WILLIAM BUTLER STAFFORD, ED.D.
ELVIN GALEN WARFEL, ED.D.

## Adjunct Professor

NANCY LARRICK, ED.D.

## Instructors

LYNN ASKEW, M.ED.
RAYMOND BELL, M.ED.
EDWARD CHARLES, M.A.
FREDERIC L. EVANS, M.ED.
THOMAS FLECK, JR., M.ED.
RICHARD T. GORTON, M.ED.
DARLENE M. JOHNSON, M.ED.
JUDITH LADNER, B.S.
CHARLES E. MARPLE, M.ED.
WILLIAM NELSON, M.ED.
RUTH B. PARR, M.ED.
JOANN SPENCER, M.ED.
JEAN ANN ZINGLER, B.S.

## Lecturers

GEORGE DOURIS, M.F.A.
WILLIAM E. KEIM, ED.D.
JOHN WYCLIFFE KHOURI, ED.D.
WILLIAM WALLACE OSWALT, ED.D.
HENRY WILLIAM RAY, ED.D.
RICHARD C. RICHARDSON, PH.D.
SYLVIA RUTKOFF, M.A.
STEPHEN ALAN SCHAFER, M.H.L.
MARGARET MELCHIOR SEYLAR, M.A.

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## 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 Ameri-

can institutions are shown. Undertaken in cooperation with selected European universities. Summer session. Prerequisite: consent of the instructor. Mr. Stoops

### 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. First and second semesters. Mr. Miller

### 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. First semester. Mr. Guditus and Staff

#### For Advanced Undergraduates and Graduates

(For further information see the
School of Education, page 94.)

### 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. First or second semester.

Messrs. Sam, Stoops and Staff

### 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. First semester. Mr. Ray

#### 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. First semester. Mr. Stafford

### 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. Mrs. Rinehart

### 403. Teaching in the Two Year College (3)

Major theories of teaching, learning, and measurement are studied with particular reference to the problems of instruction in the two year college. The characteristics of students in two year colleges are examined. Participants undertake research in the field. First or second semester. Mr. Guditus

### 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. First semester. Mr. Leight

### 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. First and second semesters. Mr. Stoops

### 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. Second semester. Mr. Warfel

### 409. The Two-Year College (3)

Historical and philsophical 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. First or second semester. Mr. Guditus

### 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.

Mr. Stoops and Staff

### 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 analysed with regard to changing conceptions of self and the interplay of emotion and intellect. First semester; alternate years. Prerequisite: Consent of instructor. Mr. Edmiston

### 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. Second semester; alternate years. Prerequisite: Consent of instructor.                           Mrs. Grandovic, Mr. Mierzwa

### 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 institutions. The research and current trends in counseling on educational, social, and vocational problems are studied. Precepts and practices in mental health screening are examined. First semester; alternate years. Prerequisite: Consent of instructor.    Messrs. Edmiston, Mierzwa

### 414. Child Development (3)

A study of physical, intellectual, emotional, and social aspects of child development as they relate to the elementary schools. Second semester.          Mr. Castaldi

### 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. Second semester.
Messrs. Leight, Warfel

### 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. Second semester.
Mr. Stoops

### 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. First or second semester.                      Mrs. Grandovic

### 423. Diagnostic and Remedial Teaching (3)

The role of the classroom teacher as a diagnostician of corrective learning difficulties. Emphasis is placed on the nature and methods of educational diagnosis and the specifics of diagnostic teaching important to daily classroom instruction at all levels. Opportunities are offered for experiences in diagnosis and program prescription. First and second semesters.                    Mr. Oswalt

### 424. Linguistics in Education (3)

Emphasis on the nature of language, phonetic applications, and the relationships of linguistics to instruction in the language arts. Second semester.          Miss Reddin

### 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 learn-

ing 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. First and second semesters.       Mr. Kender

### 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 (6) credits may be earned in a semester. First or second semester.                          Staff

### 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. First or second semester.

Messrs. Leight, Warfel

### 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. First and second semesters.                     Messrs. Leight, Warfel

### 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. First and second semesters.                     Messrs. Leight, Warfel

### 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. First and second semesters.          Mr. Kender

### 433. Reading in Elementary Education (3)

Miss Reddin

### 434. Mathematics in Elementary Education (3)

Mrs. Williams

### 435. Social Studies in Elementary Education (3)

Mr. Warfel

### 436. Science in Elementary Education (3)

Mr. Castaldi

### 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.    Mr. Sam

### 438. Fine Arts in Elementary Education (3)

Mrs. Rutkoff, Mr. Douris

### 443. Elementary School Administration (3)

The major problems of organization and administration of elementary schools; types of organization, pupil promo-

tion, time allotment, service agencies, and plant and equipment. Required for a principal's certificate. First semester.
Miss McCormick

### 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. Second semester.
Miss McCormick

### 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.
Miss Larrick

### 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. First semester.
Mr. Ashby

### 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. First semester.
Mr. Ashby

### 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. First or second semester.
Miss Reddin, Messrs. Tate and Miller

### 456. Statistics II (3)

Review of descriptive statistics. Movements 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. First semester.
Messrs. Tate and Miller

### 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. Second semester.      Messrs. Miller, Tate

### 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. First semester.      Messrs. Miller, Tate

### 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. Second semester.      Mr. Miller

### 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. First or second semester.      Mr. Mierzwa

### 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. Second semester.      Mr. Cartwright

### 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. First or second semester.      Miss McCormick

### 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. Second semester.      Mr. Richardson

### 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. First or second semester.
Miss McCormick

### 468. Administration of Student Services 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 matters 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. Second semester.
Mr. Richardson

### 470. Practicum in Analysis of Reading Difficulties

An investigation of research as it relates to analysis of reading difficulties; practice in administration of test materials and the analysis of reading difficulties. First or second semester.      Mr. Kender

### 471. Evaluation in Education (3)

Primarily for classroom teachers and counselors. Construc-

tion 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.
Messrs. Castaldi, Kender, Miller

#### 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. First or second semester.
Mr. Miller

#### 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)
Mr. Burbank

#### 475. Seminar in Business Management (3)
Mr. Cartwright

#### 476. Seminar in School Finance (3)
Mr. Cartwright

#### 477. Seminar in School-Community Relations (3)
Mr. Burbank

#### 478. Seminar in School Personnel Problems (3)
Mr. Ashby

#### 479. Seminar in School Law (3)
Mr. Cartwright

#### 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. Second semester.
Mr. Stafford

#### 482. Philosophy and Principles of Guidance (3)

Introduction to the guidance of children and youth in elementary and secondary school and to the 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. First or second semester.
Mr. Stafford

#### 483. Counseling (3)

An intensive examination of theories and techniques of counseling. Students will conduct counseling interviews. Prerequisite: Educ. 482. First or second semester.
Messrs. Edmiston, Mierzwa

#### 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. First or second semester.
Mr. Mierzwa

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

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

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

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

#### 489. Reading Specialists Clinic (3-12)
Mr. Kender

#### 491-492. Advanced Seminars in Education (3)
Mr. Stoops, Staff

#### 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. First and second semesters.
Miss Reddin, Mr. Tate

#### 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. First and second semesters.
Mr. Miller, Staff

#### 496. Seminar in Research Methods (3-6)

For specialists in measurements and research. Research designs and application to various kinds of educational problems; data collection and analysis. Seminar will include criticism and evaluation of student proposals. First or second semester.
Mr. Miller, Staff

#### 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. First or second semester.
Mr. Stoops, Staff

# ELECTRICAL ENGINEERING

## Professors

ALFRED KRISS SUSSKIND, S.M., *Chairman*
JOHN J. KARAKASH, M.S., *Distinguished Professor*
WALTER EMIL DAHLKE, PH.D.
ARTHUR IRVING LARKY, PH.D.

## Associate Professors

WILLIAM AVON BARRETT, PH.D.
NIKOLAI EBERHARDT, PH.D.
CARL SANFORD HOLZINGER, PH.D.
DANIEL LEENOV, PH.D.
LESLIE GUY MCCRACKEN, JR., PH.D.

## Assistant Professors

BRUCE DALE FRITCHMAN, PH.D.
WILLIAM FOWLER HOLLABAUGH, PH.D.
JOHN GEORGE ONDRIA, PH.D.
KENNETH KAI-MING TZENG, PH.D.

## Adjunct Professor

LAVEEN KANAL, PH.D.

## Instructors

HANS R. GUERLICH, M.S.
FRED H. IRONS, E.E.
DONALD LEE TALHELM, M.S.

## Lecturers

RUDD H. CANADAY, PH.D.
EDWARD FRANKLIN REIS, M.S.
JOHN EDWARD ROTH, M.S.

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### 15.   Circuit Theory I (3)

Introductory linear network analysis: waveforms, network equations, network functions, forced and natural modes of response, network theorems, pole-zero analysis, sinusoidal steady-state analysis, flow graphs, harmonic analysis. In weekly problem session/laboratory: programming in compiler and assembly languages applied to circuit study; introduction to laboratory techniques and experiments illustrating linear network behavior. Prerequisites: Phys. 3, Math. 23 previously or concurrently. First semester.

### 16.   Circuit Theory II (4)

Continuation and completion of E.E. 15. Includes weekly problem session/laboratory. Prerequisite: E.E. 15. Second semester.

### 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.   Semiconductor Diode Theory (3)

Energy levels and band theory; introduction to quantum statistics. Intrinsic and extrinsic semiconductors; conduction mechanisms in solids. Theory of p-n junctions. Characteristics and equivalent circuits of semiconductor diodes. Special diode devices. Diode circuit applications. Prerequisite: Phys. 4. First semester.

### 104.   Linear Systems Analysis (3)

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. First semester.

### 105.   Introduction to Transistor Theory and Circuits (4)

Transistor action and characteristics. Biasing and thermal stabilization. Small-signal, low-frequency transistor models and amplifier circuits. High-frequency transistor models and untuned amplifier circuits. Includes a weekly laboratory session. Prerequisites: E.E. 16, E.E. 103. Second semester.

### 106.   Machine Theory (4)

Principles of electromagnetic fields and forces. Introduction to analysis and design of transformers. Elements of direct current machines, induction motors, and synchronous machines. Survey of thermoelectric, photoelectric, thermionic, chemical, and fluid-dynamic converters. Includes a weekly laboratory session. Prerequisite: E.E. 16. First semester.

### 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. First semester.

### 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. First semester.

### 152.   Senior Laboratory II (2)

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

A. Project laboratory. Similar to E.E. 151.

B. 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.

C. 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. First and second semesters.

### 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. First and second semesters.

### 162. Electrical Laboratory (1)

Experiments on circuits, machines, and electronic devices. Prerequisite: E.E. 160 concurrently. First and second semesters.

#### For Advanced Undergraduates and Graduates

*The following courses are departmental electives with the exception of E.E. 231 and E.E. 245.*

### 201. Introduction to Digital Systems (3)

Number representation and coding. Serial and parallel arithmetic operations; instruction decoding. Design of a small general-purpose digital computer. Design simulation. Prerequisites: E.E. 16 or Math. 105; E.E. 241 previously or concurrently. Mr. Larky

### 205. Pulse and Digital Circuits (3)

Analysis of functional circuits: wave shapers, multivibrators, logic circuits, pulse and timing generators. Models of semiconductor devices. Methods of nonlinear analysis and worst-case design. Feedback and negative resistance. Prerequisite: E.E. 105. Mr. Holzinger

### 212. Control Systems (3)

Introduction to feedback control. Dynamic analysis of linear feedback systems in the time and frequency domain, with emphasis on stability and steady-state accuracy. Major analytical tools: signal-flow graphs, root-locus method, Nyquist plot, Bode analysis. Cascade compensation techniques. Introduction to sampled data and state-variable concepts. Prerequisite: E.E. 104. Mr. Talhelm

### 231. Electric and Magnetic Fields (3)

Fundamentals of static electric and magnetic fields. Laplace's equation. Polarizability of matter. Boundary conditions. Conformal mapping. Numerical methods in potential theory. Prerequisite: Math. 208. Second semester.

### 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. First semester.

### 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. Second semester.

### 241. Logic and Switching Theory (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. Mr. Tzeng

### 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. First semester.

### 306. Solid State Magnetic and Dielectric Devices (3)

Origin of magnetic and dielectric properties of materials. Performance of ferrites at high frequencies. Analysis of rectangular hysteresis-loop magnetic circuits. Characterization of electrostrictive and magnetostrictive materials Analysis of magnetic amplifiers and core memories. Magnetic recording techniques. Ferro-resonance. Piezoelectric resonators. Ceramic transformers and transducers. Prerequisite: E.E. 231. Mr. Barrett

### 307. Transistor Theory and Circuits I (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. First semester.

Messrs. Leenov, Ondria

### 308. Transistor Theory and Circuits II (3)

Large-signal theory of p-n junction devices. Analysis of switching, Linvill, Ebers-Moll and charge-control models. High level injection, temperature and power limitations. Special circuit applications. Field effect transistors and their circuit applications. Prerequisite: E.E. 307. Second semester. Messrs. Leenov, Ondria

### 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.

Mr. Fritchman

### 346. Microwave Circuits and Techniques (3)

Impedance transformation along waveguides. Matching techniques. Resonant cavities as circuit elements. Scattering and transfer matrices. Periodic structures. Selected microwave devices. Basic techniques of microwave measurements. Prerequisite: E.E. 245. Mr. Eberhardt

### 350. Special Topics (3)

Selected topics in the field of electrical engineering not included in other courses. Mr. Susskind

### 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 proper-

ties of materials. Prerequisites: Met. 91, Math. 221 or 205.
Mr. Leenov

**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. Offered alternate years.          Mr. Larky

**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. First semester.
Mr. Canaday

**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. Offered alternate years.          Mr. Holzinger

**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. Offered alternate years.          Mr. Eberhardt

**410.   Electronics of Microwave Tubes (3)**

Ballistic theory of transit-time tubes. Llewellyn-Peterson equations. Free space-charge waves and their interaction with electromagnetic waves. Optics of electron beams. Electron guns. Offered alternate years.          Mr. Eberhardt

**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.
Mr. Fritchman

**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.          Mr. Fritchman

**413.   Active Networks (3)**

Synthesis of active networks to prescribed frequency characteristics. Stability and realizability criteria. Parameter drift effects. Offered alternate years.          Mr. Larky

**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. First semester.          Mr. Kanal

**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. Second semester.          Mr. Kanal

**425. Power System Analysis (3-6)**

Steady-state and transient analysis of power systems. Traveling waves; free and forced oscillations; reflections; transition points; multi-conductor systems; multi-velocity waves. Attenuation and distortion; lightning surges; switching surges; arcing grounds; protective devices. Surges in transformer and machine windings.

**426. Power System Stability and Protection (3-6)**

Power flow and power limits of systems having synchronous and asynchronous machines. Stability criteria and other related topics. Principles of system protection.

**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, algebraic machine structure theory and its application to synthesis, error diagnosis in switching circuits, fault masking in switching circuits. First semester. Mr. Susskind

**432. Finite and Infinite State Machines (3)**

Emphasis on behavioral aspects of digital machine models. Major topics included: descriptions of sequential behavior, Gedanken experiments, error control, information losslessness, iterative systems, introduction to Turing machines and computability. Offered alternate years. Mr. Susskind

**435. Coding Theory (3)**

Fundamental concepts and recent developments in the theory of error-correcting codes. Topics include linear codes; Hamming codes; polynomial algebra and structure of finite fields; cyclic codes for random and burst-error correction, Bose-Chaudhuri-Hocquenghem codes, Fire codes; codes derived by modifying or combining other codes; convolutional codes. Extensive survey of recent approaches to the decoding problem through implementation in computational procedures and hardware organization. Mr. Tzeng

**443. Network Theory (3)**

Properties of driving-point and transfer functions; synthesis; realizability and positive-real functions. Introduction to active network synthesis. First semester.

Mr. Larky

**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. Offered alternate years. Mr. Eberhardt

**447. Nonlinear Phenomena (3)**

Investigation of nonlinear effects in the behavior of electric circuits with emphasis on methods of analysis. Jump phenomenon in passive resonators; generation of harmonics; van der Pol's theory: role of non-linearities in feedback oscillators; stability criteria; coupled non-linear oscillators and synchronization. Offered alternate years. Mr. Eberhardt

**450. Special Topics (3)**

Selected topics in the field of electrical engineering not covered in other courses. Mr. Susskind

**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. Messrs. Dahlke, Leenov

**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. Offered alternate years. Messrs. Dahlke, Leenov

**453. Solid State Device Theory II (3)**

Properties of semiconductor surfaces; tunneling theory. Applications to tunnel diodes and field-effect transistors. Prerequisite: E.E. 451. Offered alternate years.

Messrs. Dahlke, Leenov

**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. Offered alternate years. Mr. Dahlke

**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. Offered alternate years.

Mr. Dahlke

# ENGLISH

## English Composition

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 and 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 satisfactory performance 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 perform satisfactorily 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. First and second semesters.

**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. Second semester.

**1X. English for Foreign Students (3)**

Practice in reading, writing, and speaking the English language, with exercise in listening and note taking. A substitute for Engl. 1 for foreign students who demonstrate a need. Open also to transfer and graduate students. Prerequisite: Consent of chairman of department. First semester.

**2X. English for Foreign Students (3)**

Continuation of Engl. 1X. A substitute for Engl. 2 for foreign students who demonstrate a need. Prerequisites: Engl. 1X or its equivalent and consent of chairman of department. Second semester.

**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 students who have taken Engl. 36. First semester.

**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. Second semester.

## 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. First semester.

**5. A Study of the Drama (3)**

Continuation of Engl. 4. Prerequisite: Engl. 2 or 12. Second semester.

**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. First and second semesters.

**8. English Literature (3)**

A survey of English literature from *Beowulf* through the Pre-Romantics, with selected readings. Prerequisite: Engl. 2 or 12. First semester.

**9. English Literature (3)**

A survey of English literature from Wordsworth to Housman. Prerequisite: Engl. 2 or 12. Second semester.

**18. The Novel (3)**

A study of a selection of novels as noteworthy works of literature. Prerequisite: Engl. 2 or 12. First semester.

**19. The Novel (3)**

Chronological continuation of Engl. 18. Prerequisite: Engl. 2 or 12. Second semester.

**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. First semester.

**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. Second semester.

**35. Poetry (3)**

The 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. Second semester.

**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. First and second semesters.

**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. First and second semesters.

**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. First and second semesters.

**181. Undergraduate Thesis (3)**

Open to advanced undergraduates who wish to submit theses in English. Prerequisite: Consent of chairman of department. First semester.

**182. Undergraduate Thesis (3)**

Continuation of Engl. 181. Prerequisite: Consent of chairman of department. Second semester.

**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. First semester.

**184. Readings in English Literature (3)**

Continuation of Engl. 183. Prerequisite: Consent of chairman of department. Second semester.

## 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 1969-70, 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 interests 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. A reading knowledge of two foreign languages is required, usually Latin, French, or German; and the candidate must give evidence of such knowledge, through examination, either before, or soon after, he is accepted.

For the purposes of the general examination for the doctorate in English, each candidate will select the following fields to be examined upon:

1. Major field, in which primary materials (literature) and secondary materials (scholarship and criticism) will be examined.
2. Two minor fields, in which primary materials only will be examined.
3. Three major figures, concerning whom primary and secondary materials will be examined. The three major figures must be chosen outside the major and minor fields in 1 and 2 above, and at least one of them must be a figure not studied in a graduate seminar. They must not be figures already treated by the candidate in a master's thesis or to be treated in the doctoral dissertation.

The three fields (one major and two minor) and the three major figures must be chosen from the following groups, one field and one figure from each group.

### Group I

Old English (to 1050)
Middle English (1050-1500)
Renaissance (1500-1600)
Elizabethan and Jacobean Drama (1500-1642)

### Group II

Seventeenth Century to Restoration (1600-1660)
Restoration and Augustan (1660-1740)
Age of Johnson (1740-1800)

### Group III

Romantic (1800-1835)
Victorian (1835-1900)
American Literature to 1900
English and American Literature 1900 to World War II

The major figures are to be chosen in consultation with the doctoral committee and with the approval of the chairman of the department.

### 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. Summer session.                    Mr. Hartung

### 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. Summer session.                    Mr. Strauch

### 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 technique of the novel. Summer session.                    Mr. James

### 321. Twentieth-Century American Literature (3)

American literature before World War II. Lectures and class discussion of major fiction and poetry. First semester.
                    Messrs. Strauch, Frakes

### 322. Twentieth-Century European Literature (3)

English and Continental literature before World War II. Lectures and class discussion of major fiction and poetry. Second semester.                    Messrs. Strauch, Frakes

### 323. Shakespeare and the Elizabethan Drama (3)

The development of the English drama, including the important plays of Shakespeare. First semester.    Mr. Hook

### 324. Shakespeare and the Elizabethan Drama (3)

Continuation of Engl. 323. Second semester.    Mr. Hook

### 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. First semester.                    Mr. Harson

### 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. Second semester.                    Mr. Bross

### 331. Milton (3)

The life and works of John Milton in connection with the history of his times and the chief sources of his inspiration. First or second semester.                    Mr. Greene

### 333. Restoration and Augustan Literature (3)

Prose and poetry from 1660 to 1745, with special emphasis upon the works of Dryden, Pope, and Swift. First or second semester.                    Mr. Dilworth

### 334. Age of Johnson

English prose and poetry from 1745 to 1798. Dr. Johnson and his circle and the Pre-Romantics, including Burns and Blake. First or second semester.                    Mr. Dilworth

### 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. First or second semester.
                    Mr. Vickrey

### 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. First or second semester.
                    Mr. Criswell

### 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. First semester.
                    Mr. Greene

### 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. Second semester.                    Mr. Armstrong

### 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. First or second semester.
                    Messrs. Beidler, Hartung

**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. First or second semester.

**341. Contemporary American Literature (3)**

American literature since World War II. Lectures and class discussion of new writers and of recent works by established writers. First semester.

Messrs. Frakes, De Bellis, James

**342. Contemporary European Literature (3)**

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

Messrs. Frakes, De Bellis, James

**343. American Romanticism (3)**

A study of the chief American Romantics, Emerson, Thoreau, Whitman, Hawthorne, Melville, and Emily Dickinson. The European and American philosophical, historical, and social background as well as the formal aesthetic study of romantic masterpieces. First or second semester.

Mr. Strauch

**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. First or second semester. Mr. Frakes

**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. First or second semester. Mr. Hartung

### For Graduates

**400. Old English (3)**

A study of the Old English language and literature. First or second semester. Mr. Vickrey

**401. Beowulf (3)**

A study of the Beowulf poem and some of the pertinent scholarship. Second semester. Mr. Vickrey

**404. Literature of the Fourteenth Century (3)**

Types of medieval literature, with special attention to Langland, Gower, and Chaucer.

**405. Chaucer (3)**

A study of the life and works of Chaucer. Readings, reports and class discussions. First semester. Mr. Hartung

**406. Chaucer (3)**

Continuation of Engl. 405. Second semester.

Mr. Hartung

**407. Middle English Metrical Romances (3)**

A study of the Middle English non-Arthurian verse romances. Mr. Hartung

**408. Arthurian Literature of the Middle Ages (3)**

A study of the development of Arthurian literature from its Celtic beginnings to Malory's *Morte Darthur*.

Mr. Hartung

**412. Shakespeare's History Plays (3)**

A study of the English history plays as an introduction to advanced work in Shakespeare. First or second semester.

Mr. Hook

**413. Shakespeare's Roman Plays (3)**

An intensive critical study of *Julius Caesar*, *Antony and Cleopatra*, and *Coriolanus*. Mr. Hook

**414. Sixteenth-Century Drama (3)**

A study of plays representing the development of English drama before Shakespeare. Mr. Hook

**415. Seventeenth-Century Drama (3)**

A study of representative plays from the major Jacobean and Caroline dramatists. Mr. Hook

**418. Donne (3)**

A study of the complete body of Donne's verse, with especial concern for its meanings. Mr. Armstrong

**444. Pope (3)**

A study of the works of Pope and their literary background. First or second semester. Mr. Dilworth

**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. Mr. James

**448. Studies in the Eighteenth Century (3)**

Studies in, and reports on, one or more authors or issues in eighteenth-century English literature. Mr. Dilworth

**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. Mr. Strauch

**461. Conrad (3)**

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

Mr. Greene

**465. Joyce (3)**

A sequential study of the works of James Joyce, their place in Irish and world literature, and their influence on twentieth-century prose. Mr. Frakes

**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. First or second semester. Mr. Strauch

**473. Melville and Whitman (3)**

The major works of Melville and Whitman contrasted and compared in terms of Romantic doctrine. First or second semester. Mr. Strauch

**477. Twain and James (3)**

Selected works of Twain and James representing the development of American fiction after the Civil War. Mr. Strauch

**480. Hemingway and Faulkner (3)**

A thematic and stylistic examination of the major works of Hemingway and Faulkner. Mr. Frakes

**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. First semester.

**487. Literary Criticism (3)**

Continuation of Engl. 486. Second semester.

**492. Bibliography and Methods of Research (3)**

A study of the bibliographical tools essential to an advanced student of English literature. Survey of historical, or critical bibliography, of both printed books and manuscripts; of practical bibliography, including direction in the compilation of a list of books and articles on an assigned subject and in the procedures of thesis writing; and of enumerative bibliographies of English language and literature. First or second semester.

**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. First semester. Mr. Hartung

**494. The Teaching of College English (1)**

Continuation of Engl. 493. Second semester. Mr. Hartung

**495. Graduate Seminar (3)**

An intensive study of the works of one or more English or American authors or of a type of literature. Summer session.

**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). First semester.

**497. Graduate Seminar (3)**

Same as Engl. 496. Second semester.

**498. Graduate Thesis (3)**

First semester. Mr. Hartung and others

**499. Graduate Thesis (3)**

Second semester. Mr. Hartung and others

## 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 disturbances of voice and speech, as well as those with more serious handicaps. Open to all students in need of corrective treatment and to those desiring speech tests. By appointment. No credit.

**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 art. Students enrolling for their first semester register for Speech 11; for their second semester, Speech 12, etc. First and second semesters.

**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. First and second semesters.

**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. First and second semesters.

**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. First and second semesters.

**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. First and second semesters.

**33.   Parliamentary Procedure (1)**

Study and drill in modern rules and methods of conducting organized group-deliberation. First and second semesters.

**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. First and second semesters.

**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.                                             Mr. Davis

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# 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. First and second semesters.

**11.   News Writing (3)**

Definition, determinants, and components of news; news story structure and style; sources; interviewing; practice in gathering and writing news. First semester.

**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. Second semester.

**17.   Magazine Article Writing (3)**

Writing and marketing non-fiction magazine articles. First or second semester.

**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. First semester.

**22.   Creative Writing (3)**

Continuation of Journ. 21. Prerequisite: Engl. 2. Second semester.

**111.   Problems in Advanced Reportage (3)**

Intensive practice in the reporting of complex events. First semester.

**112.   Problems in Advanced Reportage (3)**

Continuation of Journ. 111. Second semester.

**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. First semester.

**115.   Interpretive Writing (3)**

Editorial interpretation of current events; practice in interpretive writing, including editorials. Prerequisite: Journ. 12. Second semester.

**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. Second semester.

**120.   Journalism Proseminar (3)**

Survey of the press in its relation to public affairs. Extensive research and reports. Prerequisite: Consent of chairman of department. First semester.

**121.   Law of the Press (3)**

Constitutional development of freedom of the press; rights and responsibilities of the press. First semester.

**122.   Law of the Press II (3)**

Law of and defenses in libel; privacy; contempt; copyright; obscenity. Second semester.

# FINE ARTS

**Professor**

FRANCIS JOSEPH QUIRK, DIPL., *Chairman*

**Associate Professor**

CARLOS J. ALVARE, M.C.P.
RICHARD JAMES REDD, M.F.A.

**Assistant Professor**

LEON N. HICKS, JR., M.A., M.F.A. (SEPTEMBER, 1970)

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**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. Lectures. First semester.

**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. Lectures. Second semester.

**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. Lectures. Second semester. Alternate years.

**15. 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 individual effort. Lectures. First semester, alternate years.

**17. 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. Lectures. First semester. Alternate years.

**33. Painting Practices and Principles (3)**

Focus is on the broader aspects of creative expression and the effective production of paintings accenting an area of optional specialization. Assignments in complimentary areas, research and experimentation in combined media. Prerequisites: F. A. 35 or 36, or consent of chairman of department. Studio. First semester.

**34. Painting Practices and Principles (3)**

Similar to F.A. 33. Further penetration of manners and means of expression in chosen area and style. Easel and mural painting. Assigned projects. Prerequisites: F. A. 35

or 36 or consent of chairman of department. Studio. Second semester.

**35. Drawing and Graphics (3)**

An introductory course emphasizing instruction in drawing in various media, leading to woodcut and intaglio printmaking. Studio. First semester.

**36. 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. Second semester.

**37. Printmaking (3)**

Guided independent practice in graphic techniques on an intermediate level. Relief and intaglio printmaking. Prerequisite: F.A. 35. Studio. First semester.

**38. Printmaking (3)**

Continuation of F.A. 37. Prerequisite: F.A. 35. Studio. Second semester.

**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. First and second semesters.

**44. 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. First and second semesters.

**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: Consent of chairman of department.

**131. Advanced Studio Practice (3)**

Primarily for students with thorough art foundation. Painting, drawing, graphics. Industrial projects. Woodblock, etching, oil painting, silver-point, tempera. Prerequisite: Consent of chairman of department. First semester.

**132. Advanced Studio Practice (3)**

Continuation of F.A. 131. Familiarization with variety of media and techniques. Prerequisite: Consent of chairman of department. Second semester.

**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.

# GEOLOGICAL SCIENCES

Prerequisite: consent of chairman of department. First and second semesters.

### 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. Second semester.

Mr. Quirk

### 219. 19th Century Painting (3)
From Neoclassicism through the development of Naturalism. Emphasis on Impressionism from Manet to Cezanne. Written reports. Discussions. The analytical and appreciative approaches. First semester. Alternate years.

Mr. Redd

### 220. Form and Milieu in 20th Century Art (3)
Sequential movements in contemporary painting and sculpture. Their interrelations as cultural expression. Museum reports and critical interpretation. Second semester.

Mr. Redd

### 251. 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 instructor and chairman of department. Conferences and critiques. May be repeated for credit. Prerequisite: Consent of chairman of department. First semester.

Mr. Alvare

### 252. Architectural Design (1-3)
As in F.A. 251. Second semester.

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

### 273. Special Topics in Studio Practice (1-4)
Individually directed projects for advanced students capable of undertaking independent creative work in applied art. Prerequisite: F.A. 131 or F.A. 132, or consent of chairman of the department.     Staff

**Professors**

J. DONALD RYAN, PH.D., *Chairman*
ROBERT TAYLOR GALLAGHER, D.E.M.
ADRIAN F. RICHARDS, PH.D.
CHARLES BERTRAM SCLAR, PH.D.
DALE RODEKOHR SIMPSON, PH.D.

**Associate Professors**

PAUL BENTON MYERS, JR., PH.D.
JAMES MARSHALL PARKS, PH.D.

**Assistant Professors**

EDLEN EVERETT MACNAMARA, PH.D.
DONALD FRAZIER MCLEROY, PH.D.

**Adjunct Professor**

GUNNAR KULLERUD, PH.D., D.SC.

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### 1. Principles of Geology (3)
Fundamental concepts of geology; the composition, structure, and development of the earth; processes of geologic change. Lectures, laboratory work, and field trip. First and second semesters.

### 10. Computer Applications (1)
The use of computers in the solution of geological problems. Introduction to FORTRAN; the use of published and available programs. Second semester.     Mr. Parks

### 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. Second semester.     Mr. Ryan

### 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. Second semester.

Mr. Myers

### 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. First semester.

### 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. First semester.

Mr. Myers

### 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.     Staff

**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. Summer session.

**203. Geology Workshop (3)**

Field and laboratory exercises in geology. Must be taken concurrently with Geol. 201. Summer session.

**211. Environmental Planning (3)**

The systems approach to resource development as it relates to analysis of the needs 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. First semester. Mr. MacNamara

**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. Second semester.
Mr. MacNamara

**281. Geological Research (1-3)**

Independent investigation of a special problem in the field, laboratory, or library. Prerequisite: Consent of chairman of department. First semester. Staff

**282. Geological Research (1-3)**

Similar to Geol. 281. May be elected as a continuation or separately. Prerequisite: Consent of chairman of department. Second semester. Staff

**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. First semester. Mr. Gallagher

**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. Second semester, alternate years.
Mr. Gallagher

**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. First semester. Mr. Parks

**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. Second semester.
Mr. Parks

**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. First semester. Mr. Ryan

**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. First or second semester, Summer session. Mr. Parks

**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. First semester. Mr. Sclar

**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. First semester. Messrs. Myers, McLeroy

**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. Second semester. Mr. Simpson

**337. (Met. 333) X-ray Methods (3)**

For description, see Met. 333.

**338. (Met. 334) Electron Metallography (3)**

For description, see Met. 334.

**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: Geology 333 or consent of chairman of department. Second semester. (Offered in alternate years). Mr. Sclar

**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. Second semester. Alternate years.

Mr. Gallagher

**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. First or second semester.

Mr. McLeroy

**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.)

Mr. Richards

**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 physicochemical 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. Second semester.

Mr. Sclar

**390. Problems of Geology (3)**

History and present status of controversial basic geologic problems. Prerequisite: Geol. 312 or consent of chairman of department.

Staff

**391. Field Seminar (1)**

Study of geological problems using field methods of analysis. Field trips, reading, reports, and discussion. Prerequisites: Geol. 23, 315. First or second semester.

Messrs. Myers, Ryan

### For Graduates

The graduate program in Geology is mainly directed toward the study of geologic processes. Candidates for the master's degree receive instruction in most fields of geology and are expected to take courses in appropriate collateral fields of science. Advanced graduate students, working toward the doctorate, specialize in one field of geology.

Research is an important part of the graduate program. In general, students are encouraged to choose research problems which for their solution require the use of integrated laboratory and field studies.

In the fall of 1969, 15 M.S. candidates and 10 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 section of this catalog headed "Degrees," page 84.

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. First semester, alternate years.

Mr. Gallagher

**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. Second semester, alternate years.

Mr. Gallagher

**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. First semester, alternate years.

Mr. Gallagher

**411. Advanced Paleontology (4)**

Classification, evolution, biometrics, and paleoecology; study of fossil and modern populations and assemblages. Lectures and laboratories. Prerequisite: Geol. 311. First or second semester.

Mr. Parks

**417. Sedimentary Petrography (3)**

The theory and application of petrographic methods in the study and classification of sedimentary rocks. Prerequisites: Geol. 312, 334. First semester. Offered alternate years.

Mr. Ryan

**418. Sedimentary Petrogenesis (3)**

The origin and development of sedimentary rock types; mineral provenance, environment of deposition, diagenesis, sediments in time, stratigraphic synthesis. Prerequisite: Geol. 417. Second semester. Offered alternate years.

Mr. Ryan

**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. First semester. Offered alternate years.                                      Mr. Myers

**422. Tectonics (3)**

Continuation of Geol. 421. Second semester. Offered alternate years.                                      Mr. Myers

**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. Second semester. Offered alternate years.          Mr. Myers

**433. Sulfide Phase Equilibria (3)**

The thermodynamics of sulfide type ores based on experiments in laboratory systems. First semester.
                                      Mr. Kullerud

**435. Advanced Mineralogy (3)**

Topics of contemporary interest in mineralogy. Prerequisite: Chem. 302 or equivalent. First semester. Offered as required.                                      Mr. Simpson

**436. Advanced Mineralogy (3)**

Similar to Geol. 435. Prerequisite: Chem. 302 or equivalent. May be elected separately. Second semester. Offered as required.                                      Mr. Simpson

**437. Advanced Igneous Petrology (3)**

Origin of the diversity of igneous rocks as revealed by field and laboratory studies. Lectures, laboratory, and field trips. First semester. Offered in alternate years.
                                      Mr. Sclar

**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. Second semester. Offered in alternate years.
                                      Mr. Sclar

**439. Ore Microscopy (3)**

Microscopic study of selected ore mineral suites with special attention toward applications of phase equilibria. Prerequisite: Geol. 433. First semester.      Mr. Kullerud

**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.                                      Mr. McLeroy

**442. Genesis of Metallic Ores (3)**

Research on the genesis of metallic ore suites by use of optical, spectrographic, chemical, etc. methods. One lecure, two laboratories. As required. Consent of the chairman of department.                                      Mr. McLeroy

**451. Examination of Mineral Deposits (3)**

Systematic exploration and examination; theory of sampl-

ing; statistical analysis. Second semester, alternate years.
                                      Mr. Gallagher

**461. Marine Geology (3)**

Geology of the margins and the floors of the oceans. Offered in alternate years.                      Mr. Richards

**462. Paleoecology (3)**

Reconstruction of paleoenvironments based on principles of paleoecology and sedimentary petrology. Prerequisites: Geol. 311, 313. Second semester. Offered alternate years.
                                      Mr. Parks

**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°C. Effect of water as a free phase at high-pressure, and the pressure dependence of ionization phenomena in aqueous systems. Lectures and laboratories. First semester. Offered in alternate years.
                                      Mr. Sclar

**472. Solution Geochemistry (3)**

The processes of solution, transport, and deposition under hydrothermal conditions. Prerequisite: Consent of chairman of department.                                      Mr. Simpson

**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. First semester.                                      Staff

**482. Geological Investigation (1-6)**

Similar to Geol. 481. Credit above three hours granted only when a different problem is undertaken. Second semester.
                                      Staff

**483. Thesis (3)**

May be elected only by master's degree candidates. First semester.                                      Staff

**484. Thesis (3)**

Continuation of Geol. 483. Second semester.      Staff

**490. Special Topics (3)**

An extensive study of selected topics not covered in more general courses. First semester. Offered as required.
                                      Staff

**491. Special Topics (3)**

Similar to Geol. 490. May be elected separately. Second semester. Offered as required.                      Staff

# GERMAN & RUSSIAN

**Professor**

JOHN HARMS UBBEN, PH.D., *Chairman*

**Associate Professors**

ARTHUR PARCEL GARDNER, PH.D.
ANNA PIRSCENOK HERZ, PH.D.

**Assistant Professors**

DOUGLAS A. WALDENRATH, PH.D.
RICHARD A. K. WATT, PH.D.

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## 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. First semester.

**2. Elementary German (3)**
Continuation of Ger. 1. Prerequisite: Ger. 1. Second semester.

**11. Intermediate German (3)**
German prose and poetry; outside reading; composition. Prerequisite: One year of college German or two units of entrance German. First semester.

**12. Intermediate German (3)**
Continuation of German 11. Prerequisite: Ger. 11. Second semester.

**27. Scientific German (3)**
Reading of material with stress on chemistry and physics. Prerequisites: Ger. 2, or three units of entrance German; sophomore standing or consent of the chairman of the department. First semester.

**31. Conversation and Composition (3)**
Remedial exercises in grammar; phonetics; conversation and composition stressing situations taken from daily life. Prerequisites: Ger. 12, or three units of entrance German. First semester.

**32. Conversation and Composition (3)**
Continuation of Ger. 31. Oral and written reports, personal and business letters, fundamentals of good style. Prerequisite: Ger. 31. Second semester.

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

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

**52. Goethe's Faust (3)**
Reading of the Faust drama and collateral material. Prerequisite: Ger. 31 or 43, or consent of chairman of department. Second semester.

**101. The European Drama (4)**
Readings and live theater performances in Germany. Prerequisite: 3 semesters of college German or the equivalent.

**102. Conversation and Composition in Germany (5)**
Intensive practice with group discussion on selected cultural, historical and political topics. Prerequisite: German 101 or its equivalent.

**111. Humanities in Germany (2-4)**
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 (2-4)**
Continuation of German 111. Prerequisite: German 102 or its equivalent.

**113. Humanities in Germany (2-4)**
Continuation of German 112. Prerequisite: German 102 or its equivalent.

**121. Social Sciences in Germany (2-4)**
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 (2-4)**
Continuation of German 121. Prerequisite: German 102 or its equivalent.

**123. Social Sciences in Germany (2-4)**
Continuation of German 122. Prerequisite: German 102 or its equivalent.

**131. Sciences in Germany (2-4)**
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 (2-4)**
Continuation of German 131. Prerequisite: German 102 or its equivalent.

**133. Sciences in Germany (2-4)**
Continuation of German 132. Prerequisite: German 102 or its equivalent.

### For Advanced Undergraduates and Graduates

*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.            Mr. Ubben

**203. Nineteenth Century German Drama (3)**
Survey of developments and reading of outstanding dra-

matic works in German literature from the end of the Classical Period through the Age of Naturalism.

Mr. Ubben

### 205. Twentieth Century German Literature (3)

Study of developments since the downfall of Naturalism; reading of works illustrative of trends and authors.

Mr. Gardner

### 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.

### 311. Introduction to Lyrical 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, or 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: Ger. 31, 32, 43 or 44, or consent of chairman of department. First semester.

### 341. Advanced Conversation and Composition (3)

For undergraduates and teachers. Prerequisites: Ger. 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: Ger. 31 or 43 or 44, or consent of chairman of department. Second semester.

### 381. Cultural Studies (3-6)

A program in Germany, during the summer, for in-service teachers of German and graduate students.

### 411. Modern German Poetry (3)

Beginning with George, Rilke, and Hofmannsthal. Discussion and analysis. 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

### 1. Elementary Russian (3)

Classroom and laboratory introduction to the fundamentals of conversational and grammatical patterns; practice in pronunciation, simple conversation, reading and writing. First semester.

### 2. Elementary Russian (3)

Continuation of Russ. 1. Prerequisite: Russ. 1. Second semester.

### 11. Intermediate Russian (3)

Classroom and laboratory practice in conversation. Development of reading and writing skills. Prerequisites: One year of college Russian, or two units of entrance Russian. First semester.

### 12. Intermediate Russian (3)

Continuation of Russ. 11. Prerequisite: Russ. 11. Second semester.

### 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: Russ. 12, or 3 units of entrance Russian, or consent of chairman of department. First semester.

### 42. Conversation and Composition (3)

Continuation of Russ. 41. Prerequisite: Russ. 31, or consent of chairman of department. Second semester.

### 251. Special Topics (3)

Intensive study of literary or linguistic topics. Prerequisite: Russ. 32, or consent of chairman of department.

### 252. Special Topics (3)

Continuation of Russ. 251. Prerequisite: Russ. 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

**Professor**

CHARLES ALLAN MCCOY, PH.D., *Chairman*

**Associate Professors**

DONALD DELYLE BARRY, PH.D.
FRANK THOMAS COLON, PH.D.
LEONARD I. RUCHELMAN, PH.D.

**Assistant Professor**

STEPHEN D. BRYEN, PH.D.
JOHN LOREN WASHBURN, PH.D.

**Instructor**

HOWARD R. WHITCOMB, M.A.

**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.

**103. Modern Political Philosophy (3)**

Analysis of schools of political thought, including Contract Theorists, Utilitarians, Idealists, and Marxists.

Mr. McCoy

### For Advanced Undergraduates and Graduates

**302. Comparative State Politics (3)**

Analysis of major questions relating to the role of the states in the American federal system and their relationship with the national government. Mr. Colon

**304. Political Parties (3)**

The organization, functions and techniques of political parties and pressure groups; nomination and election methods, voting behavior and public opinion; government and politics.

**308. Classical Political Heritage (3)**

The contribution of significant political theorists from Plato to Machiavelli. Mr. McCoy

**310. 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. Mr. Washburn

**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. Summer session.

**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. Summer session.

**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. Summer session.

**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. Summer session.

**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. Mr. Barry

**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. Prerequisite: Senior standing or consent of chairman of department. Mr. Bryen

**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. Mr. Bryen

**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.

Mr. Whitcomb

**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.

Mr. Whitcomb

**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 consitutional principles.                                    Mr. Barry

### 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.     Mr. Colon

### 358.  Community and Regional Politics (3)

Analysis of the changing political dimension of community in the context of regionalism. Attention directed to "the metropolitan problem."            Mr. Ruchelman

### 359.  The Legislative Process (3)

Organization and procedure of legislative and constituent assemblies. Legislative leadership. Role of administrative and judicial agencies in law-making. Pressure groups, parties, and policy determination. Direct legislation.
                                                Mr. Whitcomb

### 360.  Public Administration (3)

The nature of administration; problems of organization and management; public personnel policies; budgeting and budgetary systems; forms of administrative responsibility.                                     Mr. Colon

### 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.                                   Mr. Colon

### 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.
                                                   Mr. Barry

### 363.  Contemporary Political Thought (3)

Analysis of selected concepts of contemporary political science; the alleged decline of political theory; positivistic and utopian political thought; the political person, political elites, and modes of political and governmental control.
                                                Mr. Washburn

### 364.  Contemporary Political Thought (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.     Mr. Bryen

### 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 the department.

### 381, 382.  Special Topics (3)

A seminar on a topic of special interest in a particular political institution, process, or policy. Prerequisite: Consent of charman of department.                 Staff

### For Graduates

Graduate students desiring to major in political science should have had at least twelve semester hours of undergraduate work bearing on this field or should in other ways satisfy the department that they are qualified to pursue the required program of study.

Candidates for the master's degree in political science may qualify by completing thirty hours of approved course work and passing an examination covering the entire field or by completing twenty-four hours in approved courses and submitting a satisfactory thesis. The choice between these plans shall be made by each candidate upon the advice and with the approval of the chairman of the department.

All graduate students seeking the master's degree in political science shall enroll for a minimum of eighteen hours of courses in the political science field. International relations courses fall in the political science category. Appropriate courses in other fields, among the economics, history, philosophy, social relations, and public finance may be selected to meet the total of hours required for the master's degree.

The department offers a Master of Arts degree for students interested in a variety of vocations. M.A. candidates are interested principally in pursuance of additional advanced work for the Ph.D. in preparation for college or university teaching; career in state, local or national government; teaching in community colleges and junior colleges; teaching in public schools; governmental and private research programs; or journalism.

The department has a limited number of students who come together in small seminars where personal attention is the keynote.

### 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.     Mr. Washburn

### 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.          Mr. Washburn

### 413.  Modern Political Philosophy (3)

A study of selected modern political philosophers and their continuing effect on politics and political philosophy.
                                                   Mr. McCoy

**414. Democratic Theory (3)**

A critical evaluation of democratic theory in light of the contemporary challenges to the democratic process.

Mr. McCoy

**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. Mr. Bryen

**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.

Mr. Bryen

**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 adminstrative systems.

Mr. Colon

**431. Public Administration (3)**

The study of bureaucracy and the problems of public organization and management; executive leadership; personnel, budgeting and regulatory administration.

Mr. Colon

**432. Public Policy Process (3)**

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. Mr. Whitcomb

**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. Mr. Whitcomb

**451. Comparative Politics (3)**

The political systems of nations, with emphasis on Western and Western-type democracies. Approaches to the study of comparative politics. Mr. Barry

**452. Comparative Communist Political Systems (3)**

The political systems of communist nations, with emphasis on the Soviet Union and Eastern Europe. Examination of methods and approaches used in the comparative study of communism. Mr. Barry

**461. Community Power Structure (3)**

A focus on power relations and decision-making on the community level. Special attention given to theories of community power. Mr. Ruchelman

**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.

Mr. Ruchelman

**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. Staff

**482. Special Topics (3)**

Continuation of Govt. 481. Staff

# HISTORY

## Professors

LAWRENCE H. LEDER, PH.D., *Chairman*
RAYMOND GIBSON COWHERD, PH.D.
JOSEPH ALBERT DOWLING, PH.D.,
JOHN MCVICKAR HAIGHT, JR., PH.D.

## Associate Professors

GEORGE MARK ELLIS, PH.D.
JOSEPH LOGSDON, PH.D.
WILLIAM GERALD SHADE, PH.D.
CHARLES LEON TIPTON, PH.D.

## Adjunct Associate Professor

WINFRED A. KOHLS, PH.D.

## Assistant Professors

PIERRE JULIARD, PH.D.
JAMES S. SAEGER, PH.D.

## Instructor

DAVID C. AMIDON, JR., M.A.

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### 1. Course of Civilizations (3)

An examination of civilizations in the East, West, and Africa from earliest times to 1700. First semester.

### 2. Course of Civilizations (3)

An examination from 1700 to the present of civilizations in the East, West, and Africa. Second semester.

### 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. First semester.

### 14. American Civilization (3)

American civilization since 1865. Industrialism; Urbanization; Social Darwinism; Pragmatism; the Frontier; Progressivism and the New Deal; the two World Wars. Second semester.

### 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. First semester.

### 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 philsophies will be studied. Second semester.

### 21. (Greek 21) Ancient History (3)

For course description, see Classics.

### 22. (Latin 22) Ancient History (3)

For course description, see Classics.

### 49. History of Latin America (3)

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. First semester.

### 50. History of Latin America (3)

Continuation of History 49. The development of the Latin American nations in the nineteenth and twentieth centuries. Second semester.

### 51. Freshman Seminar (3)

An intensive analysis of a particular period, problem, or area of history, emphasizing readings, discussions, and reports. The topic 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.

### 199. Senior Seminar (3)

Required of all history majors and offered through full academic year. Readings and discussions in small groups, emphasizing the nature, purpose, and meaning of history in the western tradition. Open to non-history majors only by consent of chairman of department.

## For Advanced Undergraduates and Graduates

### 319. Seventeenth Century America (3)

A study of the founding and growth of English, French, and Dutch colonies in North America. Attention will be paid to motives behind European expansion as well as to developments in the colonies.          Mr. Leder

### 320. Eighteenth Century America (3)

Continuation of Hist. 319. A study of American political, economic, and cultural developments including the War for American Independence and the founding of a new nation.          Mr. Leder

### 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. Mr. Amidon

### 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. Mr. Dowling

### 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. Mr. Dowling

### 329. American Foreign Policy (3)
The French alliance; independence and boundaries; commercial restrictions; French Revolution and neutrality; purchase of Louisiana; War of 1812: acquisition of Florida; Monroe Doctrine; relations with France and Great Britain; Oregon and Texas; the Mexican War; Civil War diplomacy. Staff

### 330. American Foreign Policy (3)
Maximilian in Mexico; Seward and expansion; Alaska boundary; War with Spain; the new Caribbean policies; the World War of 1914-1918 and its aftermath; diplomatic events preceding Pearl Harbor; outbreak and prosecution of the war; plans for peace; the "Cold War"; diplomacy since 1945. Staff

### 331. The Negro in America (3)
Negro subculture in America from the colonial period to the present, emphasizing the struggles for emancipation and equal rights. Topics include: racialism, slavery, Reconstruction, urbanization, protest movements, and the "Second Reconstruction." Prerequisite: Consent of chairman of department. Mr. Logsdon

### 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. Mr. Logsdon

### 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. Mr. Amidon

### 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. Mr. Shade

### 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.
Messrs. Logsdon, Shade

### 337. United States, 1877-1920 (3)
Political, economic, and social responses to industrial America. The rise of the Populist and Progressive movements, coming of World War I, and post-war developments. Mr. Amidon

### 338. United States, 1920 to the 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 chairman of department. Mr. Dowling

### 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. First semester. Mr. Ellis

### 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. Second semester. Mr. Ellis

### 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. Mr. Cowherd

### 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.
Mr. Cowherd

### 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. Mr. Tipton

### 350. The High Middle Ages (3)
A continuation of Hist. 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. Mr. Tipton

### 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. Mr. Juliard

### 356. European Intellectual History (3)

A continuation of Hist. 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. Mr. Juliard

### 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. Mr. Juliard

### 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. Mr. Juliard

### 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. Mr. Haight

### 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. Mr. Haight

### 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. Mr. Saeger

### 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; and rightist revolutions, socialism, and communism in the twentieth century. Prerequisite: History 49, 50, or consent of chairman of department. Mr. Saeger

### 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. Mr. Saeger

### 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. Mr. Saeger

### 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. First semester.

### 372. Special Topics in History (3)

Continuation of Hist. 371. Prerequisite: Consent of chairman of department. Second semester.

### 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 1. 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* | *Other Fields* |
|---|---|
| Great Britain | Medieval-Renaissance |
| Colonial America | Modern Europe to 1789 |
| United States since 1789 | Modern Europe since 1789 |
| | 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. First semester. Mr. Tipton

### 402. Historiography (3)

A continuation of Hist. 401. A study of the aims, methods, and accomplishments of some of the most renowned historians of Europe and America. Second semester.
Staff

### 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. Staff

### 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. Staff

### 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.
JOHN MILLAR CARROLL, PH.D.
GARY E. WHITEHOUSE, PH.D.

**Assistant Professor**

MIKELL PORTER GROOVER, PH.D.

**Lecturer**

DONALD MCILVAIN, M.S.

**Instructors**

JOHN DAVID LANDIS, M.S.
URBAN MEYER, M.S.
M. WAYNE SHIVELEY, M.S.
EMORY W. ZIMMERS, JR., M.S.

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**11. Applied Probability Laboratory (1)**
Experimental sampling to approximate the different common models of probability distributions, including distributions of both data and related estimators. Prerequisite: Math. 231 concurrently. Second semester.

**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. First semester.

**18. Information Processing Theory (3)**
Principles of organizing, sorting, and searching data; representation of data in various file media; analysis of work flow in computer systems; logic structure tables. Prerequisite: I.E. 17. Second semester.

**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.

**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. Prerequisites: Math. 231. First semester.

**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. Prerequisites: I.E. 121 and 221. Second semester.

**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.

**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. 3. First and second semesters.

### For Advanced Undergraduates and Graduates

**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. First semester.
Staff

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

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

**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.
Mr. Smith

**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; sorting 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. 222 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.                              Staff

### 322. Experimental Industrial Engineering (3)

Continuation of I.E. 321.                              Staff

### 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. 121 and 222.        Mr. Gould

### 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. 122 or I.E. 166.                              Mr. Smith

### 335. Sampling and Quality Control (3)

Stratified, proportional cluster, optimal sampling; multistage, multiphase, interpenetration; and concomitant variables. Stochastic methods and Bayesian procedures Prerequisite: I.E. 221 or consent of 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. 221 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. 122 or I.E. 121.                              Mr. Gould

### 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. 121, 241.

Mr. Kane

### 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. 241, Math. 231.                              Mr. Kane

### For Graduates

A program leading to the Ph.D. degree is offered by the Department of Industrial Engineering in the following fields: Manufacturing Engineering, Information Systems, and Operations Research.

Manufacturing Engineering offers opportunity for work in work systems and manufacturing processes. The course work given in work systems covers design and evaluation as well as administration of direct and indirect labor. Examination is also made of both incentive and measured-day work systems of labor controls. The course work offerings in Manufacturing Processes are directed toward both production and research. The course work given with production emphasis is coupled with industrial project work to give the student first hand experience in professional development. The Manufacturing Processes Laboratory is coupled with course offerings in which the emphasis is on research in manufacturing processes. This laboratory is available for experimental work by the student whose interest is research in manufacturing processes.

Graduate study in the field of information systems is directed toward management information for decision making, operational systems for man-machine activity control, data base development for storage and retrieval, computer application packages, and methods for evaluation of systems. Students are expected to develop substantial skill in utilizing digital computers and in applying operations research techniques in order to improve performance.

The primary interest of the Operations Research group of the Industrial Engineering Department is in the application of operations research and applied statistics to the fields of Manufacturing Engineering and Information Systems, rather than the development of new Operations Research techniques.

A student who wishes to complete his work for the M.S. in Industrial Engineering in one year of full-time study must have completed a course of study equivalent to that required for the B.S. in Industrial Engineering at Lehigh University.

The minimum program consists of twenty-four hours of approved course work and completion of a satisfactory thesis. Students with less than the required undergraduate program may be required to devote additional time to prerequisite and basic courses. In any event, a satisfactory thesis must be completed by all candidates.

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. 438, Labor Management Administration; Acctg. 422, Managerial Accounting; Psych. 455, Engineering Psychology. As part of a purposeful major program, collateral courses may be taken in other branches of engineering, mathematics, economics, psychology and Information Science.

The laboratories of the department are located in the James Ward Packard Laboratory and available for graduate work are a modern metal processing research laboratory, a CDC 6400 computer, and a work measurement laboratory.

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 special field of industrial engineering. Staff

**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.
Messrs. Luh, Smith

**409. Industrial Engineering Standardization (3)**
Identification of the basic variable that exist 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. Mr. Kane

**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. Mr. Richardson

**416. Dynamic Programming (3)**
The principle of optimality; one-dimensional processes, multi-dimensional processes, lagrange multiplier technique; markovian decision processes; applications. Mr. Adams

**417. (Mgt. 417) Advanced Mathematical Programming (3)**
For description, see Mgt. 417.

**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. Mr. Carroll

**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. Mr. Adams

**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. Mr. Adams

**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.
Mr. Richardson

**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. Operations Research Seminar (3)**
Extensive study of selected topics in techniques and models of Operations Research. Staff

**433. Manufacturing Engineering Seminar (3)**
Extensive study of selected topics in the research and development of Manufacturing Engineering techniques.
Staff

**437. Information Systems Seminar (3)**
Extensive investigation of selected topics in theory, analysis and design of information systems. Staff

**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.
Mr. Kane

**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.
Mr. Gould

**461. Readings (1-3)**
Intensive study of some area of industrial engineering which is not covered in general courses. Staff

**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.
Mr. Smith

# INTERNATIONAL RELATIONS

**Professor**

CAREY BONTHRON JOYNT, PH.D., *Chairman*

**Adjunct Professor**

PERCY ELWOOD CORBETT, M.A.

**Associate Professors**

HENDERSON BAMPFIELD BRADDICK, PH.D.

AURIE NICHOLS DUNLAP, PH.D.

OLES M. SMOLANSKY, PH.D.

**Instructor**

FREDERICK ROBERT GLADECK, M.A.

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**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 change. First semester.         Mr. Dunlap

**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. Second semester.    Mr. Dunlap

**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.         Mr. Braddick

**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.         Mr. Braddick

**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. First semester.         Mr. Gladeck

**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. Second semester.         Mr. Gladeck

**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. First semester.     Mr. Smolansky

**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. Second semester.         Mr. Smolansky

**133. The Diplomacy of Russia to 1917 (3)**
Development and expansion of the Russian Empire; principles of Russian foreign policy and their specific applications under the Tsarist and Provisional Governments, treated partially as backgrounds of Soviet policy; interaction between Russian domestic and foreign affairs. First semester.         Mr. Smolansky

**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. First and second semesters.         Mr. Smolansky

### 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.         Mr. Braddick

**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.
                                  Mr. Braddick

**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.
                                  Mr. Gladeck

**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.
                                  Mr. Gladeck

**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 con-

cepts in world politics, with application to historic and current issues of international politics. Consent of chairman of department. First semester. Mr. Joynt

**342. International Relations (3)**
Continuation of I.R. 341. Prerequisite: Consent of chairman of department. Second semester. Mr. Joynt

**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 organizations. Mr. Braddick

**352. International Institutions (3)**
Continuation of I.R. 351, with emphasis upon the United Nations. Second semester. Mr. Braddick

**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. Mr. Dunlap

**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. Mr. Dunlap

**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. First semester. Staff

**372. Readings in International Relations (3)**
Continuation of I.R. 371. May be repeated for credit. Prerequisite: Consent of chairman of department. Second semester. Staff

**381. Special Topics (3)**
An intensive study of some aspects of international politics not covered in another course. Prerequisite: Consent of chairman of department. Staff

**382. Special Topics (3)**
A continuation of I.R. 381. Prerequisite: Consent of chairman of department. Staff

**391. The Teaching of International Relations (3)**
Lectures, readings and discussion of fundamental concepts, principles and problems of international relations, with currrent applications. Open only to present and prospective junior and senior high school teachers. Mr. Dunlap

### 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. First semester. Mr. Joynt

**442. Seminar in International Relations (3)**
Continuation of I.R. 441. Second semester. Mr. Joynt

**451. Seminar in International Organization (3)**
Intensive analysis of selected agencies and activities of the League of Nations and affiliated institutions. First semester.

**452. Seminar in International Organization (3)**
Continuation of I.R. 451, with emphasis upon the United Nations. Second semester.

**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. First semester. Mr. Corbett

**462. Seminar in International Law (3)**
Continuation of I.R. 461. Second semester. Mr. Corbett

**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. Staff

**472. Special Topics (3)**
Continuation of I.R. 471. May be repeated for credit. Prerequisite: Consent of chairman of department. Second semester. Staff

# MANAGEMENT AND FINANCE

**Professors**

ELI SCHWARTZ, PH.D.
L. REED TRIPP, PH.D.

**Associate Professors**

JAMES B. HOBBS, D.B.A., *Chairman*
EARL B. FRENCH, PH.D.
LEON ELWOOD KROUSE, PH.D.
THOMAS CHARLES KUBELIUS, LL.B.
BENJAMIN LITT, PH.D.
MAX DONALD SNIDER, M.B.A.
EFRAIM TURBAN, PH.D.
GARY E. WHITEHOUSE, PH.D.

**Assistant Professors**

CARL R. BEIDLEMAN, PH.D.
CHARLES F. VIHON, J.D.

**Adjunct Professors**

REESE D. JONES, M.S.
H. LOUIS THOMPSON, M.B.A.

**Instructors**

JAMES A. GREENLEAF, M.S.
JAY C. LACKE, M.B.A.
EDWARD W. SCHMITT, M.B.A.

## MANAGEMENT

### 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 major, or senior standing in College of Business and Economics with consent of department chairman. Second semester.

Messrs. Hobbs, Thompson

### 302. Survey of Management Science Applications (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.                Messrs. Greenleaf, Turban

### 314. Operations Analysis (3)

Linear programming, duality, nonlinear programming, integer programming, dynamic programming, input-output analysis, cardinal utility, game theory, and decision theory. Prerequisites: Eco. 206, Eco. 352.

Messrs. Schmitt, Turban

### 321. Business and Organizational Behavior (3)

An analysis and survey of various theories of organization: management theory, concepts, and practices; human resources development. First and second semesters.

Mr. French

### 371. Readings (1-3)

Readings in various fields of management, designed for the student who has a special interest in some field of manage-

ment not covered by the regularly rostered courses. Prerequisite: Permission of instructor. First or second semester.

### 372. Readings (1-3)

Continuation of Mgt. 371. First or second semester.

### 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. Second semester.                Mr. French

### 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: a course in linear programming. First semester.

Messrs. Turban, Whitehouse

### 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. Prerequisite: Mgt. 302 and 417. Second semester.

Mr. Turban

### 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. First and second semesters.                Mr. Hobbs

### 471. Special Topics (3)

An extended study of an approved topic in the field of management. First or second semester.                Staff

### 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. First or second semester.

Staff

## MARKETING

### 111. Marketing (3)

A detailed and critical analysis of the principles of marketing, designed to acquaint the student with the institutions and functions involved in the distribution of goods and services, and with the problems of marketing management. An intensive review of marketing literature to serve as a foundation for advanced courses. Prerequisite.: Eco. 3. First and second semesters.

### 113. Advertising (3)

The principles, practices, and problems of advertising. Evaluation of techniques utilized in its management and

control, with special reference to economic and social aspects. Prerequisite: Mkt. 111. First semester. Mr. Lacke

### For Advanced Undergraduates and Graduates

**214. Sales Management (3)**

A comprehensive study of contemporary sales force management; control of sales operation; sales forecasting and market analysis; product and channel of distribution planning; budgeting and marketing cost allocation. Prerequisite: Mkt. 111 or consent of chairman of department. Second semester. Mr. Lacke

**217. Industrial Marketing (3)**

Problems in the marketing of industrial as differentiated from consumer goods; product planning and development; industrial marketing research; marketing channels; management of the sales force; industrial advertising; and government regulations. Prerequisite: Mkt. 111 or consent of chairman of department. First semester. Mr. Lacke

**312. Marketing Research (3)**

Analysis of the techniques of marketing research; determination of research objectives; procedures involved in the conduct of marketing investigations. Prerequisite: Two courses in marketing. Second semester. Mr. Schmitt

**315. Consumer Behavior (3)**

This course relates behavioral concepts, methods, and research findings to decision-making in marketing. Topics include consumer's needs and wants, behavioral and perceptual patterns with respect to household decision-making, shopping behavior, relationships between buyer and products, brands and sellers, market segmentation, communications, cultural, social, psychological and economic influences on behavior, product adoption and diffusion. Prerequisites: Marketing 211 and Economics 45. Second semester. Mr. Schmitt

**371. Reading (3)**

Selected readings in areas of marketing not covered in scheduled courses. Prerequisite: Preparation in marketing acceptable to the department chairman. First or second semester. Staff

**372. Readings (3)**

Continuation of Mkt. 371. First or second semester. Staff

### For Graduates

**450. Marketing Management (3)**

A study of the factors affecting consumer demand and methods of satisfying it; the structure of the market; marketing methods and problems of various agencies; competitive practices; the management of the selling activities of a business, distribution policies, pricing, and the planning of marketing operation. Prerequisite: Mktg. 111 or equivalent. First and second semesters.

Messrs. Litt, Snider

**471. Special Topics (3)**

Individual inquiry into selected areas of marketing. Prerequisite: Preparation in marketing acceptable to the department chairman. First or second semester. Staff

**472. Special Topics (3)**

Continuation of Mkt. 471. First or second semester. Staff

## FINANCE

**125. 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. Prerequisite: Eco. 3 and Acctg. 51 or Acctg. 108. First and second semesters. Mr. Beidleman

### For Advanced Undergraduates and Graduates

**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. First and second semesters. Messrs. Beidleman, Krouse

**324. Investments (3)**

A project course in investment analysis for advanced students who are already familiar with investment principles. Sources of data and analysis procedures: the securities of industrials, railroads, public utilities, and municipalities. Prerequisite: Fin. 323. Second semester.

Messrs. Beidelman, Krouse

**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. Second semester. Messrs. Krouse, Schwartz

**331. Bank Credit Management (3)**

Problems surrounding the extension of loans to customers and the purchase of open-market paper by the individual banker; detailed consideration of legal regulations and restrictions, instruments of bank credit extension, and analysis of the bank borrower's credit position treated in detail. Prerequisite: A course in money and banking. Second semester. Mr. Krouse

**371. 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 schedule courses. Prerequisite: Preparation in finance acceptable to the department chairman. First or second semester. Staff

**372. Readings (3)**

Continuation of Fin. 371. First or second semester. Staff

### For Graduates

**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. First and second semesters.                     Messrs. Krouse, Schwartz, Beidleman

**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. Prerequisites: A course in investments. Second semester.  Messrs. Greenleaf, Krouse

**471.   Special Topics (3)**

Selected topics not covered in scheduled courses in the Department. First or second semester. (Offered as required.)                                          Staff

**472.   Special Topics (3)**

Continuation of Fin. 471. First or second semester. (Offered as required.)                      Staff

# LAW

**1.   Business Law (3)**

The law of contracts, agency, bailments, and sales; legal thought and the judicial process. First and second semesters.                        Messrs. Vihon, Kubelius

**102.   Business Law (3)**

The law of negotiable instruments, partnership, corporations, real property, insurance, and security devices. Prerequisite: Law 1. Second semester.
                                Messrs. Vihon, Kubelius

**103.   Business Law for Engineers (3)**

The law of contracts, agency, partnerships, corporations, and property rights with special emphasis upon the legal problems of the engineering profession. First semester.
                                        Mr. Kubelius

**160.   Insurance (3)**

A non-mathematical course in the economic principles and business practice of insurance, particularly life, fire, and casualty insurance. Prerequisite: Law 1. Second semester.

### For Advanced Undergraduates and Graduates

**204.   Wills, Estates, and Trusts (3)**

A study of the basic legal and management principles and practices involved in the planning and administration of wills, estates, and trusts. Prerequisite: A course in business law. Second semester.               Mr. Kubelius

**211.   Legal Concepts (3)**

Study of legal reasoning, law as a process of resolving dis-

putes, law as an instrument of social control; selected problems in ownership; provisions for the redress of harm; maintenance of law and order.                 Mr. Vihon

### 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 1 or 103. First semester.
                                Messrs. Vihon, Kubelius

# MATHEMATICS

**Professors**

ARTHUR EVERETT PITCHER, PH.D., *Chairman
and Distinguished Professor*
BHASKAR KUMAR GHOSH, PH.D.
THEODORE HAILPERIN, PH.D.
CHUAN-CHIH HSIUNG, PH.D.
SAMIR ANTON KHABBAZ, PH.D.
ALBERT WILANSKY, PH.D.

**Associate Professors**

EDWARD F. ASSMUS, JR., PH.D.
SAMUEL LINIAL GULDEN, M.A.
JERRY PORTER KING, PH.D.
GREGORY T. MCALLISTER, PH.D.
GERHARD RAYNA, PH.D.
MURRAY SCHECHTER, PH.D.
ANDREW KAGEY SNYDER, PH.D.
GILBERT ALLAN STENGLE, PH.D.

**Assistant Professors**

FRANKLIN S. BRENNEMAN, PH.D.
GILBERT DARREL FRIEND, PH.D.
DONALD L. PRULLAGE. PH.D.
PETER JULES RICHETTA, PH.D.
JOEL C. W. ROGERS, PH.D.
HERBERT BANCROFT SKERRY, PH.D.
DOUGLAS HENLEY TAYLOR, PH.D.
DAVID TRUTT, PH.D.

**Instructors**

MARGUERITE B. GRAVEZ, M.A.
GARY BERNARD LAISON, M.A.
JACK YOGISHWAR NARAYAN, M.S.

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### 21. Analytic Geometry and Calculus I (4)
Functions and graphs; limits and continuity; derivative and differential; indefinite and definite integral; logarithm and exponential. First and second semesters.

### 22. Analytic Geometry and Calculus II (4)
Trigonometric and hyperbolic functions; integration; vector algebra and calculus; solid analytic geometry. Prerequisite: Math. 21. First and second semesters.

### 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. First and second semesters.

*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 the chairman of the department. First semester.

### 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. Second semester.

*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. First and second semesters.

### 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: Mathematics 21 or 41, previously or concurrently. Second semester.

### 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. First semester.

### 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, interpolations procedures for differential equations, systems of linear equations, numerical solution of differential equations. Prerequisite: Mathematics 41 and 43, or 21 and 43, or consent of chairman of the department. Second semester.

### 54. Advanced Geometry (3)
An introductory course in projective geometry and noneuclidean geometry. Prerequisite: Math. 22 or consent of chairman of department. First semester.

### 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. First and second semesters.                    Messrs. Johnson, Rayna

### 171. Reading Courses in Mathematics (I)
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. First and second semesters.

### 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. First and second semesters.

### 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. First and second semesters. Staff

### 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. First and second semesters. Staff

### 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. First and second semesters. Staff

### 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. Second semester.

### 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. First semester.

### 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. First and second semesters. Staff

### 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: Mathematics 205. First and second semesters.

### 244. Algebra (3)

A continuation of Mathematics 243. Prerequisite: Math. 243. First and second semesters.

### 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. First semester.

### 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. Second semester.

### 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: Mathematics 219 or consent of the chairman of the department. First or second semester.

### 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. Mr. Schechter

### 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. First semester. Mr. Hailperin

### 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. Second semester. Mr. Hailperin

### 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. First semester.

### 308. Algebraic Topology I (3)

Polyhedra, fundamental group, simplicial and singular homology. Prerequisite: Math. 307 and Math. 327. Second semester. Messrs. Khabbaz, Taylor, Pitcher

### 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 biologi-

cal science. Prerequisite: Math. 23, Math. 32, or nine semester hours of differential and integral calculus. First or second semester.                    Messrs. Ghosh, Stengle

### 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. First or second semester.

Messrs. Schechter, Stengle, McAllister

### 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. First and second semesters.                                          Staff

### 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. Second semester.      Messrs. Rogers, Stengle

### 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. First semester.
Messrs. Assmus, Brenneman

### 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. Second semester.

Messrs. McAllister, Schechter

### 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. First or second semester.      Mr. Ghosh

### 350. Special Topics (3)

A course covering special topics not sufficiently covered in the general courses. Prerequisite: Consent of the chairman of department. First or second semester. May be repeated for credit.                                          Staff

### 362. Computer Languages (3)

An examinination 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. First or second semester.      Mr. Rayna

### 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. First or second semester. May be repeated for credit.

### 373. (I.S. 373) Mathematical Methods in the Information Sciences (3)

For course descripton see I. S. 373.

### 381. Probability and Statistics (3)

Combinatorial problems, theory of probability, various frequency distributions, standard deviation, sampling, correlation. Prerequisite: Open to secondary school teachers who present at least eighteen hours of undergraduate mathematics.

### 382. Algebra (3)

Fundamentals of algebra, axiomatic method, set theory, notions of group, ring, integral domain, and field. Prerequisite: Same as Math. 381.

### 385. Higher Geometry I (3)

Logical systems, postulates, synthetic projective geometry, analytic projective geometry, affine, euclidean and non-euclidean geometry. Prerequisite: Same as Math. 381.

### 387. Intermediate Analysis (3)

The real number system, functions, limits, continuity, derivative, law of the mean, Taylor's formula, definite integral. Prerequisite: Open only to secondary school teachers of mathematics who present at least 18 semester-hours of undergraduate mathematics including a course in analysis.

### For Graduates

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 1969 there are about sixty graduate students of mathematics, of whom about twenty are 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 ordinary include Math. 307, 308, 327, 401, 415, 423, and 428. A student with unusually strong background, or specialized interests, may be permitted to make substitutions.

The M.S. degree requires either a thesis or a comprehensive examination at the discretion of the department chairman. The same examination is used as the comprehensive examination for the M.S. degree and the qualifying examination for the Ph.D. degree. Thus it is usually required for the M.S. degree for those students who plan to continue to the Ph.D. A syllabus for the examination is available.

The plan of work for the Ph.D. degree will ordinarily include courses in algebra, analysis, geometry, and topology at the 400 level and several courses including seminars in the field in which the dissertation is to be written. The department accepts candidates for the Ph.D. who wish to specialize in and to write a dissertation on some aspect of any of the following areas of advanced work: analysis with emphasis on pure mathematics or applied mathematics, algebra, functional analysis, differential geometry, mathematical logic, probability, statistics, and topology.

One may wish to refer to the description of the Center for the Application of Mathematics on page 102.

### 401.   Theory of Functions of a Real Variable (3)

A study of significant classes of real valued functions, distinguished by such properties as continuity, semi-continuity, bounded variation, absolute continuity, differentability, integrability. Prerequisite: Math. 307. First semester.
Messrs. King, Schechter, Snyder

### 402.   Measure and Integration (3)

The general theory of measure and integration, with Lebesgue measure and integration as a significant example. Prerequisite: Math. 401. Second semester.
Messrs. Laison, Pitcher

### 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. Second semester.          Mr. Hailperin

### 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. First semester.
Messrs. McAllister, Stengle

### 406.   Partial Differential Equations (3)

Continuation of Math. 405. Prerequisite: Math. 405. Second semester.    Messrs. McAllister, Stengle, Schechter

### 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.      Messrs. Gulden, Schechter

### 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.
Messrs. Schechter, Rogers

### 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. First or second semester.          Staff

### 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. First or second semester.       Staff

### 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. First semester.

### 416.   Complex Function Theory (3)

Continuation of Mathematics 415. Prerequisite: Mathematics 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. First or second semester.          Mr. Trutt

### 421.   Probability (3)

Measure theoretic approach to probability; random variables, characteristic functions; the uniqueness theorem; limit theorems; stochastic processes with discrete and continuous states; Kolmogorov equations; Markov chains, the ergodic theorem. Prerequisite: Math. 309. First or second semester.          Messrs. Ghosh, Stengle

### 423.   Differential Geometry I (3)

The differential geometry of curves and surfaces in Euclidean space, including problems in the large. First semester.
Mr. Hsiung

### 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.          Mr. Hsiung

### 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.
Mr. Hsiung

### 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. Second semester.
Messrs. Assmus, Brenneman

### 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. First semester.
Messrs. McAllister, Pitcher

**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. First semester.
Mr. Wilansky

**436. Functional Analysis II (3)**

Continuation of Math. 435. Prerequisite: Math. 435. Second semester.
Mr. Wilansky

**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. Second semester.
Mr. Gulden

**444. Algebraic Topology II (3)**

Continuation of Math. 308. Cohomology theory, products, duality. Prerequisite: Math. 308. First semester.
Messrs. Taylor, Khabbaz

**445. Algebraic Topology III (3)**

Homotopy theory, obstruction theory, spectral sequences. Prerequisite: Math. 444. Second semester.
Messrs. Taylor, Khabbaz

**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. First or second semester.

**453. Topics in 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. First semester.

**457. Topics in 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.

**471. Homological Algebra (3)**

Modules, tensor products, categories and functors, homology functors, projective and injective modules. Prerequisite: Math. 428. First or second semester.
Messrs. Assmus, Brenneman, Taylor

**472. Finite Groups (3)**

An intensive study of the structure of finite groups and their automophisms. Prerequisite: Math. 428. First or second semester.

# 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. First and second semesters.
Mr. McCluskey

**104. Stellar Astronomy and Astrophysics (3)**

Introduction to astrophysics; the sun considered as a star; physical characteristics of the stars; stellar motions; binary stars; theory of binary star orbits; stellar aggregations; cosmogony. Prerequisites: Math. 22, and Phys. 16 or Phys. 3. First or second semester.
Mr. McCluskey

**250. Topics in Astronomy (3)**

A course covering one or more topics not covered in other courses. Prerequisite: Consent of the chairman of department. First or second semester. May be repeated for credit.

# MECHANICAL ENGINEERING and MECHANICS

## Professors

FERDINAND PIERRE BEER, PH.D., *Chairman*
RUSSELL EDWARD BENNER, PH.D.
FAZIL ERDOGAN, PH.D.
GEORGE FRANKLIN IRWIN, 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.

## Associate Professors

PHILIP ANTHONY BLYTHE, PH.D.
FORBES TAYLOR BROWN, SC.D.
JAMES VANDEUSEN EPPES, M.S.
VEDANTH KADAMBI, PH.D.
ROBERT ALAN LUCAS, PH.D.
JOSEPH C. OSBORN, M.S.
RICHARD ROBERTS, PH.D.
ROBERT GUY SARUBBI, PH.D.
THEODORE ALFRED TERRY, PH.D.
ROBERT PEH-YING WEI, PH.D.

## Assistant Professors

KEMAL ARIN, PH.D.
VAHRAM BIRICIKOGLU, PH.D.
RONALD JOHN HARTRANFT, PH.D.
PETER D. HILTON, PH.D.
EDWARD KENNETH LEVY, PH.D.
JAMES PETER RIES, PH.D.
ERIC PAUL SALATHE, PH.D.
DEAN PEARSON UPDIKE, PH.D.

## Instructors

DENNIS FRANCIS TOROK, M.S.
WALTER BARRY WAGNER, M.S.M.E.

## MECHANICAL ENGINEERING

### 10. Analysis of Engineering Problems 1 (1)
Elementary analyses of problems in the field of mechanical engineering. Methods and techniques of solution. Use of digital computers. Prerequisite: Consent of chairman of department.

### 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. Prerequisite: Math. 23, Phys. 3.

### 105. Thermodynamics II (3)
Thermodynamics applications. Reversible and irreversible processes and cycles with various fluids. Gas and vapor mixtures. Compressible and incompressible fluid flow. Prerequisite: M.E. 104.

### 108. Laboratory I (2)
Lectures and laboratory exercises relating to various phases of engineering laboratory technique and procedures. Includes planning, execution, and analysis of tests and writing of reports. Prerequisite: M.E. 105.

### 109. Laboratory II (2)
Continuation of M.E. 108 with emphasis on project investigations.

### 110. Thesis (1-3)
Candidates for the degree of B.S. in M.E. may, with the approval of the director of the curriculum, undertake a thesis as a portion of the work during the senior year.

### 160. Thermodynamics (3)
Fuels; combustion; principles of engineering thermodynamics; properties of steam; steam power plant equipment and cycles; internal combustion engines. Prequisites: Math. 23; Phys. 3.

### 161. Mechanical Engineering Laboratory (1)
Testing of mechanical engineering equipment. Prerequisite: M.E. 160, or 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 and 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 measurement 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 formulation for multiple degree of freedom systems. Simple continuous and non-linear systems. Engineering applications. Prerequisite: Mech. 102.

### 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. Prerequisites: Consent of chairman of department. Staff

### 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. Mr. Terry

### 320. Thermodynamics III (3)

Kinetic theory of gases, statistical thermodynamics. Advanced and specialized topics in thermodynamics. Prerequisite: M.E. 104. Second semester. Mr. Owczarek

### 321. 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. Mr. Levy

### 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. First semester. Prerequisites: M.E. 231, M.E. 104, Math. 205 Mr. Owczarek

### 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. Messrs. Jackson, Stenning

### 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. Mr. Owczarek

### 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. Second semester. Messrs. Benner, Terry

### 342. Mechanical Vibration Analysis (3)

Analysis of physical systems and setting up equations: development of significant engineering relationships. Emphasis on engineering application. Prerequisite: Math. 221. Second semester. Mr. Terry

### 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.

### 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. Second semester. Mr. Stenning

#### For Graduates

In the thermal-fluid sciences, research is in progress on boundary layers under various conditions with application to turbomachinery. Study is also being made on the flow instabilities and heat transfer in two-phase flows. Investigation continues on basic fluid phenomena with special emphasis being given to the area of fluidics including work on wall jets, confined jets and jet interaction. In addition studies of the dynamics of fluid amplifiers, transmission

line characteristics, noise and modeling of fluidic devices are underway. A specially designed water table has been constructed to investigate fluid amplifier dynamics and experiments on plexiglass models are being conducted to determine velocity profiles and pressure distributions on curved walls. In the area of heat transfer analytical and experimental work is underway on heat pipes. A specially designed closed jet water tunnel is available for research on the boundary layer flow in adverse pressure gradient with distributed wall suction. Three-dimensional flows in axial compressors are being studied using a large single-stage test apparatus.

The department is well equipped for experimental stress investigations including instrumentation for research with resistance strain gages, photo-elasticity, photostress, and Moire fringes. Recent investigations have been made on viscoelastic materials as well as metals. Research in crack propagation and fatigue is underway which involves the interaction of students and faculty of the department of mechanical engineering and mechanics with the metallurgy and materials sciences 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 innovative design projects. The two core courses are in advanced engineering design (M.E. 445, M.E. 446). In addition the student will register for six 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.

The taking of mathematics courses which are required in the undergraduate mechanical engineering curriculum may be considered as making up a deficiency so that a larger number of credits than the minimum may be necessary. 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 doctor's degree should submit a general plan to the chairman of the department during his first year and arrange for the qualifying examination.

### 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.
Messrs. Owczarek, Stenning

### 421. Topics in Thermodynamics (3)

Emphasis on theoretical and experimental treatment of combustion processes including dissociation, flame temperature calculations, diffusion flames, stability and propagation; related problems in compressible flow involving one-dimensional, oblique shock waves and detonation waves. Methods of measurement and instrumentation.
Mr. Owczarek

### 423. Boundary Layer Analysis (3)

Navier-Stokes equations, laminar boundary layer theory, analysis of friction drag, heat transfer and separation; transition from 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.
Messrs. Kadambi, Owczarek, Stenning

### 425. Convective Heat Transfer (3)

Boundary layer theory; laminar and turbulent free and forced convection inside ducts and over external surfaces. Problems of phase change; condensation, boiling. Two-phase liquid-vapor flows. Prerequisite: M.E. 321.
Mr. Levy

### 426. Thermal Radiative Transfer (3)

Principles of radiative transfer. Radiation properties of real substances; radiative interchange between bodies with and without a radiatively participating intervening medium; radiative transfer through absorbing, emitting, and scattering media.

### 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. Second semester.
Mr. Owczarek

### 432. Topics in Gas Dynamics (3)

The equilibrium thermodynamic properties of a dissociating mixture of gases. Equilibrium flow of dissociating gases. Vibrational and chemical nonequilibrium. Criteria for thermodynamic equilibrium of gas flow. Chemical kinetics of gaseous reactions. Equations of flow of a reacting gas mixture. Nonequilibrium flows. Application to design of ram-jets and rocket nozzles and of re-entry vehicles. Prerequisites: M.E. 320, M.E. 322.　Mr. Owczarek

### 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　Messrs. Owczarek, Stenning

### 441. Applied Stress Analysis (3)

Application of methods of the theory of elasticity to mechanical design problems. Direct, approximate, and numerical methods of analysis applied to problems in plane stress, plane strain, torsion, thermal stresses, and residual stresses. First semester.　Mr. Benner

### 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. First semester.　Messrs. Erdogan, Lucas

### 443. Analytical Methods in Engineering II (3)

Continuation of M.E. 442. Second semester.
Messrs. Erdogan, Lucas

### 444. Experimental Stress Analysis in Design (3)

Applications of experimental stress analysis to mechanical design problems. Second semester.　Messrs. Roberts, Wei

### 445. Advanced Engineering Design (3)

The application to mechanical systems of the systems engineering process, environmental and needs research, the economic theory of demand and value, decision making, systems analysis and synthesis techniques. Computer-aided design including simulation, optimum seeking methods, and design-logic programming. Prerequisite: Math 231, previously or concurrently.  Mr. Benner

### 446. Advanced Engineering Design (3)

Continuation of M.E. 445. Reliability engineering for mechanical systems and components including system effectiveness, data collection and analysis procedures, redundancy, reliability allocation, prediction and testing. Maintainability analysis.  Mr. Benner

### 447. Control Systems (3)

Design of compensating elements for linear systems. Describing functions, phase plane, series approximation and other selected topics in nonlinear systems analysis. Prerequisite: M.E. 343.  Mr. Ries

### 450. Special Topics (3)

An intensive study of some field of mechanical engineering not covered in more general courses.  Staff

### 451. Seminar (1-3)

Critical discussion of recent advances in mechanical engineering.  Staff

### 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.  Messrs. Benner, Terry

## Mechanics

### 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. 1. First and second semesters.

### 11. Mechanics of Materials (3)

Strength and elasticity of materials; theory of stresses and strains; deflection of beams and shafts; torsion; buckling of struts. Prerequisites: Mech. 1; Math. 23. previously or concurrently. First and second semesters.

### 13. Materials Testing Laboratory (1)

Experiments to study the mechanical properties of engineering materials; correlation of the properties of different materials, of their behavior under different types of load application, and of mechanical properties to design criteria. Verification of certain assumptions used in Mech. 11. Prerequisite: Mech. 11, preferably concurrently. First and second semesters.

### 102. Dynamics (3)

Kinematics and kinetics of particles and rigid bodies; relative motion; dynamic equilibrium; work and energy; impulse and momentum; mechanical vibrations. Prerequisites: Mech. 1; Math. 23. First and second semesters.

#### For Advanced Undergraduates and Graduates

### 201. Advanced Mechanics of Materials (3)

Introduction to two-dimensional theory of elasticity; theories of failure; bending and torsion of prismatic bars; principles of indeterminate analysis; instability. Prerequisite: Mech. 11; Math. 205, previously or concurrently. First semester.  Messrs. Paris, Roberts

### 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; Math. 205. First semester.  Messrs. Beer, Osborn, Paris

### 303. Mechanics of Continua I (3)

Fundamental principles of the mechanics of deformable bodies. Study of stress, strain, velocity and acceleration fields. Compatibility equations, conservation laws. Applications to viscous and non-newtonian fluids, perfectly plastic and perfectly elastic materials. Prerequisites: Mech. 201 and M.E. 231. First semester  Messrs. Sih, G. F. Smith

### 304. Mechanics of Continua II (3)

Formulation of constitutive equations; invariance principles. Large elastic deformations; theory of dislocations; couple-stress theory; hereditary materials and viscoelasticity; elements of crystal physics and continuum physics. Prerequisite: Mech. 303. Second semester.  Messrs. Sih, G. F. Smith

### 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. First semester.  Messrs. Irwin, Paris

### 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.  Messrs. Blythe, Venkataraman

### 350. Special Topics (3)

A study of some field of Engineering Mechanics not covered in the general courses. Prerequisite: Consent of chairman of department. First or second semester.  Staff

#### For Graduates

The graduate courses in Mechanics are open in general to students who have been graduated from a curriculum in

engineering mechanics, engineering mathematics, engineering physics, civil engineering, or mechanical engineering at a recognized institution.

A candidate for the M.S. degree in Applied Mechanics is expected to possess a thorough knowledge of undergraduate mathematics and mechanics. Math. 205, 208 and 322, and Mech. 201 and 302, 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 electro-mechanical 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. Optimization 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. Fundamentals of linear and non-linear theories of shells. Free and transient vibrations of shells. Concepts of stability of rotationally symmetric shells. Piezo-electric effects in thin shells. Analysis of shells with imperfections. Inelastic shell analysis.

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.

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 application 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. Second semester.      Mr. Beer

### 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; application to failure prediction. Prerequisite: Consent of chairman of department. Second semester.      Mr. Beer

### 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. Second semester.      Mr. Erdogan

### 407. Wave Propagation in Solids (3)

Wave propagation in deformable elastic solids; problems in half-space and layered media; application of integral transforms. First semester.      Mr. Erdogan

### 409. Theory of Elasticity I (3)

Theoretical foundations of the mechanics of linear elasticity theory. Kinematics of deformation; analysis of stress, stress-strain relations; strain-energy. Reciprocal and uniqueness theorems; St. Venant's principle; minimum and variational principles and their applications. Methods for boundary value problems; theory of biharmonic functions; Galerkin, Papkovich, Neuber functions; integral transforms. Fundamental problems in two- and three-dimensions; singular solutions; torsion, bending and plane problems. Prerequisites: Math. 205; Mech. 201, or C.E. 309, or equivalent introductory course in theory of elasticity. First semester.      Messrs. Sih, G. F. Smith

### 410. Theory of Elasticity II (3)

Advanced topics in the theory of elasticity. The subject matter may vary from year to year and may include, e.g., theory of potential functions, linear thermoelasticity, dynamics of deformable media, integral transforms and complex-variable methods in classical elasticity. Problems of boundary layer type in elasticity; current developments on the micro-structure theory of elasticity. Prerequisites: Mech. 409, Math. 208, or consent of chairman of department. Second semester.      Messrs. Sih, G. F. Smith

### 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. 201, or C.E. 309, or equivalent course in theory of elasticity. First semester.      Mr. Updike

### 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 nonhomogenous effects. Prerequisites: Mech. 201, Math. 208 or consent of chairman of department.

Messrs. Irwin, Paris, Sih

**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 deformation of cantilever column. Dynamic buckling with nonconservative forces. Buckling of columns on elastic foundation. 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. First semester.                                          Mr. Kalnins

**416. (C.E. 464) Theory of Plates and Shells (3)**

Governing equations of classical theory of plates. Solutions for rectangular and circular plates. Reissner's theory of plates. Vibration of circular plates. Nonlinear theories of plates. Differential geometry of surfaces. Governing equations of bending of thin elastic shells. Methods of solution for cylindrical, spherical, and arbitrary shells of revolution. Shallow shells. Approximate theories of shells. Prerequisites: Math. 205; Mech. 201, or C.E. 309, or equivalent introductory course in theory of elasticity. Second semester.
                                          Mr. Kalnins

**421. Fluid Mechanics (3)**

Kinematics of fluid flow. Lagrangian and Eulerian descriptions. Basic conservation laws. Review of thermodynamics. Constitutive relations. Vorticity, circulation, irrotational flow. Bernoulli theorems. Vortex motion, velocity potential, stream function. Potential flow in two and three dimensions. Compressible flow: sound waves, simple waves; gas dynamic discontinuities. First semester.

                                Messrs. Salathe, Varley

**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. Second semester.

                                Messrs. Salathe, Varley

**424. Unsteady Fluid Flows (3)**

Gas dynamics: finite amplitude disturbances in perfect and real gases; channel flows; three-dimensional acoustics; theories of the sonic boom. Motions in Fluids with a Free Surface: basic hydrodynamics; small amplitude waves on deep water; ship waves; dispersive waves; shallow water gravity waves and atmospheric waves. Hemodynamics: pulsatile blood flow at high and low Reynolds number. Models of the interaction of flow with artery walls.
                                          Mr. Varley

**437. (Met. 437) 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. First or second semester.
                                          Staff

**451. (Phys. 471) Nonlinear Continuum Mechanics (1-3)**

An introduction will be given to the nonlinear 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 nonlinear theories to specific problems will be given.
                                          Mr. Rivlin

# METALLURGY and MATERIALS SCIENCE

## Professors

GEORGE POWELL CONARD II, SC. D., *Chairman*
JOSEPH FRANCIS LIBSCH, SC.D., *Alcoa Professor*
BETZALEL AVITZUR, PH.D.
RALPH WAYNE KRAFT, PH.D.
RICHARD MOORE SPRIGGS, PH.D.
ROBERT DANIEL STOUT, PH.D.

## Associate Professors

SIDNEY ROY BUTLER, PH.D.
YE TSANG CHOU, PH.D.
WALTER CHARLES HAHN, JR., PH.D
RICHARD WARREN HERTZBERG, PH.D.
GEORGE KRAUSS, JR., SC.D.
ALAN WIGGINS PENSE, PH.D.
STEPHEN KENNETH TARBY, PH.D.
DAVID ALDEN THOMAS, PH.D.
JOHN DUDLEY WOOD, PH.D.

## Assistant Professors

WESTON H. FEILBACH, JR., PH.D.
JOSEPH IRWIN GOLDSTEIN, PH.D.
MICHAEL RICHARD NOTIS, PH.D.
DONALD LAWRENCE RITTER, PH.D.
ROBERT BENJAMIN RUNK, PH.D.

## Instructors

RONALD NORMAN CARON, M.S.
KENNETH HALL ECKELMEYER, M.S.
RONALD CHARLES GOWER, M.S.
JAMES PAUL HICKERSON, JR., M.S.
WILLIAM RINGO HOOVER, M.S.
MELVIN ROBERT JACKSON, M.S.
RICHARD FRANKLIN LYNCH, M.S.
JOHN DONALD OAKEY, M.S.
FRED ROBERT SAUERWINE, M.S.
JAMES WILLIAM SIMPSON, B.S.
STEPHEN STAHL STRUNCK, M.S.

### 10. Metallurgy Laboratory (1-2)

Elementary analysis of metallurgical problems for programming in computer solution; application of equipment for laboratory study of structure and properties of metals. Prerequisite: Met. 63 or 91 previously or concurrently. Second semester.

### 63. Engineering Materials and Processes (3)

A study of engineering materials and properties. Methods and effect of fabrication and treatment. Application and use of materials in engineering. Primarily metals, but including plastics, ceramics, and other engineering materials. Prerequisites: Chem. 3 or 13; Phys. 16 or 1. First and second semesters.

### 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 recita-

tion. Prerequisites: Chem. 3, 13 and Phys. 3 or 16 previously or concurrently. First and second semesters.

### 100. Industrial Employment

In the summer following the junior year students in the curriculum of metallurgy and materials science are required to secure at least eight weeks of experience in industrial plants or research organizations.

### 101. Professional Development (1)

Meetings with the department staff for the purpose of developing a professional outlook of the engineering student. Required reading, oral reports and term papers. Prerequisite: Junior standing. Consent of chairman of department. Second semester.

### 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, Met. 91 or 63, and Phys. 4. First semester.

### 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. Rationalization of microstructures. Recovery, recrystallization, and grain growth. Lectures and laboratory. Prerequisites: Met. 207, Met. 210. Second semester.

### 210. Metallurgical Thermodynamics (3)

The application of thermodyamic 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. Prerequisites: Met. 10, Math. 23. First semester.

### 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. Second semester.

### 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 selected 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 metal-

lurgy 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. Second semester. Mr. Hahn

### 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. First semester. Mr. Tarby

### 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. First semester. Messrs. Krauss, Pense

### 312. (Ch.E. 312) Fundamentals of Corrosion (3)

For course description, see Ch.E. 312.

### 313. Materials Fabrication (3)

Basic concepts of stress, strain, and stress-strain behavior under load. Analysis and description of metal forming, metal cutting, casting, joining, and powder metallurgy. Lectures and laboratory. Prerequisites: Met. 208 or equivalent. First semester. Messrs. Avitzur, Feilbach

### 315. Physical Ceramics (3)

Correlation of internal structure with physical and mechanical behavior of ceramic materials. Effect of processing on structure and behavior. Sintering and grain growth. Lectures and laboratory. Prerequisites: Met. 208 and 218 or consent of chairman of department.

Messrs. Spriggs, Runk

### 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 and 208 or equivalent.

Messrs. Conard, Notis

### 317. Imperfections in Crystals (3)

Study of the types of imperfections in crystals and their effects on the behavior of crystalline materials with particular emphasis on dislocations. Prerequisite: Met. 218.

Messrs. Chou, Conard, Krauss

### 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.

Staff

### 320. Analytical Methods in Materials Science (3)

Selected topics in modern analysis and their application to materials problems in such areas as thermodynamics, crystallography, deformation and fracture, and diffusion. Prerequisite: Math. 231 or Math 205. Mr. Chou

### 325. Industrial Metallurgy (8)

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. First semester. Mr. Tarby

### 333. (Geo. 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: Physics 4, Met. 91 or equivalent.

Messrs. Goldstein, Kraft, Runk

### 334. (Geo. 338) Electron Metallography

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. Staff

### 343. (Chem 393) Physical Polymer Science (3)

For course description, see Chem. 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 to develop approach to and judgment of engineering problems involving materials. Lectures, problems. Prerequisites: Met. 307 and Met. 313, or consent of chairman of department. Second semester.

Messrs. Thomas, Wood

### 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. Mr. Fouchaux

### 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. Mr. Conard

## 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 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 offer programs 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. A faculty advisor is assigned to each student upon acceptance. Under his direction the student plans a course of study to satisfy his needs and interests. The department has established specific recommended programs for the master of science or doctor of philosophy 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* has recently been strengthened and expanded by development of a co-operative "Chem.-Met." Program with the chemical engineering department. Through cooperation with the mechanical engineering department similar arrangements have now 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.

The requirements of the Graduate School for either the master's degree or the Ph.D. are explained on page 84. 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 should 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 on pages 67 and 68.

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 stipened to be tax free. For details of graduate scholarships, fellowships and assistantships please refer to page 90.

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

*Chemical Metallurgy*

Gas-solid reactions.
Mathematical modeling of metallurgical processes.
Oxide semiconductors.
Slag-metal reactions.
Thermodynamic relationships in sulfide systems.
Thermodynamics of binary metallic solutions.
Thermodynamics of liquid metals.

*Materials Science*

*Characterization of metal oxide films.
*Deformation and recrystallization texture studies.
Dislocations in composite materials.
*Eutectic research including solidification, microstructure, and property studies.
Magnetic materials.
Meteorites.
*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.
Strengthening mechanisms of dilute iron alloys.
*Structure and behavior of solid state materials.
*Structure and properties of sputtered, evaporated, and plated thin films.
Quantitative metallography.

*Mechanical Metallurgy*

Correlation of microstructure with mechanical behavior of low-alloy high-strength steels, especially fatigue, creep and brittle fracture.

Development of criteria to prevent defects in drawing operations.
Ductile fracture.
Flow through converging conical dies.
Forming of polymers.
Friction measurement.
Hydrostatic extrusion.
*Influence of welding on fatigue characteristics of weldments.
Metal powder consolidation.
Pressure-induced ductility.
Rod shaving and orthogonal cutting.
Theoretical analysis of metal forming methods and correlation with metallurgical parameters.
Toughness of weld metal.
Weldability of steels.

*Physical Ceramics*

*Ceramic-to-metal bonding.
*Correlation between surface condition and mechanical strength.
Deformation mechanisms.
*Oxide semiconductors.
Press forging (compressive deformation).
Processing behavior of alumino-silicate ceramic materials.
*Reactively sintered polycrystalline garnets.
*Sintering mechanisms.
*Strengthening mechanisms.
Synergetic press forging.

*Physical Metallurgy*

*Creep-rupture and aging, and brittle fracture characteristics, and fatigue properties of low-alloy, high-strength steels.
Diffusion controlled growth.
*Electron fractography.
*Environmental crack kinetics.
*Fatigue crack propagation studies.
*Induction heating.
*Kinetics of solid state reactions.
*Mechanical behavior of anisotropic materials.
*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.
*X-ray measurement of residual stresses.

*Polymers*

*Environmental effects on polymers to protect concrete against corrosion..
*Fatigue behavior of reinforced epoxy resins.
*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 areas 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. First and second semesters.                              Staff

**402.   Metallurgical Investigation and Thesis (3)**
Continuation of Met. 401. First and second semesters.
                                                         Staff

**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.                              Staff

**406.   Solidification (3)**
Structure, theory and properties of liquids. Homogeneous and heterogeneous nucleation, theory and experimental results. Solidification phenomena in pure, single and multiphase materials including the nature of the freezing interface, segregation, constitutional super-cooling, dendritic growth, crystallographic effects, the origin of defects, crystal growing. Zone processes. Prerequisite: Consent of chairman of department.                       Mr. Kraft

**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: Physics 363.                              Mr. Conard

**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.                              Mr. Krauss

**409.   Recent Developments in the
          Theory of Materials (3)**
Current topics and theoretical developments in materials. This course may be repeated for credit with permission of the instructor. Prerequisite: Consent of the chairman of the department.                              Staff

**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.
                              Messrs. Butler, Hahn, Tarby

**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.
                              Messrs. Stout, Pense

**412   Electrical and Magnetic Properties of Materials (3)**

The study of semiconducting, dielectric, magnetic and similar materials and their properties. Brief discussion of band theory, conduction and emission mechanisms and related topics. The relation between structure (including imperfections) and physical properties. Prerequisites: Met. 316 or Physics 363, Chem. 196; or consent of chairman of department.                     Messrs. Conard, Notis

**413.   Analysis of Metal Forming Processes (3)**

Three dimensional stress and strain analysis. Yield criteria, plastic flow and the upper and lower bound theorems. Analysis of metal forming processes, including drawing and extrusion, press work, rolling and spinning. The emphasis is on presenting several approaches to each problem.
                                              Mr. Avitzur

**414.   Physical Chemistry of Metallurgical Reactions (3)**

Development of quadratic formalism for representation of the thermodynamic properties of binary and ternary metallic solutions. A study of the thermodynamic and kinetic aspects of process metallurgy reactions. Emphasis on the kinetic behavior of important slag-metal reactions. Prerequisite: Met. 410.                          Mr. Tarby

**415.   Physics of Ceramic Solids (3)**

Lattice dynamics of ceramic materials including theoretical bases for thermal, optical, dielectric, and elastic behavior. Defect properties including ionic conductivity, ferroelectricity, ferrimagnetism, color centers, and crystal field theory. Prerequisites: Met. 315 or Met. 316 or consent of chairman of department.                          Mr. Runk

**416.   Atom Movements (3)**

Phenomenological and atomistic development of the laws of diffusion and their solution. Influence of gradients of concentration, potential, temperature and pressure. Effects of structural defects on diffusion in metals and non-metals. Prerequisite: Math. 23 and Chem. 196 or the equivalent.
                                       Messrs. Goldstein, Hahn

**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.                          Mr. Hertzberg

**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.                          Mr. Pense

**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.                          Mr. Libsch

**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.
                                              Mr. Spriggs

**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.                          Mr. Kraft

**437.   (Mech. 437) Theory of Dislocation (3)**

The mathematical theory of dislocations. Geometrical interpretation; elastic properties of dislocations; force on 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.                     Messrs. Chou, Wei

**443.   (Chem. 443) Solid State Chemistry (3)**

For course description, see Chem. 443.

**458.   Materials Design (3)**

Analysis of design requirements for materials components. Selection of materials and processes. Study of failures in process and service and application of recent metallurgical and materials science knowledge for improved design. Solution and discussion of industrial problems, and outline of experimental approach. Prerequisite: consent of chairman of department.                     Messrs. Thomas, Wood

# MUSIC

Professors

ROBERT BENJAMIN CUTLER, M.A., *Chairman*
JONATHAN BRITTON ELKUS, M.A.

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Lehigh University has a cooperative agreement with Moravian College (Bethlehem) which enables Lehigh students to benefit from instruction in Music on the Moravian College campus. Mus. 21 through 133 are cross-listed with Moravian College courses. Instruction is on the Moravian campus.

### 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. Mus. 1 and 3. first semester only.

### 5-8. Choral Music (1)

Study and peformance 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 vocal ensemble, as determined by the Department of Music, is an integral part of the course. May be repeated. Prerequisite: Consent of chairman of department.

### 11-18. Private Lessons (1)

The study of the techniques and literature of the voice or any instrument on which private instruction may be available; remedial or advanced work in musicianship. Graded Pass-Fail. May be repeated for credit. (Fees must be borne by the student.) Prerequisite: Consent of chairman of department.

### 20. Introduction to Musical Literature (3)

An approach to musical style through the study of works by representative composers from 1600 to the present.

### 21. Fundamentals (4)

Hearing the materials of music; notation, dictation, sight-singing and musicianship. Taught on the Moravian College campus. Prerequisite: Consent of instructor and chairman of Lehigh department.
Two 75-minute periods.
Two 50-minute periods.

### 22. Fundamentals (4)

Continuation of Music 21. Prerequisite: Music 21 and consent of instructor and chairman of Lehigh department.

### 41. String Techniques (1)

Beginning class instruction in playing with emphasis on the teaching of violin and other instruments of the string choir. Taught on the Moravian College campus. Prerequisite: Consent of instructor and chairman of Lehigh department. One or two 50-minute periods.

### 42. String Techniques (1)

Continuation of Music 41. Prerequisite: Mus. 41 and consent of instructor and chairman of Lehigh department.

### 51. Wind and Percussion (1)

Beginning class instruction in playing with emphasis on the teaching of the flute, clarinet, trumpet, trombone, snare drum and other wind and percussion instruments. Taught on the Moravian College campus. Prerequisite: Consent of instructor and chairman of Lehigh department. One or two 50-minute periods.

### 52. Wind and Percussion (1)

Continuation of Mus. 51. Prerequisite: Mus. 51 and consent of instructor and chairman of Lehigh department.

### 101. Music Before 1600 (3)

Music from its earliest evidence through the Renaissance. Extensive score analysis and listening. Taught on the Moravian College campus. Prerequisite: Mus. 21 and consent of instructor and chairman of Lehigh department. First semester, 1971. Alternate years. Two 75-minute periods.

### 102. The Seventeenth and Eighteenth Centuries (3)

Music literature of the Baroque, Rococo and Classic periods. Extensive score analysis and listening. Taught on the Moravian College campus. Prerequisite: Mus. 21 and consent of instructor and chairman of Lehigh department. Second semester, 1970. Alternate years. Two 75-minute periods.

### 103. The Nineteenth Century (3)

Beethoven and his romantic heirs. Extensive score analysis and listening. Taught on the Moravian College campus. Prerequisite: Mus. 21 and consent of instructor and chairman of Lehigh department. Fall, 1970. Alternate years. Two 75-minute periods.

### 104. The Twentieth Century (3)

Post-romanticism, impressionism, atonality, dodecaphony, experimentalism. Taught on the Moravian College campus. Prerequisite: Mus. 21 and consent of the instructor and chairman of Lehigh department. Second semester, 1971. Alternate years. Two 75-minute periods.

**121. Modal Counterpoint (2)**
Theory integrated with Mus. 101. A study of Medieval melody. Writing organum and the motet-madrigal contrapuntal style. Taught on the Moravian College campus. Prerequisite: Mus. 22 and consent of instructor and chairman of Lehigh department. First semester, 1971. Alternate years.
Three 50-minute periods.

**122. Traditional Practices (2)**
Theory integrated with Mus. 102. Writing and playing chords and harmonic progressions. Dominant-tonic relationship and its extension. Association of voices, contrapuntal devices and textures. Taught on the Moravian College campus. Prerequisite: Music 22 and consent of instructor and chairman of Lehigh department. Second semester, 1970. Alternate years.
Three 50-minute periods.

**123. Chromatic Harmony (2)**
Theory integrated with Mus. 103. The tonal harmonic perspective culminating in the music of Wagner. Taught on the Moravian College campus. Prerequisite: Mus. 22 and consent of instructor and chairman of Lehigh department. First semester, 1970. Alternate years.
Three 50-minute periods.

**124. Contemporary Techniques (2)**
Theory integrated with Mus. 104. Working with compositional ideas that approach a common usage. Manipulating sound formations expressively. Taught on the Moravian College campus. Prerequisite: Mus. 22 and consent of instructor and chairman of Lehigh department. Second semester, 1971. Alternate years.
Three 50-minute periods.

**131. Conducting (2)**
Technique and expression in conducting. Score study of choral and instrumental literature. Rehearsal procedures. Field trip observation. Taught on the Moravian College campus. Prerequisite: Mus. 122 or 123 and consent of instructor and chairman of Lehigh department.
Two 75-minute periods.

**132. Conducting (2)**
Continuation of Mus. 131. Prerequisite: Mus. 131 and consent of instructor and chairman of Lehigh department.

**133. Orchestration (2)**
Integrated with Mus. 132. Instrumental characteristics, nomenclature and notation. Score analysis, scoring and arranging. Taught on the Moravian College campus. Prerequisite: Mus. 122 or 123 and consent of instructor and chairman of Lehigh department.
Two 75-minute periods.

**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 instuments; description of the mechanics of keyboard instruments, such as the organ, harpsichord, and piano. Prerequisite: Consent of chairman of department.

**144. Aesthetics and Criticism of Music (3)**
An analytical approach to writings of Hanslick, Nietzsche, Stravinsky, Thomson, Langer, and others with particular attention to the questions of meaning, intent, and expressive values in music. Prerequisite: Consent of chairman of department.

**145. The Viennese Classic Period (3)**
Exercises in tonal harmony and study of forms and procedures in western music 1750-1825. Prerequisite: Consent of chairman of department.

**146. 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.

**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 the chairman of the 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 suitably qualified undergraduates.
The Glee Club will perform at concerts on the campus and away, and will collaborate with choruses of women's colleges in performing major works with orchestra.
Rehearsals will be held twice weekly, and, in addition, provisions may be made for required additional section rehearsals.
Members will purchase their own blazers and trousers which are worn for all performances.

# PHILOSOPHY

**Professors**
DONALD JOHN HILLMAN, M.LITT., *Chairman*
THOMAS MORRIS HAYNES, PH.D.

**Associate Professors**
ROBERT FEATHERSTON BARNES, PH.D.
JOHN RALPH LINDGREN, PH.D.
NORMAN PAUL MELCHERT, PH.D.,
    *Head, Division of Philosophy*
JOHN J. O'CONNOR. PH.D.

**Instructor**
NICHOLAS ANTHONY LAPARA, M.A.

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## PHILOSOPHY

Norman P. Melchert, Ph.D., *Head*

**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. First and second semesters. Staff

**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. First and second semesters.

**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. First and second semesters. Mr. Haynes

**42. The Scientific Process (3)**
A study of the ways in which scientific conceptions of nature are generated. Study of the historial development of some landmark achievements in science provides the background for understanding the logic of this intellectual activity. Second semester. Mr. LaPara

**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. First and second semesters. Mr. Haynes

### For Advanced Undergraduates and Graduates

**261. Philosophy of the Natural Sciences (3)**
An analysis of the logical structure and significance of scientific knowledge and methodology. Scientific method, whether logic of discovery or logic of testing. The rationality of scientific method. The meaning of scientific laws, universal and statistical. The structure of theories, whether explanation or correlation. Science and value. First semester. Mr. LaPara

**271. Readings in Philosophy (2 or 3)**
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: Consent of chairman of department. First semester. Staff

**272. Readings in Philosophy (2 or 3)**
A course of readings designed primarily for undergraduate philosophy majors. Prerequisite: Consent of chairman of department. Second semester. Staff

**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. First or second semester. Mr. Haynes

**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. Second semester. (Offered alternate years). Mr. Barnes

**316. Contemporary Ethics (3)**
The course includes a preliminary survey of major types of ethical theory, but consists essentially of a critical reading of contemporary books and journal articles which reflect current concerns and philosophic methods in ethics. Topics dealt with include analysis of various types of meaning (descriptive, evaluative, directive, emotive, etc.) embodied in moral language, and a study of the logic of moral discourse. The relations of the latter to social sciences will be studied. Prerequisite: Phil. 15 or consent of the instructor. Second semester. Mr. Haynes

**331. 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. First semester. Staff

**335. 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. First semester. Mr. Lindgren

**337. 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. Second semester.
Messrs. Lindgren, Melchert

**339. 20th Century Philosophy (3)**
A study of major contemporary philosophic movements in the West, including pragmatism, idealism, realism, existen-

tialism, 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. Second semester.

Mr. Melchert

### 341. The Evolution of Scientific Ideas (3)

A study of the leading concepts, theories and revolutions in the history of science, and the changing conceptions of the nature of the scientific enterprise. Topics to be treated include: ancient cosmology and physics; late medieval and renaissance developments, from alchemy to chemistry; theories of evolution; classical mechanics and astronomy; philosophical aspects of relativity and quantum theory. First semester.                                    Mr. LaPara

### 351. Analytical Philosophy and Religion (3)

A critical look from the viewpoint of contemporary analytic philosophy at some of the main problems of religion: the nature of religious belief and language, the meaning and justification of religious symbols, and the problems of evil, the meaning of "God", the existence of God, and religious truth. First or second semester.

Messrs. Melchert, LaPara

### 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 the department. Second semester.

Mr. LaPara

### 364. Logic and Language (3)

A study of the properties of natural and formal languages and an investigation of the logical and semantical problems which arise. Special attention will be given to the following topics: the construction of logical models of language and their role in the analysis of communication; logico-linguistic grammars for the generation of language; the use of contemporary logical theories of language to examine the problems of meaning and reference. Second semester.

Mr. LaPara

### 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 contemporary counterparts. Second semester.                                           Mr. Barnes

### For Graduates

The department of philosophy offers advanced programs in two major areas of concentration, in each of which it is possible to proceed to the M.A. or M.S. degree and the Ph.D. degree. For the 1970-71 year, new graduate students will be accepted only in information science and 400-level course will be taught only in this division.

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 intelli-

gence. 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 admission to candidacy.

The doctoral program 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.

The second area of concentration for graduate study in philosophy is of a more traditional character, emphasizing work in the history of philosophy, ethics, value theory, contemporary philosophical issues, logic, epistemology and the philosophy and history of science. This program is designed primarily for the student who wishes to pursue a career in philosophy as one of the liberal arts.

Adequate preparation for graduate study in either of these programs will normally include undergraduate courses in basic logic. Additional course work for the program in the information sciences should include training in mathematics and methodology. However, students with a sound background in a systematic discipline may also be admitted to this program. Additional preparation for the program in traditional philosophy should include undergraduate courses in ethics and the history of philosophy.

A candidate for the M.A. degree may qualify for the degree either by completing successfully twenty-four hours of approved course work and submitting a satisfactory dissertation, or by completing thirty hours in approved courses and passing an examination covering his chosen area of concentration. Each candidate will select the plan better suited to his needs and abilities with the advice and approval of the chairman of the department.

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 admission to candidacy.

The doctoral program in the information sciences 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.

The doctoral program in traditional philosophy is also based on original research and collateral course work. In this area of concentration, the department accepts candidates who wish to specialize in one of the following fields: history of philosophy; contemporary philosophy; ethics and value theory; logic and methodology; philosophical analysis; philosophy of science.

The doctorate in the information sciences serves to qualify students for careers in universities, government, industry and research.

Support in the form of fellowships, research assistantships and graduate assistantships is provided for a restricted number of well-qualified students.

### 401. Philosophy of Mind (3)

An examination of several problems in the philosophy of mind: the current status of the mind-body problem, knowledge of other minds, the "logical geography" of mind-talk, the scientific status of psychoanalysis, and problems of mind and machine. First semester (offered alternate years).
Mr. Melchert

### 416. Value Theory (3)

A review of major types of practical problems deriving from conflict and confusion in evaluation is followed by a critical study of value theory, with emphasis on such topics as these: types of value and modes of value judgment; evidence and authority of value judgments; the logic of normative discourse; techniques of normative analysis; the relation of value judgments to science. Exemplification will be made largely in the fields of morality and law, with some references to politics, economics, art and religion. Prerequisite: Consent of the instructor. Second semester.
Mr. Haynes

### 421. Plato (3)

Intensive study of the mature thought of Plato, dealing with both the epistemological and moral issues in the later *Dialogues*. First semester (offered alternate years).
Mr. Lindgren

### 423. Aristotle (3)

Advanced study of selected themes which appear throughout the Aristotelian Corpus. Students will read widely in the *Organon*, *Physics*, *De Anima*, *Metaphysics*, *Nic. Ethics* and *Politics*. First semester (offered alternate years).
Mr. Lindgren

### 424. The Rationalists (3)

Detailed study of the principal works of Descartes, Spinoza and Leibniz. Second semester (offered as required). Staff

### 426. The Empiricists (3)

Detailed study of the principal works of Locke, Berkeley and Hume. Second semester (offered as required). Staff

### 428. Kant (3)

Intensive analysis of Kant's metaphysic of human experience as set forth in the *Critique of Pure Reason*. Second semester (offered as required). Mr. Lindgren

### 429. Kant Seminar (3)

A study of the *Critique of Practical Reason* and the *Critique of Judgment*, or of the later moral philosophy of Immanuel Kant. (offered as required). Mr. Lindgren

### 430. Nineteenth Century German Philosophers (3)

A study of the writings of major figures in German philosophy of the last century, focusing principally upon Hegel, Schopenhauer, and Nietzsche. Second semester (offered as required). Staff

### 432. Nineteenth Century English Philosophers (3)

A detailed study of the principal works of Bentham, Mill and Bradley. Second semester (offered as required). Staff

### 439. Epistemology (3)

Selected topics in the theory of knowledge, such as the phenomenalism-realism debate, the *a priori* and empirical knowledge, and the development of alternative epistemological systems. First semester. Mr. Melchert

### 443. The Analysts (3)

A detailed and critical study of the main works of one or more recent analytical philosophers, e.g., Russell, Moore, Wittgenstein, or the schools of logical positivism or ordinary language philosophy. First semester (offered as required). Mr. Melchert

### 445. The Phenomenologists (3)

An examination of phenomenology as found in the writings of Husserl, with study of the tradition after him, e.g., Merleau-Ponty, Sartre or Heidegger. First semester (offered as required). Mr. Melchert

### 447. The Pragmatists (3)

A critical examination of the principal writings of one or more philosphers usually placed in the pragmatic tradition: Peirce, James, Dewey, or Lewis. First semester (offered as required). Staff

### 451. Logical Investigations (3)

A study of formal and natural languages for the problem of content analysis. Topics to be treated include: theory of representation; logical analysis; linguistic correlates of syntactic, semantic and pragmatic features; applications to retrieval theory. First semester. Staff

### 461. Special Topics in Philosophy of Science (3)

Intensive study and research on certain selected topics, such as the philosophical assumptions and implications of recent physical science; the foundations of probability; the meaning and status of laws and theories; the concepts of space and time. Prerequisite: Phil. 261 or consent of chairman of department. First or second semester. Staff

### 464. Semantics (3)

An investigation into problems of meaning and reference, including disputes about analyticity and the *a priori*, making use of recent literature on the subject. Second semester.
Mr. Melchert

### 471. Graduate Thesis (3)

First semester.

### 472. Graduate Thesis (3)

Second semester.

### 485. Model Theory (3)

Metamathematical investigations of the relationships between formal properties of logics and structural properties of their models. Attention will center upon such topics as:

topological aspects of completeness theorems; model-theoretic separation theorems; hierarchies of definability; mathematical vs. metamathematical properties of structures; applications of models in the non-formal sciences. Prerequisite: Math. 404 or consent of the instructor. First or second semester.                                    Mr. Barnes

**490.  Special Topics (3)**

An intensive study of selected topics not covered in more general courses. Second semester.                        Staff

# DIVISION OF INFORMATION SCIENCE

## Professors

DONALD JOHN HILLMAN, M.LITT., *Head*
HERBERT RUBENSTEIN, PH.D.

## Associate Professors

ROBERT FEATHERSTON BARNES, PH.D.
JOHN J. O'CONNOR, PH.D.

## Assistant Professors

JAMES SPROAT GREEN, PH.D.
JOHN WILLIAM HUMES, PH.D.
ANDREW JAMES KASARDA, PH.D.

The rate of change in information technology demands that the practitioner have the conceptual background necessary to participate in and contribute to existing and developing systems. Within this framework, the M.S. and Ph.D. degree programs offered by the division of information science are designed to fulfill several objectives. Each program provides a broad base of both theory and application. Emphasis is on fundamentals, rather than techniques. Basic to the program of information science at Lehigh University is the concept that research and instruction reinforce one another. Consequently whenever possible, students are expected to participate in research and operations on a part-time basis.

The curriculum in information science is based on a B.S. degree in an engineering or scientific discipline. Desirable preparation consists of at least 12 hours of mathematics, including 9 hours of differential and integral calculus and one course beyond the calculus. In recognition of the flexibility and cross-disciplinary nature of the subject, exception to this requirement may be granted to those students with training in a systematic science. A course in computer programming or programming experience is desirable. Mathematics 105, Computer Programming, is available, without graduate credit, for those without computer background.

A candidate for the degree of master of science in information science is required to complete at least twenty-four hours of approved course work and to submit a thesis. Each student's schedule will be chosen in consultation with the head of the division. Three core areas are at the heart of the M.S. program: information processing systems; information retrieval theory; and analysis of information. Beyond this basic core, student schedules are planned on an individual basis to fit previous academic experience and career goals. Two options are open for specialization, dependent on background, ability, and interests: Systems 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 departments of electrical engineering, industrial engineering, Mathematics, philosophy, psychology, social relations, and others. For a more detailed description of the Ph.D. program in information science, see description of graduate study in philosophy.

**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. First semester.                                        Mr. Green

**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. Second semester.
                                        Mr. Green

**301.  Descriptive Linguistics (3)**

Techniques for the description of the phonology, morphology and syntax of natural languages. Special attention to transformational generative grammar. First semester.
                                     Mr. Rubenstein

**302.  (Psych. 320) Psycholinguistics (3)**

Study of the experimental and observational literature on the production and comprehension of utterances and on the acquisition of language. Consideration of performance models of the language user. Prerequisite: I.S. 301. Second semester.                              Mr. Rubenstein

**321.  Introduction to Retrieval Methods (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. First semester.    Mr. Kasarda.

**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. Second semester.
                                        Staff

**361.  Theory of Formal Grammars (3)**

The study of the structure of formal languages as deter-

mined 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). First semester. Mr. Barnes

### 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. First semester. Mr. Barnes

### 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. Second semester. Mr. Hillman

### 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, circulation and reference functions. Staff

### 402. (Psych. 448) Seminar in Psycholinguistics (3)

Selected topics in psycholinguistics examined in depth and in detail. Prerequisite: I.S. 301. Second semester. Mr. Rubenstein

### 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). Mr. Rubenstein

### 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. Second semester. Mr. Kasarda

### 431. Subject Document Retrieval (3)

Purposes of a subject document retrieval system, methods of subject indexing, (index vocabulary organization thesauri, classifications, etc.), subject request negotiation, subject indexing and natural language text searching by computer, citation indexes, and evaluation. Introduction to the principal questions and ideas in the field. Emphasis on critical discussion and (whenever feasible) empirical testing of ideas. First semester. Mr. O'Connor

### 432. Mechanized Subject Document Retrieval (3)

Purpose of a subject document retrieval system; subject indexing, vocabulary organization, and request modification by computer; computer searching of natural language text; natural language retrieval requests to a computer; man-machine compromises; evaluation. Critical survey of the problems and ideas in the field. Prerequisite: I.S. 431. Second semester (alternate years). Mr. O'Connor

### 434. Retrieval System Evaluation (3)

Purposes and costs of systems that retrieve documents by subject; defining and measuring effectiveness and cost and the variables that affect them; interpretations of empirical test results. Critical survey of the problems in the field. Prerequisite: I.S. 431. Second semester (alternate years). Mr. O'Connor

### 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. Second semester. Mr. Humes

### 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. Second semester. Mr. Barnes

### 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, categorial, and other mathematical models for description of linguistic structure. Prerequisite: I.S. 361. Second semester (alternate years). Mr. Barnes

### 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. First semester. Mr. Hillman

### 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. Offered alternate years. Staff

### 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

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**1. Mechanics of Mass Points (3)**
Introduction to physics through a study of the laws of motion and conservation principles. Two lectures and one recitation-laboratory period per week. Prerequisite: Math. 21, 31, or 41, previously or concurrently. First and second semesters, summer session.

**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. First and second semesters.

**4. Electricity, Light, and Atomic Physics (4)**
Continuation of Phys. 3. Electromagnetism, induced electromotive forces, electrical transients in circuits, geometrical and physical optics, introduction to quantum phenomena. Two lectures, one recitation, and one laboratory period per week. Prerequisites: Math. 23, previously or concurrently; Phys. 3. Second semester, summer session.

**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 of Business Administration. Lecture demonstrations and recitations. Prerequisite: Phys. 1. First semester. Mr. Borse

**17. General Physics Laboratory (2)**
A laboratory course in general physics to accompany Phys. 16. Prerequisite: Phys. 16, preferably concurrently. First semester. Mr. Borse

**62. Contemporary Physics (3)**
Atomic view of matter; quantum mechanics and probabilities; interactions between atoms and radiation; classical and quantum mechanical properties of aggregates of atoms. Prerequisites: Math. 205, Phys. 4 or Phys. 16, 17 previously or concurrently. Second semester. Mr. Smith

**90. Electrical Phenomena (1)**
Laboratory studies of elementary electric and magnetic effects. Elementary laboratory techniques. Prerequisite: Phys. 4, preferably concurrently. Second semester.
Messrs. Wheeler, Smith

**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. Second semester. Mr. Borse

**191. Laboratory Techniques (2)**
Thermometric, calorimetric and vacuum techniques. Advanced electrical measurements. Prerequisite: Phys. 4 or 17. First semester. Messrs. Wheeler, Fouchaux

**192. Advanced Physics Laboratory (1 or 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 or 2)**
Continuation of Phys. 192. Intended for seniors majoring in the field. Second semester. Staff

### 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. First semester.

**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. Second semester.

**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. First semester.

**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. Second semester.

**252. Optics (3)**
Wave theory of light, interference, diffraction, polarization. Prerequisites: Phys. 4 and Math. 23. Second semester.

**254. Optics Laboratory (2)**
Optical instruments and techniques. Examination of phenomena, of measuring procedures, and of light sources and recording devices. Prerequisite: Phys. 4. Second semester. Messrs. Van Sciver, Fouchaux

**266. Modern Physics (3)**
General foundations of quantum theory, special theory of relativity, atomic theory of origin of spectra, wave mechan-

ics, 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. First semester.

Mr. Kanofsky

### 281. Basic Physics 1 (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. Summer session.

### 282. Basic Physics II (3)

Continuation of Phys. 281. Summer session.

### 340. Heat, Thermodynamics and Pyrometry (3)

Basic principles of heat, thermodynamics and kinetic theory of gases with emphasis on physical systems.

Mr. Smith

### 362. Atomic and Molecular Structure (3)

Structure of atoms and molecules, especially as related to their spectra. Prerequisite: Phys. 62 or Chem. 191. First semester.

Mr. Van Sciver

### 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. Second semester.

Mr. Fowler

### 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. Second semester.

Mr. Kanofsky

### 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. Second semester.  Mr. Emrich

### 369. Introduction to Quantum Mechanics (3)

Principles of quantum mechanics; applications to atoms and molecules. Prerequisites: Phys. 62, 216, Math. 205. First semester.

Mr. McLennan

### 372. Special Topics in Physics (1-3)

Special topics in physics not sufficiently covered in the general courses. Lectures and recitations or conferences. First and second semesters.

Staff

### 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 nuclear structure theory. A program in experimental high energy

physics makes use of the 3 Bev accelerator in Princeton, New Jersey, 60 miles southeast of Bethlehem.

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 are required to demonstrate a reading knowledge of one language, usually chosen from French, German, or Russian. Some graduate work in mathematics usually is 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 courses generally is predicated on satisfactory completion of corresponding courses in the 200 and 300 groups or their equivalent.

Special departmental facilities for teaching and research include six shock tubes with advanced instrumentation; optical and cryogenic equipment for solid state studies; magnetic resonance equipment. Facilities of the Materials Research Center are available, including crystal preparation equipment, electron microscope facilities, and light scattering equipment. Extensive use is made for both teaching and research of the computing facilities in the Computing 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, properties of thin films, deformation of solids under rapid stress applications.

Messrs. Bergmann, Curtis, Feigl, Fouchaux, Van Sciver

*Solid State Physics* (*Theoretical*)

Energy band calculations in insulators, excited states and lifetimes of defects, properties of impurities in insulators, propagation of stress waves.

Messrs. Folk, Fowler, Martin

*Nuclear Theory*

The few nucleon problem, properties of light nuclei.

Messrs. Borse, Folk

*Physics of Fluids*

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

Messrs. Emrich, Kim, Smith

*Statistical Physics*

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

Messrs. McLennan, Radin

*Elementary Particles* (*Experimental*)

Proton-proton scattering, properties of K-mesons, streamer chambers.

Mr. Kanofsky

*Elementary Particles (Theory)*

Properties of leptons, the vector boson, methods for handling unrenormalizable field theories, SU(3) and electromagnetic interactions.　　Messrs. Bergmann, Shaffer

*"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.
Mr. Bergmann

**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. First semester.
Mr. Fouchaux

**421.　Theoretical Physics (3)**

Theory of elasticity; fluid dynamics; tensor analysis; electrostatics and magnetostatics. Prerequisite: Phys. 420. Second semester.　　Mr. Kim

**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. First semester.　　Mr. Fowler

**423.　Advanced Theoretical Physics (3)**

Electrodynamics in anisotropic media; physical optics; theory of diffraction and application to holography; applications of electrodynamics in various fields of physics; Prerequisite: Phys. 422. Second semester.　Mr. Bergmann

**424.　Quantum Mechanics (3)**

General principles of quantum theory; approximation methods; spectra; symmetry laws; theory of scattering. Prerequisite: Phys. 369 or equivalent. Second semester.
Messrs. McLennan, Borse

**425.　Quantum Mechanics (3)**

A continuation of Phys. 424. Relativistic quantum theory of the electron; theory of radiation. First semester, alternate years. (Not offered, 1969-70).　　Mr. Shaffer

**428.　Methods of Mathematical Physics (3)**

The equations of theoretical physics and the methods of their solution. First semester.　　Mr. Folk

**429.　Methods of Mathematical Physics (3)**

Continuation of Phys. 428. Second semester.　　Mr. Folk

**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. First semester, alternate years. (Not offered, 1969-70).　　Mr. Fowler

**434.　Solids and Radiation (3)**

Phenomena in solids resulting from interaction with electromagnetic radiation or charged particles. Current theories of energy absorption, transport, and emission. Pre-

requisite: Phys. 363 or equivalent. First semester, alternate years. (Not offered 1969-70).

**442.　Statistical Mechanics (3)**

General principles of statistical mechanics with applications to thermodynamics and the equilibrium properties of matter. Prerequisites: Phys. 340 and 369. First semester.
Messrs. McLennan, Radin

**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. Second semester, alternate years. (Not offered 1970-71).
Mr. McLennan

**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. Second semester, alternate years. (Not offered 1969-70).　　Mr. Shaffer

**465.　Nuclear and Elementary Particle Physics (3)**

Nuclear structure and phenomena; interactions among elementary particles and methods of studying them. Second semester, alternate years. (Not offered 1969-70).
Mr. Kanofsky

**467.　Nuclear Theory (3)**

Theory of low energy nuclear phenomena within the framework of non-relativistic quantum mechanics. Second semester, alternate years. (Not offered 1970-71).　　Mr. Borse

**471.　(Mech. 451.) Nonlinear 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 thermodynamical bases of the subject, as well as the use of invariance principles in formulating constitutive equations. Applications of the nonlinear theories to specific problems will be given.　　Mr. Rivlin

**472.　Special Topics in Physics (1-3)**

Selected topics not sufficiently covered in the more general courses. May be repeated for credit. First or second semester.　　Staff

**474.　Seminar in Modern Physics (3)**

Discussion of important advances in experimental physics. First or second semester.　　Staff

**475.　Seminar in Modern Physics (3)**

Discussion of important advances in theoretical physics. First or second semester.　　Staff

**491.　Research (3)**

Research problems in experimental or theoretical physics. First and second semesters.　　Staff

**492.　Research (3)**

Continuation of Phys. 491. May be repeated for credit. First and second semesters.　　Staff

# PSYCHOLOGY

**Professors**

FRANCIS JOSEPH WUEST, PH.D., *Chairman*
ARTHUR LIONEL BRODY, PH.D.
JOSEPH MARIA BROZEK, PH.D.

**Associate Professor**

THEODORE MILLON, PH.D.
GEORGE SHORTESS, PH.D.

**Assistant Professors**

DONALD A. MANKIN, 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.

**Teaching Interns**

GEORGE B. WALZ, PETER J. BEHRENS

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**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 the physiological bases of behavior. First semester.

**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. Second semester.

**9. Statistical Analysis (3)**
An integrated presentation of the basic methods of evaluating data in psychological research. Second semester.

**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. Second semester.

**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. First semester. Offered in 1971-72 and alternate years.

**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. First semester. (Offered in 1970-71 and alternate years.)

**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. First semester.

**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. First and second semesters.

### 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. Second semester.

**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. First semester.

**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. Second semester. Offered in 1970-71 and alternate years.

**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. First semester. Offered in 1970-71 and alternate years.

**304. Psychometric Methods (3)**
Principles of psychological measurement as related to test construction, psychophysical methods, attitude scales. Prerequisite: Psych. 3, 4, and 11. Second semester. Offered in 1971-72 and alternate years.

**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. First semester.

**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. Second semester.

**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. Second semester.

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

**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. First semester.

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

**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 Department 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 the 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. and Ph.D in selected areas of experimental psychology, namely, learning, sensation and perception, mathematical psychology and engineering 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 Psych.
    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 masters 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 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 applications forms be submitted to the University Office of Admission not later than February 15. In addition to the usual transcripts and letters of recommendation, the department requires that Graduate Record Examination scores on 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 Interships 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. First semester.          Mr. Richter

**422. Analysis and Design of Experiments (3)**

Continuation of Psych. 421. Emphasis on experimental design. Prerequisite: Psych. 421. Second semester.

Mr. Richter

**423. Seminar in Statistical Methods (3)**

Selected topics in statistics applied to psychological research. May be repeated for credit. First or second semester.          Messrs. Brody, Richter

**426. Research Methods (3)**

Planning of experiments under both laboratory and industrial conditions. Appraisal of research ideas, methodology, and instrumentation. First semester.          Mr. Brody

**428. Thesis (3)**

Original investigation for the master's thesis.          Staff

**429. Thesis (3)**

Continuation of Psych. 428.          Staff

**432. Perception (3)**

Evaluation of contemporary research and theories of human perception. Second semester. Offered in 1970-71 and alternate years.

**433. Conditioning and Learning (3)**

Coverage of a variety of empirically investigated topics in learning. First semester. Offered in 1971-72 and alternate years.          Mr. Richter

**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. Second semester. Offered in 1970-71 and alternate years.          Mr. Millon

**435. (S.R. 423) Social Psychology (3)**

Evaluation of contemporary research and theories of group behavior. First semester. Offered in 1970-71 and alternate years. Mr. Jones

**436. Physiological Psychology (3)**

The study of the anatomical, physiological and biochemical bases of behavior. Second semester. Offered in 1970-71 and alternate years. Mr. Shortess

**437. Psychophysical Measurement (3)**

An analysis of theoretical and methodological problems in psychological measurement with particular emphasis on psychophysical threshold determination and scaling. First semester. Offered in 1970-71 and alternate years.
Mr. Wuest

**438. History of Psychology (3)**

Interpretation of selected works of authors who have contributed significantly to the growth of scientific psychology. Second semester. Mr. Brozek

**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. Offered as required. Mr. Brody

**451. Vision (3)**

A systematic survey of the methods and chief results in the study of visual processes. Offered as required.
Mr. Shortess

**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 in learning with emphasis on current research, e.g., discrimination learning, avoidance learning, concept learning, problem solving, verbal learning. May be repeated for credit. First or second semester. Messrs. Brody, Newman, Richter

**454. Theories of Learning (3)**

Critical survey of major theories of learning. Second semester. Offered in 1970-71 and alternate years.
Mr. Brody

**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. First or second semester. Offered as required. Messrs. Mankin, Wuest

**456. (S.R. 434) Advanced Social Psychology (3)**

Intensive treatment of theory and empirical research in an area of current interest in social psychology. Second semester. Offered as required. Mr. Jones

**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. Second semester. Mr. Shortess

**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. Offered as required. Mr. Wuest

**460. Special Study (1-3)**

Study of some special topic not covered in the regular course offerings. Staff

**461. Research (1-3)**

Original research not connected with master's or doctoral thesis. Staff

**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. First and second semesters. May be repeated for credit. Staff

**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. First and second semesters. May be repeated for credit. Staff

**482. Abnormal Psychology (3)**

Principles underlying the major forms of behavior pathology. Prerequisites: Psych. 383. Open only to graduate students specializing in guidance and counselling or reading in the School of Education. Offered as required.
Mr. Millon

**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 counselling or reading in the School of Education. Offered as required.
Mr. Millon

**484. Projective Techniques (3)**

Administration, 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 counselling or reading in the School of Education. Second semester. Offered as required. Mr. Millon

**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 counselling or reading in the School of Education. Offered as required.
Mr. Millon

# RELIGION

Professor

ARTHUR ROY ECKARDT, PH.D., *Chairman*

Associate Professor

RAYMOND EUGENE FUESSLE, B.D.

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### 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. First and second semesters.

### 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. First semester.

### 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 of St. Paul. The theological viewpoint of the primitive Church as reflected in the New Testament. Second semester.

### 101. Faiths of the Orient (3)
Study of the rise, development, and teachings of selected major religions of India, China, Japan, and Southeast Asia. First semester.

### 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. Second semester.

### 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 antisemitism 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. First or second semester.

### 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 orthodoxy, the demythologization of Scripture, the crisis of technology and secularization, theologies of "the death of God," and the ecumenical movement. First semester.

### 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." Second semester.

# RESERVE OFFICERS' TRAINING CORPS

Students in the Colleges of Arts and Sciences 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, B.S., M.A., *Chairman*

**Associate Professor**
MAJOR JAMES M. LYLE, B.A.

**Assistant Professors**
CAPTAIN WATSON GARRARD CAUDILL, JR., B.S.
CAPTAIN JOHN JOSEPH HUBER, B.A.
CAPTAIN CHARLES EDWARD KLATT, B.S.

**Assistants**
SERGEANT MAJOR MARION AUBREY SPICER
MASTER SERGEANT JOSEPH BRODERWAY
STAFF SERGEANT HENRY PHILLIPS

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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 COURSE: 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 $160.50 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 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 than 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: Qualified students transferring from other institutions 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 Sciences 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. Practical exercises demonstrate the care and use of individual 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. First semester.*

### 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. He studies the organization of small Army units, with emphasis on specific duties and 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. Second semester.*

### 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 hours of leadership laboratory per week. First semester.

### 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. Second semester.

### 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 planning, 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. First semester.*

### 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. Second semester.

### 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 on 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 development through the assignment of 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. First semester.

### 108. Advanced Military Science (1)

An analysis is made of selected leadership and 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. Second semester.*

*Students are required to take an approved three credit-hour course from the curricula of the Colleges of Arts and Science, Business and Economics or Engineering which contributes to their potential as military officers.

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.

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### Department of Aerospace Studies

**Professor**

LIEUTENANT COLONEL GLENN F. STAUFFER, PH.D.
*Chairman*

**Assistant Professors**

MAJOR JOSEPH C. SURICO, M.A.
CAPTAIN JAMES L. BANNON, M.B.A.
CAPTAIN WILLIAM A. WOJCIECHOWSKI, M.ED.

**Assistants**

STAFF SERGEANT JESSE F. MARSH
STAFF SERGEANT DONALD G. PODOLL
STAFF SERGEANT HARRY R. WALKER

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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 requirement 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 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 instructions 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 junior 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 operation 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 supports 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 MANUEL VALENZUELA, PH.D.

## Assistant Professors
BIRUTA CAP, PH.D.
ANJE C. VAN DER NAALD, PH.D.

## Instructors
WALTER F. MARSHALL, M.A.
ALBERTO ROMERO, LICENTIATUS

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## FRENCH

### 1. Elementary French (3)
Basic conversational French illustrating essential grammatical principles. Emphasis on aural-oral learning with required laboratory practice. First semester.

### 2. Elementary French (3)
Continuation of Fr. 1, with the addition of simple vocabulary-building tests. Prerequisite: Fr. 1. Second semester.

### 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. First semester.

### 12. Intermediate French (3)
Continuation of Fr. 11. Prerequisite: Fr. 11. Second semester.

### 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: French 12, or 3 units of entrance French, or consent of chairman of department. First semester.

### 42. French Oral and Written Composition (3)
Continuation of Fr. 41. Prerequisite: Fr. 41, or consent of chairman of department. Second semester.

### 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: French 42 or 4 units of entrance French or consent of chairman of the department. First semester.

### 52. A Survey of French Literature (3)
Reading and discussion of respresentative works of the nineteenth and twentieth centuries. Outside reading and reports. Conducted in French. Prerequisites: French 51 or consent of chairman of department. Second semester.

### 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, reports, and collateral reading. Conducted in French. Prerequisites: French 51-52, or 5 units of entrance French, or consent of chairman of the department. First semester.

### 62. Seventeenth Century French Literature (3)
Continuation of Fr. 61. Conducted in French. Prerequisite: Fr. 61, or consent of chairman of department. Second semester.

### 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: French 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. Second semester.

### 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 chairman of department. First semester.          Mr. Marshall

### 68. Twentieth Century French Literature (3)
A study of the drama and poetry of 20th Century France with readings chosen to illustrate the principal dramatists and poets as well as literary movements. Conducted in French. Prerequisite: Fr. 51-52 or consent of chairman of department. First semester.          Mr. Marshall

### 81. French Cultural Program (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

### 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. First semester.

### 272. Readings (3)
Continuation of Fr. 271. Prerequisite: Fr. 271 or consent of chairman of department. Second semester.

### 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. First semester.

### 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 translation. Conducted in English. Prerequisite: Fr. 51-52, including a thorough reading knowledge of the language, or consent of chairman of department. Second semester.                    Mrs. Cap

### 308.    Symbolism (3)

An intensive study of the symbolist school of poetry from Baudelaire through Mallarmé and the end of the 19th Century. Conducted in French. Prerequisite: Fr. 51-52 or consent of chairman of department. Second semester.
                    Mr. Marshall

### 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. First semester.                    Mr. Van Eerde

### 312.    French Classicism (3)

Continuation of Fr. 311. Conducted in French. Prerequisite: Fr. 311 or consent of chairman of department. Second semester.                    Mr. Van Eerde

### 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. Second semester.                    Mr. Van Eerde

### 314.    The Age of Enlightenment (3)

Continuation of Fr. 313. Conducted in French. Prerequisite: Fr. 313 or consent of chairman of department. Second semester.                    Mr. Van Eerde

### 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 discussions. Conducted in French. Prerequisite: Fr. 52 or consent of chairman of department. First semester.                    Mrs. Cap

### 316.    Late Medieval and Renaissance Literature (3)

Readings and analysis of representative lyric poetry from the Troubadours to the Pléiade. Lectures, reports, and class discussions. Conducted in French. Prerequisite: Fr. 51 or consent of chairman of department. Second semester.
                    Mrs. Cap

### 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. First semester.                    Mr. Marshall

### 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. Second semester.                    Mr. Marshall

### 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. First semester.                    Mr. Marshall

### 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. First semester.                    Mr. Van Eerde

### 412.    Stendhal and Flaubert (3)

The major works of Stendhal and Flaubert with particular consideration to style, theme, and influence. Conducted in French. Prerequisite: 300-level course or equivalent, or consent of chairman of department. Second semester.
                    Mr. Marshall

### 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. First semester.                    Mrs. Cap

### 414.    French Heritage (3)

Continuation of French 413. Prerequisite: Fr. 413. Second semester.                    Mrs. Cap

### 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. Second semester.
                    Mr. Marshall

## Italian

### 1.    Elementary Italian (3)

Grammar; composition; rapid reading of easy modern prose. No previous study of Italian required. First semester.

### 2.    Elementary Italian (3)

Continuation of Ital. 1. Prerequisite: Ital. 1. Second semester.

**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. First semester.

**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. Second semester.

## PORTUGUESE

**1. Elementary Portuguese (3)**

A study of Portuguese grammar and forms; practice in writing and speaking Portuguese. First semester.

**2. Elementary Portuguese (3)**

Continuation of Port. 1. Prerequisite: Port. 1. Second semester.

## SPANISH

**1. Elementary Spanish (3)**

Basic conversational Spanish illustrating essential grammatical principles. Emphasis on aural-oral learning with required laboratory practice. First semester.

**2. Elementary Spanish (3)**

Continuation of Span. 1, with the addition of the use of simple vocabulary-building and reading texts. Prerequisite: Span. 1. Second semester.

**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. First semester.

**12. Intermediate Spanish (3)**

Continuation of Span. 11. Prerequisite: Span. 11. Second semester.

**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. First semester.

**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. Second semester.

**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. Conducted in Spanish. Prerequisite: Span. 12 or four units of entrance

Spanish, or consent of chairman of department. First semester.

**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. Second semester.

**53. Introduction to Spanish Fiction (3)**

Readings and discussion of selected novels and short stories; outside reading and reports. Conducted in Spanish. Prerequisite: Spanish 51-52 or five units of entrance Spanish, or consent of chairman of department. First semester.

**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. Second semester.

### For Advanced Undergraduates and Graduates

**231. 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: Sp. 51-52 or 53-54 or consent of chairman of department.          Mr. Valenzuela

**232. 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: Sp. 51-52 or 53-54 or consent of chairman of department.          Mr. Valenzuela

**271. Readings (3)**

A study of the works of some author or groups of authors, or of a period. Prerequisite: Sp. 51-52 or Sp. 53-54 or consent of chairman of department. First semester.

**272. Readings (3)**

Continuation of Sp. 271. Prerequisite: Sp. 51-52 or Sp. 53-54 or consent of chairman of department. Second semester.

**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: Sp. 53-54 or consent of chairman of department. First semester.

Mr. Valenzuela

**302. The Latin-American Essay (3)**

Reading and discussion of distinguished Spanish-American essayists of the twentieth century with emphasis on the works of Rodo, Vasconcelos, Vaz Ferreira, and Francisco Romero. Oral and written reports. Conducted in Spanish. Prerequisite: Sp. 53-54 or consent of chairman of department. Second semester.          Mr. Valenzuela

**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: Sp. 53-54 or consent of chairman of department. First semester.                                   Mr. Valenzuela

### 305.   Spanish Literature of the Middle Ages (3)

Reading and discussion of outstanding works such as: El Cid, El Libro de Buen Amor, La Celestina. Given in Spanish. Prerequisite: Sp. 53-54 or consent of chairman of department. First or second semesters.

### 306.   Latin America Literature since World War II (3)

Reading and discussion of representative works of contemporary Latin-American authors. Given in Spanish. Prerequisite: Sp. 53-54 or consent of chairman of department. First or second semesters.          Mr. Valenzuela

### 307.   The Golden Age (3)

A study of the representative works. Conducted in Spanish. Prerequisite: Spanish 53-54, or consent of chairman of the department. First semester.          Mr. Valenzuela

### 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. Prerequisite: Sp. 53-54 or consent of chairman of department. Second semester.

### 309.   Sixteenth Century (3)

Representative readings. Conducted in Spanish. Prerequisite: Spanish 53-54 or consent of chairman of department. First semester.

### 310.   Nineteenth Century Spanish Novel (3)

Representative works. Conducted in Spanish. Prerequisite: Spanish 53-54, or consent of chairman of department. Second semester.          Miss van der Naald

### 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. First semester.
Miss van der Naald

### 412.   Neruda and Mistral (3)

A study of the representative works of these authors. Conducted in Spanish. Prerequisite: a 300-level course or equivalent, or consent of chairman of department. Second semester.          Mr. Valenzuela

### 413.   Ruben Dario and "Modernismo" (3)

A study of the poetry of Ruben Dario and his relation to the "Modernismo" movement. Conducted in Spanish. Prerequisite: a 300-level course or equivalent or consent of chairman of the department. First semester.
Mr. Valenzuela

### 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. Second semester.
Miss van der Naald

### 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. Second semester.

# 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**

GIRARD E. KREBS, PH.D.
BARBARA W. LEX, PH.D.
JAMES RATHBURN MCINTOSH, PH.D.

**Instructor**

MARIE WEIL, M.S.

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**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. First semester.

**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 had or are taking S.R. 11, 21 or 31. Second semester.

**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 organization and structure, socialization, stratification, social institutions, ethnic relations, social change. Not open to students who have had or are taking S.R. 3 or 4. First and second semesters.

**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. First and second semesters.

**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. First and second semesters.

**55. Primitive Peoples (3)**
An introduction to the variety of man's social life. A num-
ber 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.                    Miss Lex

**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. Prerequisite: sophomore standing.

**75. Minority Groups (3)**
Ethnic minorities and intergroups relations. Consideration of the historical and social character of minority groups and an examination of theory and research focusing on intergroup cooperation and conflict. Prerequisite: sophomore standing.

### For Advanced Undergraduates and Graduates

**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. Second semester.

                    Mr. Herrenkohl

**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 Psychology. First semester.                    Mr. Jones

**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. Second Semester.                    Mr. Jones

**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 application 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. Second semester. May be repeated for credit.

### 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 the chairman.                    Miss Lex

### 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. Second semester.

### 335. Cultural Dynamics (3)

Critical evaluation of approaches to the problems of culture change; analysis of invention and intergroup cultural borrowing; agents and conditions conducive to change; mechanics of culture growth; and application 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 the chairman of the department. First semester.                    Miss Lex

### 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 the chairman of the department. Second semester.                    Miss Lex

### 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. First or second semesters. May be repeated for credit. Prerequisite: Six credit hours in Social Relations or consent of the chairman of the department.

### 360. Social Change in Africa (3)

An examination of the basic structures of traditional society and of the processes of social organization originating in the colonial era and continuing into the evolving system of new nations of Africa. Second semester.

Mr. Van Hoey

### 364. The Family (3)

A sociological study of man's basic institution. Includes: an analysis of historical backgrounds, interaction 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. Second semester.                    Mr. Williamson

### 366. Population Problems (3)

Quantitative and qualitative aspects of U.S. and world population. Includes: causes and effects of migrations, racial composition 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. Second semester.

### 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. First semester.                    Mr. Williamson

### 368. The Urban Community (3)

A study of urban communities in the world and in the United States. A history of the city, ecological and demographic patterns and growth, institutional organization, status systems, suburban development, resources and problems, future development and planning. Prerequisite: Six credit hours in Social Relations or consent of the chairman of the department. Second semester.   Mr. McIntosh

### 369. Social Disorganization (3)

Social disorganization in contemporary society, with emphasis on the concepts of anomie and alienation. Evaluation of various theories of social disorganization. Prerequisite: Six credit hours in Social Relations or consent of chairman of department.                    Mr. McIntosh

### 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. Second semester.                    Mr. McIntosh

### 371. Special Topics in Social Relations (1-3)

An opportunity for advanced work through supervised reading and research. Prerequisite: Consent of chairman of department. First semester.

### 372. Special Topics in Social Relations (1-3)

Continuation of S.R. 371. Second semester.

### 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. First or second semester. May be repeated for credit.                    Staff

**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.
Mr. Herrenkohl

**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. First or second semesters.

**384. Social Structure (3)**

The theory of social structure considered as a basic key to the understanding of social phenomena, with attention to such concepts as interaction, position, role and role-set, status, institutionalization, equilibrium, norm, and culture. Selected propositions concerning structural relationships and processes will be examined. Prerequisite: Six credit hours in Social Relations or consent of chairman of department. Second semester.
Mr. Van Hoey

**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. Second semester.

### 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.
Mr. Jones

**411. Advanced Research Methods (3)**

A basic course in research theory and methods. Consideration given the nature of theory, hypotheses testing, the definition of variables and methods of measurement.
Mr. Herrenkohl

**412. Practicum in Research Methods (3)**

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 upon it. Prerequisite: S.R. 411. Second semester.
Mr. Herrenkohl

**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.
Mr. Williamson

**434. (Psych. 456) Advanced Social Psychology (3)**

For description, see Psych. 456.

**435. Current Anthropological Theory (3)**

An examination of the theoretical foci of anthropology and its relation to disciplines, e.g., ecology, linquistics, ethnohistory, the cross-cultural study of cognition, etc.
Miss Lex

**464. Seminar on the Family (3)**

Societal functions of marriage and the family and the relation of this institution to the social structure and demographic variables. Particular emphasis on the treatment of family disorganization.
Mr. Williamson

**465. Organizational Behavior (3)**

Theory and research concerning the development and functioning of organizations. Structure, goals, authority and power, communication, role conflict in large organizations. Cross-institutional comparisons of industrial, research, governmental, medical, and academic organizations.
Mr. Van Hoey

**467. Latin American Social Structure (3)**

Analysis of given Latin American societies with special attention to economic and political structures. Individual projects.
Mr. Williamson

**468. Advanced Urban Sociology (3)**

Selected problems in urban research, urban and community planning and redevelopment. Relation of the city and the region to economic development and government functions.
Mr. Van Hoey

**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.
Mr. McIntosh

**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.
Staff

**472. Special Topics (3)**

Continuation of S.R. 471.
Staff

# PHYSICAL EDUCATION and 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.
JOHN STOHLER STECKBECK, M.S.

**Instructors**

MICHAEL J. CARUSO, B.A.
BARRY J. FETTERMAN, B.S.
ROBERT W. KENNEDY, B.S.
WALTER KING, B.A.
CHARLES R. MCNARON
MONROE C. NICHOLS, B.S.
STANLEY R. SCHULTZ, B.A.
JAMES WALTER SCIBLE III, B.S.
CHARLES F. TAYLOR III, M.A.
JOHN CALVIN WHITEHEAD, B.S.

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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 required 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:

A. Raise and maintain the physical standards of the University.

B. Develop and maintain a high level of all-around physical fitness so that the undergraduate student may more readily assimilate instruction.

C. Encourage regular and healthful exercise by the development of skills, techniques, and attitudes.

D. 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 upper-class 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, and rifle. In addition, there are freshman teams in all of the above sports.

## DEPARTMENT OF PHYSICAL EDUCATION AND INTRAMURAL SPORTS

The department of Physical Education and Intramural Sports has supervision and control of the required 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.

Freshman students are required to register for and engage in some form of activity under departmental supervision. This requirement calls for three hours a week in the gymnasium or participation in an organized sport. Sophomore, junior, and senior students are encouraged to continue their physical activities and participation in intramural sports.

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.

All freshmen are required to take a physical efficiency test for the purpose of classification and development. All freshmen are required to take a swimming test during the first week of regularly scheduled classes. In the gymnasium, opportunity is offered in the following activities: physical development, recreational swimming, beginners' swimming, boxing, fencing, apparatus exercises, life-saving, controlled weight lifting, badminton, and sports fundamentals. All undergraduate students must swim 75 feet

before their graduation. Students are encouraged to change activities whenever it is thought best for their all-around development.

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.

The following physical education courses are required of all physically qualified students:

**1. Physical Education (0)**
Freshman first semester. Three hours per week.

**2. Physical Education (0)**
Freshman second semester. Three hours per week.

## UNDERGRADUATE SCHOLARSHIPS AND LOANS

GENERAL STATEMENT. Lehigh University extends grant and self-help opportunities to deserving and promising students who otherwise would not be able to attend the University, to the extent that funds are available for such assistance. Last year, more than 700 students (approximately 22 per cent of undergraduate enrollment) were granted University assistance. Approximately $900,000 in scholarships, grants, and loans were awarded. In addition, outside assistance totaling over $700,000 was awarded to Lehigh students from programs sponsored by the Commonwealth of Pennsylvania, Army and Air Force ROTC, and many private and state sponsored organizations.

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 young men as funds will allow. An increasing number of students have been aided since the advent of the "package" concept of award making, 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.

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

ENDOWED AND SUPPORTED SCHOLARSHIPS, provided by individuals and by corporations either through endowments or by annual contributions and described in the following pages, 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, 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 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 National Merit Scholarship Corporation 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 are made on the basis of merit and need, at the discretion of the Committee on Undergraduate Financial Aid to the extent that loan 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 parent(s) 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 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 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 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 between $1000-$1500 annually with low interest and deferred repayment. Applications may be obtained at any banking institution with which the student's family does business.

ELIGIBILITY. Entering freshmen may apply for financial aid in accordance with instructions from the Office of Admission. 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 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 EOG and or CW-SP 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.

APPLICATION. Candidates not previously enrolled in the University should write to the Office of Admission; candidates who have been enrolled in the University one academic year or longer should apply in person to the Office of Financial Aid. Closing dates for filing applications are:

1. Entering freshmen and junior college transfer students—January 15.
2. Early Decision candidates—November 1.
3. Resident students—March 15.

Later applications for financial aid can be given consideration only if funds are available.

AWARDS. All awards are made by the faculty Committee on Undergraduate Financial Aid in accordance with policies and procedures established by that committee and announced through its Executive Secretary to students applying for financial aid.

### ENDOWMENT OF SCHOLARSHIPS

Undergraduate or graduate scholarships named to honor an individual or corporation may be established in perpetuity by arrangement with the board of trustees of Lehigh University. The income from this donation will be paid to the holder of the scholarship to be applied toward the payment of University fees. The University does not, however, guarantee that this income will be forever sufficient to pay such fees in full.

### DESCRIPTIONS OF ENDOWED SCHOLARSHIPS

#### The Annual Giving Scholarship Fund

Through the gifts of alumni, parents, friends, and companies to the 1959-60 Annual Giving Fund, this fund was established to assist young men to obtain the advantages of higher education. The income from this fund is to be used to award scholarships on the basis of financial need, character and personality, high scholastic achievement, and leadership qualities, and without restriction as to college or curriculum.

#### Atlas-Reinhold Scholarship Fund

Through its president, Paul B. Reinhold, '13, the Atlas Equipment Corporation of Pittsburgh, Pennsylvania, has established this scholarship fund. The income from this fund is used to provide scholarships covering tuition in such amounts as student need indicates, on the basis of character, intelligence, and leadership qualities.

#### Jack Barnett Scholarship Fund

This fund was established by Jack Barnett '54 in 1967, in recognition of the value of Lehigh University's contribution toward the training and education of young men. The income is to be used to award a scholarship to a worthy student on the basis of financial need, character and personality, scholastic achievement and leadership

qualities. Preference is to be given to a freshman who, if he remains qualified, will continue to receive this assistance until graduation.

#### Robert J. Bartholomew Memorial Scholarship Fund

This fund was established by the late Mary A. Bartholomew in memory of her husband, Robert J. Bartholomew '95. The gift is to be used for the purpose of providing scholarships for needy and deserving students with preference given to those who are residents of Bath, Pennsylvania, or of Northampton County, Pennsylvania.

#### The James S. and Bertha T. Bayless Scholarship Fund

James S. Bayless, M.E. '08, established this fund in 1963 to assist worthy young men to obtain the advantages of a higher education. The income from this fund is to be used to award scholarships to engineering students on the basis of financial need, character and personality, high scholastic achievement and leadership qualities. Preference is to be given to students from the Baltimore, Maryland area who enroll in the College of Engineering.

#### Frank Breckenridge Bell Memorial Scholarship Fund

This fund has been established by Mrs. Frank B. Bell as a memorial to Frank Breckenridge Bell, M.E. '98, Eng.D. (Hon.) '45 and trustee of Lehigh University from 1936 to 1949. The income arising from the fund is to be used for the purpose of awarding annually a scholarship for a student attending or about to attend Lehigh University. Primary consideration is to be given to the following factors: financial need, character and integrity, and capacity for creative or original thinking, preferably in the field of engineering.

#### The J. D. Berg Scholarship Fund

This fund was established by Mrs. J. D. Berg in memory of her husband, John Daniel Berg, M.E. '05, Eng.D. (Hon.) '47, who devoted many years to Lehigh University as alumnus and as trustee. An annual scholarship providing for tuition, fees, and an amount for books shall be awarded to a student who is in financial need and has prerequisites of character and personality, high scholastic achievement, and leadership qualities which merit the award. Preference shall be given to students residing in the West Pennsylvania district and who enroll in an engineering curriculum at Lehigh University.

#### Award of Bethlehem Fabricators, Inc.

Bethlehem Fabricators, Inc. established this scholarship fund in honor of the late Robert Parke Hutchinson, E.M. '04, and in recognition of his forty years of service to the company and devotion to his alma mater. It is hoped that these incentive scholarship awards from this fund will serve "to spread and implement his belief in the American tradition of private industrial development and his interest in the education of worthy young men to carry forward that tradition." This scholarship will be awarded annually to the engineering student about to enter his senior year who "has shown the most improvement during his sophomore and junior years," and under the rules of the Committee on Undergraduate Financial Aid.

#### The Bethlehem Fabricators' Scholarship Fund

This fund was established by Bethlehem Fabricators,

Inc., to provide tuition scholarships for students who are in need of assistance. Character and personality, high scholastic achievement, and leadership qualities shall be given consideration when these awards are made. Other qualifications being equal, preference shall be given to candidates applying from the counties of Lehigh or Northampton in Pennsylvania.

### Albert S. Blank and Gladys F. Blank
### Scholarship Fund

Albert S. Blank, Class of 1915, bequeathed one-third of his estate to Lehigh to establish a scholarship fund for engineering students. Under the terms of the will, 80% of the income from the endowment is to be made available for scholarships in engineering and the remaining 20% is to be credited to the balance of the fund.

### F. Edgar Bossard Scholarship Fund

F. Edgar Bossard, '28, established this fund by a bequest. The income is used to make awards to a student or students selected by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### The Brodhead Scholarship

Albert Brodhead, '88, left practically his entire estate to establish a fund for general University purpose. Part of the income of this fund has been designated as the Brodhead Scholarship in memory of Albert Brodhead; his father, Charles Brodhead, an early trustee of Lehigh University; his mother, Camilla Brodhead; and his sister, Kate Brodhead Wilbur. The scholarship is awarded by the Committee on Undergraduate Financial Aid to an undergraduate in the Department of Electrical Engineering.

### Eugene C. Brown Memorial Scholarship Fund

This fund was established by bequest of the late Blanche C. Brown in memory of her husband, Eugene C. Brown, E.E. '95. Awards from the income of this fund are made in accordance with regulations governing such awards.

### The Harvey M. Burkey Scholarship Fund Endowed by the American Metals Company, Limited

This fund was established by the American Metals Company, Ltd., in honor of Harvey M. Burkey, Class of 1906, and in recognition of his outstanding career in serving the Company with exceptional devotion and ability for over forty-five years. The income from the fund is to be used to award scholarships to qualified students seeking a bachelor's degree in metallurgical or chemical engineering.

### Class of '04 Scholarship Fund

Members of the Class of '04, on the occasion of their Golden Anniversary in June '54, established this scholarship fund as a memorial to the class. The income from the fund is to be used to award a senior scholarship on the basis of character, scholarship, qualifications indicating promise of future leadership, and extra-curricular activities. Financial need is not a requisite for the award.

### The William W. Coleman Fund

William W. Coleman, Met. '95 established this fund in 1951. The income provides annual awards in general equal to the amount of tuition, for undergraduates, preferably seniors in metallurgical engineering, on the basis of financial need, high scholastic achievement, character, personality, and leadership qualities.

### William Wheeler Coleman Memorial Scholarship

The Bucyrus-Erie Foundation, Incorporated has established a fund for this scholarship in memory of the late William Wheeler Coleman, Class of 1895, Chairman and President of Bucyrus-Erie Company for forty-six years. The income from the fund is used for the purpose of awarding a scholarship or scholarships to undergraduates in the College of Engineering. The awards, administered by the Committee on Undergraduate Financial Aid, are based upon financial need, character, personality, scholastic achievement, and leadership qualities. The number of awards each year depends on the income available from the fund.

### The Stewart J. Cort Scholarship

A gift to establish scholarships was made by Stewart J. Cort, El. Met. '06, Eng.D. (Hon.) '48, president of the Alumni Association, 1937-1938, and a member of the Board of Trustees from 1942 until his death in 1958. The income from this fund is to be used for scholarships for students seeking degrees in one of the engineering departments with preference being given to students in metallurgical engineering who meet the normal qualifications as to need, scholarship, character, and leadership.

### The William S. Cortright Memorial Scholarship

Mrs. William S. Cortright established in 1938 a fund, the income from which provides a scholarship annually in memory of her husband, who was graduated from Lehigh University in 1872. The award is designated for a student who is a resident of Bethlehem or the immediate vicinity and who is enrolled in the curriculum of mechanical engineering.

### The George C. Coutant Scholarship Fund

This scholarship fund was established by a bequest from Hedwig A. Coutant in memory of her husband, George C. Coutant, M.E. '00, to provide scholarship for meritorious students in need of assistance.

### The Eckley B. Coxe Scholarship Fund

Mrs. Eckley B. Coxe, the widow of a trustee who served Lehigh University from 1871 until his death in 1895, established this fund to aid needy and worthy students. The income from the fund is used for scholarships.

### Dorothy C. and Edward A. Curtis Scholarship Fund

The income from this fund, established by Edward A. Curtis, Class of 1925, is to be used for the purpose of awarding a scholarship or scholarships to worthy students attending Lehigh University. This award will be based upon financial need, athletic ability, character and personality, scholastic achievement and leadership qualities. Preference will be given to candidates applying from South Hunterdon Regional High School of Lambertville, New Jersey or any other suitable applicant residing in Hunterdon County or elsewhere in the State of New Jersey.

### The John R. W. Davis Memorial Scholarship Fund

This fund was established by Mrs. John R. W. Davis of Seattle, Washington, in memory of her husband, John

R. W. Davis, C.E. '91. The income is to provide for scholarships in civil engineering for meritorious students in need of financial assistance.

### Captain James B. Detrixhe Memorial Fund

This fund was established in 1966 by contributions received from 255 friends of Captain James B. Detrixhe, B.A. '62, of Bethlehem, who gave his life in Viet Nam while serving as an Airborne-Ranger Company Commander in the First Air Cavalry Division. While an undergraduate student at Lehigh, Captain Detrixhe was an outstanding athlete having won Eastern Intercollegiate Wrestling Association championships in 1960-61 and in 1961-62, the year in which he was co-captain of the most successful wrestling team in Lehigh's history. The income from this fund is to be used to award scholarships based on need, character and personality, scholastic achievement and leadership qualities, with preference to be given to a wrestler from Lehigh Valley area.

### The Alban and Eleanor Eavenson Scholarship Fund

This fund was established by Alban Eavenson, Chem. '91, as an expression of his interest in helping young men obtain a Lehigh education. The income from the fund is to be used to award scholarships with preference to students enrolled in either the chemistry or chemical engineering curricula.

### The Natt Morrill Emery Scholarship

Established in memory of the late Natt Morrill Emery vice-president and controller of Lehigh University, by an alumnus and former student of Dr. Emery's the Natt Morrill Emery Scholarship covers the full tuition fee. It will be awarded by Lehigh University every four years (or whenever it becomes vacant) to a graduate of the high schools of Richmond, Virginia, who during his scholastic career has exemplified in character and conduct the qualities of loyalty and ability which marked the services of Dr. Emery to Lehigh University.

### Harold Farkas Memorial Fund

The Harold Farkas Memorial Committee established an endowment fund to be known as the Harold Farkas Memorial Fund. The income from this fund is to be used for awarding a scholarship or scholarships which shall be accomplished by the regular agency of the University. Such award or awards shall be based upon financial need, character and personality, scholastic achievement and leadership qualities.

### The John T. Fuller Memorial Fund

This fund was established by Esther Fuller Warwick in memory of her father, John T. Fuller '03. The income from the fund is to be used to provide scholarships in engineering which are to be awarded to deserving students from Pennsylvania.

### Julian W. Gardy Memorial Scholarship Fund

This fund has been established as a memorial to the late Julian W. Gardy, '23. The income from the fund is used to award scholarships as determined by the Committee on Undergraduate Financial Aid on the basis of financial need, character and personality, scholastic achievement, and leadership qualities.

### The Alfred R. Glancy Fund

The late General Alfred R. Glancy, M.E. '03, Eng.D. (Hon.) '43, established this fund in 1949. The income provides for undergraduate scholarship awards made by the Committee on Undergraduate Financial Aid, in addition to the Alfred Noble Robinson Award of $1,000 annually to a selected faculty member in memory of General Glancy's grandfather.

### The Morris Goldstein Scholarship Fund

An endowed scholarship has been established through the gifts of Morris Goldstein '34. The income of the fund is to be used for a scholarship to an undergraduate in the College of Business and Economics.

### The Granite City Steel Company Scholarship Fund

The Granite City Steel Company, Granite City, Illinois, established this fund in 1951. The income provides annual awards for undergraduates in the College of Engineering, on the basis of financial need, character and personality, scholastic achievement, and leadership qualities.

### The Henry S. Haines Memorial Scholarship

Mrs. Henry S. Haines, of Savannah, Ga., established in 1889 a scholarship as a memorial to her son, Henry Stevens Haines, M.E. '87. By the terms of the bequest this scholarship is awarded to a student in the curriculum in mechanical engineering. The requirements governing the award of University scholarships apply likewise to this scholarship.

### Lillie Robb Hall Memorial Scholarship

The bequest for this scholarship came from the estate of the late William R. Hall, C.E. '02. The scholarship is awarded annually for a student's senior year in Civil Engineering and is based on character, scholarship, qualifications indicating promise of future leadership, and record in extra-curricular activities.

### James Clark Haydon Memorial Scholarship Fund

Mary Haydon Hansen bequeathed the residue of her estate to Lehigh University as a memorial to her father, James Clark Haydon. The gift is to be used for the purpose of providing scholarships for needy and deserving persons.

### The Samuel P. Hess Memorial Scholarship Fund

Recognizing the value of Lehigh University's contribution toward the training and education of young men, the family of Samuel P. Hess '10, of Detroit, Michigan, has established this scholarship fund as a memorial. The income from the fund shall be used to make awards based upon financial need, character and personality, scholastic achievement, and leadership, and leadership qualities. Preference shall be given to a student residing in the metropolitan area of Detroit, Michigan. The awarding of the scholarship or scholarships shall be accomplished by the regular agency as determined by the Board of Trustees at Lehigh University.

### Hughes Scholarship Fund

James E. Hughes, Lehigh '94, who died on July 25, 1958, bequeathed one-fourth of a trust under his will to Lehigh University to establish this fund. The Board of Trustees established this fund in memory of Mr. Hughes' generosity, with the income used to award scholarships to deserving undergraduates.

### Albert George Isaacs '04 Endowed Scholarship Fund

This fund has been established by Kenneth L. Isaacs, M.E. '25, as a memorial to his father, Albert George Isaacs, '04. The award covering tuition and an allowance for books and supplies will be made to a student selected by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### The Anna Carpenter Richards Isaacs Scholarship

This fund was established by Kenneth L. Isaacs, M.E. '25, as a memorial to his mother, Anna Carpenter Richards Isaacs. The income from this fund shall be used to provide scholarships on the basis of financial need, character and personality, high scholastic achievement, and leadership qualities, without restriction as to college or curriculum.

### The Kenneth L. Isaacs '25 Scholarship

Kenneth L. Isaacs, M.E. '25, established a fund to assist worthy young men to obtain the advantages of a higher education. The income is to be used to award scholarships to worthy students on the basis of financial need, character and personality, high scholastic achievement, and leadership qualities, without restriction as to college or curriculum.

### The Reese D. Isaacs Memorial Scholarship

Kenneth L. Isaacs, M.E. '25, established this fund as a memorial in honor of his grandfather, Reese D. Isaacs, and to assist worthy young men to obtain the advantages of a higher education. The income from this fund is used to award scholarships on the basis of financial need, character and personality, high scholastic achievement, and leadership qualities, and without restriction to college or curriculum.

### The Bernard H. Jacobson Fund

This fund was established by Bernard H. Jacobson, El. Met. '17. The income is to be used to provide financial aid, for one or more students in the College of Engineering who shall show financial need, good character and personality, high scholastic achievement, and qualities of leadership.

### Charles H. Jennings Scholarship Fund

The Charles H. Jennings Scholarship Fund was established under the will of Charles H. Jennings, M.E. '09, for the purpose of providing scholarship assistance for worthy students who might not otherwise have the privilege of obtaining a college education. The scholarships are awarded to students with financial need, scholastic achievement, high ideals, excellent character, and definite promise of future usefulness.

### The Henry Kemmerling Memorial Scholarships

These scholarships have been provided through the gifts of Henry Kemmerling, C.E. '91, M.S. '03. Preference in making the awards is to be given to graduates of the public senior high schools of Scranton, Pennsylvania. The scholarships are to cover the tuition fee of the holder thereof.

A scholarship award is to be renewed yearly to the initial holder thereof until he graduates, provided he remains in school and maintains a grade at least equal to the average of his class during the preceding year.

The following qualifications only are to be the basis of the award of the scholarship: (a) a good character, (b) need of financial assistance, (c) high scholastic ability. The awarding of these scholarships will be administered through the Committee on Undergraduate Financial Aid.

At the discretion of the Committee, each full scholarship may be divided into two or more partial scholarships so that two or more may benefit by any annual award.

### The Jacob B. Krause Scholarship Foundation

The Jacob B. Krause Scholarship Foundation was established under the will of Jacob B. Krause, B.A. '98, for the purpose of assisting needy students in the College of Arts and Science. Scholarships are to be awarded only to male students who maintain good scholastic standing and are in need of financial help.

### Lambert Scholarship Fund

This fund was established by Blanche B. Lambert under her will bequeathing one-third of her residuary estate to Lehigh University as a gift for endowment to be known as the Lambert Scholarship Fund in memory of her husband, Sylvanus E. Lambert, '89. The principal thereof and the net income therefrom is to be used by the University for loans and scholarships to needy students of character, ability, and promise at the University, and is to be administered by the Officials of the University currently in charge of administering scholarships and loans to students at the University, in a manner approved by the Board of Trustees of the University. Mrs. Lambert stated in her will, "Lehigh University offered the benefit of its teaching staff and equipment, tuition free, for four years to my now deceased husband; hence this bequest."

### The J. Porter Langfitt Scholarships

The I. A. O'Shaughnessy Foundation, Incorporated, established a fund of $50,000, the income from which is to be used to establish scholarships in honor of J. Porter Langfitt, B.A. '24, M.E. '25, president of the Alumni Association, 1954-1955, and an alumnus member of the Board of Trustees from 1956. The scholarships shall be awarded on the basis of financial need, character, personality, leadership qualities, and high scholastic achievement.

### The Lehigh Alumni of Tau Delta Phi Scholarship Fund

This fund was established by the Lehigh Alumni of Tau Delta Phi Fraternity in recognition of the achievements of the University and to provide for the continued growth of its educational program. A prominent portion of this fund was contributed by the Dale Memorial Committee as a memorial to the honor of the brothers Herbert Dale, class of 1933, and Robert Tiefenthal, class of 1935. In recognition of the special opportunities offered by Lehigh University for the education and training of young men, the income from the fund is to be used to award scholarships based on financial need, character and personality, scholastic achievement, and leadership qualities. Preference shall be given to any applicant who is an undergraduate member of Tau Chapter of Tau Delta Phi.

### The Lehigh Portland Cement Company Scholarship Fund

The Lehigh Portland Cement Company established this fund in 1952. The income from the fund is to be used for the purpose of awarding scholarships to undergraduate students on the basis of financial need, character and well

adjusted personality, intelligence, and above average potential for leadership.

### Arthur Lehr Memorial Scholarship Fund

The Arthur Lehr Memorial Scholarship Fund has been established under an agreement between Anne Lehr and Lehigh University. The awarding of the scholarship or scholarships shall be accomplished by the regular agency as determined by the Board of Trustees of Lehigh University. Such award or awards shall be based upon financial need, character and personality, scholastic achievement and leadership qualities.

### John W. Macartney '31 Memorial Fund

This fund was established by Zaida A. Macartney in memory of her husband, John W. Macartney, Jr., Business Administration '31. The income from this fund shall be used to award scholarships on the basis of financial need and scholastic performance.

### Alvan Macauley Scholarship Fund

This fund was established by Mrs. Alvan Macauley in honor of her husband, Alvan Macauley '92, who was chairman of the board of the Packard Motor Car Company. The income from this fund is to be used to award scholarships to worthy students in need of financial assistance.

### Albert B. Maginnes Memorial Fund

This fund was established through contributions received in memory of Albert B. Maginnes, B.A. '21, LL.D. (Hon. '65), member of the Board of Trustees from 1954 until his death in 1966. The income from this fund is to be used for scholarships.

### The Mart-Hammonton Scholarship

The late Leon T. Mart, M.E. '13, formerly president of the Marley Company of Kansas City, Missouri, established this scholarship fund in 1953. The income from the Mart-Hammonton Scholarship Fund is to support one continuous tuition scholarship in the College of Engineering at Lehigh University. Preference shall be given to graduates of Hammonton High School, Hammonton, New Jersey, or graduates of any of the public or private secondary schools of the greater Kansas City area — this shall include schools of Jackson County, Missouri, and Johnson County, Kansas. In the event that no suitable candidates from these areas are available the scholarship can be awarded at large.

### Alexander and Clara Maysels Scholarship Fund

Dr. Alexander Maysels, of Bethlehem, established this fund as a memorial to his wife, Clara Maysels. The awarding of the scholarship or scholarships shall be accomplished by the regular agency as determined by the Board of Trustees of Lehigh University. The basis of award shall be financial need, character and personality, high scholastic achievement, and leadership qualities regardless of race, creed, or color.

### R. L. McCann Scholarship

Raymond L. McCann, E.M. '17, has established a fund to assist young men with limited financial support to obtain an engineering education. The scholarship is to be awarded to a student seeking a degree in one of the engineering departments with preference being given to Metallurgical Engineering. The basis of the award shall be financial need, character, personality, leadership qualities, and scholastic attainment.

### Herbert Weymouth McCord Memorial Scholarship

Mrs. Celia M. Couch, Mrs. Henry Eccles, and Frank P. McCord have established this scholarship fund, as a memorial to their brother Herbert Weymouth McCord, C.E. '27. The income from this fund is to be used to award an annual scholarship to a senior student in the College of Engineering. The basis of the award shall be financial need, character and integrity, high scholastic achievement, and leadership qualities.

### The Fred Mercur Memorial Fund Scholarship

Friends of the late Frederick Mercur, of Wilkes-Barre, Pa., general manager of the Lehigh Valley Coal Company, desiring to establish a memorial of their friendship and esteem, and to perpetuate his memory, contributed and placed in the hands of the trustees of the University a fund called the Fred Mercur Memorial Fund. The income from this fund is awarded to students of the University.

### The Mansfield Merriman Scholarship Fund

This fund was established under the will of Bazena T. D. Merriman to provide a scholarship in civil engineering in memory of her husband. Dr. Merriman served as professor of civil engineering at Lehigh University from 1878 to 1907, during which time his textbooks were widely adopted by engineering schools in the country and translated into many foreign languages.

### The Henry L. Moses Scholarship

Mrs. Henry L. Moses established this fund as a memorial to her husband to assist worthy and deserving students. The income from this fund is used to make awards to a student or students selected by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### The Theophil H. Mueller '18 Scholarship Fund

This fund was established by the late Theophil H. Mueller, a corporate trustee of the University. The income is to be used to assist in defraying the expenses of some worthy student or students who are in need of financial assistance, provided, however, that if it is possible and advisable the student or students selected to receive such financial assistance shall be of the Moravian faith and preferably from Bethlehem, Pennsylvania, or its environs.

### Franklin C. Murphey Scholarship Fund

This fund was established under the will of Franklin C. Murphey, Bus. Ad. '32. The income from the fund is to be used to award scholarships to high school graduates who are legal residents of the State of Ohio. However, if there are no acceptable applicants from the State of Ohio, then the awards shall be made to any applicant under the regular requirements governing the award of other University scholarships.

### The Ray Sands Nostrand Memorial Scholarship

The Ray Sands Nostrand Memorial Scholarship was established by the late Benjamin Nostrand, Jr., M.E. '78, in memory of his son, Ray Sands Nostrand '17. The income

from this fund is awarded to students of the University. The requirements governing the awards of University scholarships apply likewise to this scholarship.

## C. Henry and Emily Nancy Offerman Scholarship

This fund was established by the late Emily N. Offerman in 1959. The income from this fund shall be used to provide scholarships to worthy students of good moral character, maintaining satisfactory scholastic grades and who require financial assistance to enable them to further their education.

## Charles L. Orth Scholarship Fund

This fund was established by Mrs. Emma P. Orth in memory of her husband, Charles L. Orth, E.E. '04, retired district sales manager, Allis Chalmers Manufacturing Company. The income from this fund is used for scholarships for needy and worthy students enrolled in Electrical Engineering.

## John Howell Powell (M.E. '04) Scholarships

In 1954 Mr. Powell of the Borough of Latrobe, County of Westmoreland, Pennsylvania, set up a Deed of Trust with the Mellon National Bank and Trust Company of Pittsburgh, the principal of which is to continue in perpetuity for scholarships to be awarded by Lehigh University, with first preference to be given to applicants who are from the Borough of Latrobe or who are graduates of the Mining and Mechanical Institute, Freeland, Pennsylvania.

## The Murtha P. Quinn Scholarship

Mr. Murtha P. Quinn, '78, left one-thirteenth of his residual estate to Lehigh University for the purpose of granting scholarship aid with preference given to students whose homes are in South Bethlehem.

## Isadore Raiff Memorial Fund Scholarship

The fund was established by the Raylass Department Stores, New York City, in honor and in memory of their late President, Isadore Raiff. The income from the fund is to be used to award a scholarship to worthy students in the College of Business and Economics. Preference will be given to candidates from the states of Georgia, New York, North Carolina, Tennessee, and Virginia.

## The Victor C. Records L. U. '98 Delaware Scholarship Fund

The income from this fund, established by Victor C. Records, Class of 1898, is to be used for the benefit of students attending Lehigh University who are in need of financial assistance to enable them to carry on or complete their studies at the University and who by character and application are deemed worthy of such assistance. Preference shall be given to residents of the state of Delaware with particular attention being paid to the counties of Laurel, Sussex, Kent, and New Castle.

## Elijah Richards Endowed Scholarship Fund

This fund was established by Kenneth L. Isaacs, M.E. '25, as a memorial to his grandfather, Elijah Richards. The awarding of the scholarship or scholarships shall be accomplished by the regular agency as determined by the Board of Trustees of Lehigh University. The basis of award for the Elijah Richards scholarship or scholarships shall be financial need, character and personality, high

scholastic achievement, and leadership qualities. Preference shall be given to students from Luzerne or Lackawanna Counties, Pennsylvania.

## The Benjamin DeWitt Riegel Scholarship

This fund was established by Mrs. Benjamin DeWitt Riegel as a memorial scholarship in honor of her late husband, M.E. '98. This award is available to undergraduates of any college or curriculum who qualify on the basis of financial need, character and personality, high scholastic achievement, and leadership ability.

## The Rust Engineering Company Fund

The Rust Engineering Company established this fund in memory of two of its co-founders, E. M. Rust, and E. J. Lee Rust, for the purpose of awarding scholarships to students in the College of Engineering of Lehigh University on the basis of financial need, character and well adjusted personality, intelligence, and above average potential for leadership.

## Frederick C. Seeman, Jr., Scholarship Fund

This scholarship fund was established by a bequest from Aringdale D. Seeman of Baltimore, Maryland, in memory of his son, Frederick C. Seeman, Jr. '27, who was killed in an automobile accident in 1927. Income from the fund is to be used to award scholarships to worthy students from the state of Maryland who are in need of financial assistance.

## Billy Sheridan Memorial Fund

This fund was established by the late Mrs. Inez J. Warriner, widow of R. Dexter Warriner, '24, who while a student wrestled under Lehigh's renowned coach, William Sheridan. The income from this fund is to be used for scholarships, with preference given to students who are wrestlers.

## Shipley-Humble, Inc. Scholarship Fund

This fund was established by York-Shipley Inc. of York Pa., through its president, S. H. Shipley, Ch.E. '32. The income is to be used to provide scholarships to worthy students in need of financial assistance enrolling in the College of Engineering, with preference being given to students from the County of York in Pennsylvania enrolling in the mechanical engineering curriculum.

## Donald B. and Dorothy L. Stabler Scholarship Fund

This fund was established by Donald B. Stabler, C.E. '30, M.S. '32, to provide scholarships at Lehigh for needy prospective students or undergraduates, the recipients being determined by their character, motivation, and personal achievements. In recognition of the financial aid received under this program while a student at Lehigh, each recipient is asked to sign a statement of intent that, after his graduation from college and insofar as financially able, he will make contributions to this fund equivalent to the aid which he received. Thus a student of a later college generation may enjoy the same financial aid which made it possible for the original recipient to attend Lehigh.

## The David R. Thomas Memorial Fund

This fund was established by Professor and Mrs. Harold P. Thomas after their son's death in a plane crash on South Mountain in June, 1950. Donations from friends and family have been included in the fund. The income is to be

used for tuition scholarships for one or more students who have completed at least one year at Lehigh University and are in need of financial assistance to complete their education. The award or awards will be made to students who exemplify in their lives the high ideals which were characteristic of David up to his untimely death.

### Helen A. and Nathaniel Thurlow Memorial Scholarship Fund

This fund was established under the will of Helen A. Thurlow, sister of Nathaniel Thurlow, '95. The income from the endowment is to be used for the awarding of scholarships by the regular agency of the University.

### Sonia and Alfred D. Tiefenthal Memorial Scholarship Fund

This fund was established by Alfred D. Tiefenthal for the purpose of awarding from income a scholarship or scholarships to a student or students enrolled in the College of Business and Economics. The awarding of the scholarship is to be accomplished by the regular agency of the University, and is to be based upon financial need, character and personality, scholastic achievement, and leadership qualities.

### Treadwell Corporation Scholarship Fund

The Treadwell Corporation of Easton, Pennsylvania, has established at Lehigh University the Treadwell Corporation Scholarship Fund for annual tuition scholarships in such number and amounts as the income will support. The scholarships are for students in mechanical engineering, with preference given to candidates from Lehigh and Northampton counties in the state of Pennsylvania.

### The Samuel Foster York Memorial Scholarship Fund

This fund was established by Warren W. York, B.S. '24, as a memorial to his father, Samuel Foster York. The income is to be applied towards tuition scholarships for needy and worthy graduates of Allentown, Pennsylvania, secondary schools who desire to pursue business administration courses at Lehigh University.

### The Luther Rees Zollinger Memorial Fund

The sister of Luther Rees Zollinger left the residue of her estate to Lehigh University to establish this memorial fund to provide tuition scholarships for worthy students who are in need of financial assistance.

## DESCRIPTIONS OF SUPPORTED SCHOLARSHIPS

### Air Force ROTC College Scholarship

The Air Force ROTC college scholarship program is designed to offer one, two, or three year scholarships to outstanding young men participating in the four-year Air Force ROTC program. These scholarships provide for free tuition, textbook allowance, and a $50 per month allowance for the period that the scholarship is in effect. These scholarships are provided for under the provisions of the ROTC Vitalization Act of 1964.

### Alcoa Foundation Scholarships

The Aluminum Company of America supports at Lehigh University several undergraduate scholarships. The University also receives a grant-in-aid to the amount of $125 per student recipient. The awards are to be made by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### The Allied Chemical Foundation Scholarship

The Allied Chemical Corporation, through its Foundation, supports a scholarship at Lehigh University for a student in chemical engineering. In making the selection the Committee on Undergraduate Financial Aid places emphasis upon intellectual capability, scientific ability, breadth of interests, and leadership qualities.

### Army 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 currently enrolled in the four-year ROTC program who are completing either their freshman, sophomore, or junior years of college.

### Frank Breckenridge Bell Memorial Scholarship

The Edgewater Steel Charitable Trust has established an annual scholarship of $1,000 in honor of Frank Breckenridge Bell, M.E. '98, Eng.D. '45, former chairman of the board of Edgewater Steel Company, and a trustee of Lehigh University from 1936-1949. The award is available to a student in any college or curriculum, on the basis of financial need, character and integrity, and capacity for creative or original thinking, preferably in the field of engineering.

### Carpenter Technology Scholarships

The Carpenter Steel Company makes available two scholarships for entering freshmen who are sons of employees of the Company and plan to major in specialized fields of engineering and science. The amount of the award, as determined by an analysis of the Parents' Confidential Statement, ranges from $250 to $1,500 annually. Scholarships may be renewed on recommendation of the Committee on Undergraduate Financial Aid.

### Chevron Oil Company Scholarship

The Chevron Oil Company has established a scholarship in the amount of $500 for a senior in chemical engineering. A cost-of-education grant of $500 is also made to the Department of Chemical Engineering in support of the scholarship. The award is made by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### Chevron Oil Company Scholarships
#### The California Company Division

The Chevron Oil Company has established a scholarship in the amount of $500 to an outstanding junior or senior for study in the Department of Geological Sciences. The award is made by the Committee on Undergraduate Financial Aid under the established rules governing the award of the University scholarships.

### Chevron Oil Company Scholarships
#### Geophysical Division

The Chevron Oil Company has established a scholarship in the amount of $500 for a freshman or sophomore who has expressed an interest in studying in the field of geophysics. The award is made by the Committee on Undergraduate Financial Aid under the established rules governing the award of the University scholarships.

### Henry Farmer Foundation

The Trustees of the Henry Farmer Foundation have established a scholarship fund in the amount of $10,000 to be expended for scholarships to students in the pre-medical program of the University. The awards are made by the Committee on Undergraduate Financial Aid under the established rules governing the awards of University scholarships.

### General Motors Scholarships

The General Motors Corporation in its program of aiding private colleges has made available to Lehigh University several undergraduate scholarships. These scholarships which are renewable range up to $2,000 annually depending upon "demonstrated need." In addition the University receives a grant-in-aid for each award.

### Kennecott Copper Corporation Scholarship Program

The Kennecott Copper Corporation has established an annual undergraduate scholarship in the amount of $1000 for a junior or senior whose program emphasizes Mineral Sciences at Lehigh University. The recipient is selected by the Committee on Undergraduate Financial Aid with the approval of Kennecott or a subsidiary company. Selection criteria include: proficiency in studies; enthusiasm, leadership, cooperativeness, initiative, ambition; good health and sturdy constitution; and financial need.

### The Lebovitz Fund Scholarship

Through the Lebovitz Fund, Samuel L. Lebovitz, E.M. '23, President of The Modern Transfer Company of Allentown, Pennsylvania, has established at Lehigh University a scholarship in the amount of $1,000 a year which is awarded annually by the Committee on Undergraduate Financial Aid. This award is made on the basis of high intelligence, financial need, and the qualities that give promise of leadership.

### Lehigh University Merit Scholarships

In cooperation with the National Merit Scholarship Corporation Lehigh University will annually award up to twenty four-year Merit Scholarships financed through the Annual Giving Program of the alumni. The National Merit Scholarship Corporation conducts the competition for these scholarships as well as all the 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 National Merit Scholarship Corporation 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.

### Lever Brothers Company Scholarship

The Lever Brothers Company has established two scholarships, one for a junior and the other for a senior in chemical engineering. A cost-of-education grant is also made to the Department of Chemical Engineering in support of the scholarships. The awards are made by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### Christian R. and Mary F. Lindback
#### Foundation Scholarship

The Trustees of the Christian R. and Mary F. Lindback Foundation have established a scholarship fund in the amount of $1,000 to be expended for scholarships to deserving students who are residents of one of the states of New Jersey, Pennsylvania, Delaware or Maryland, without regard to race or religious affiliation and who, "by reason of their scholastic attainment, character, personality, and all-around ability give great promise of benefiting therefrom and be useful and valuable citizens of their communities."

### Lubrizol Foundation

The Lubrizol Foundation has established a scholarship in the amount of $200 to be awarded to a sophomore, junior, or senior in Mechanical Engineering. Selection is to be based on financial need and ability.

### Pennsylvania Power & Light Company Scholarships

The Pennsylvania Power and Light Company, in its program of aiding both public and private colleges within its 29 county service area, has made available to Lehigh University 8 undergraduate scholarships, 4 of which are restricted to study in either electrical or mechanical engineering. Each scholarship is in the amount of $300 annually and is renewable. In addition the University receives a grant-in-aid for each award. The candidate for such a scholarship should secure an appropriate form from his secondary school counselor and should also complete the normal financial aid procedures outlined elsewhere in the catalog.

### Pitcairn-Crabbe Christian Education Scholarships

These scholarships have been provided by the Pitcairn-Crabbe Foundation for students with strong Christian motivation, pre-ministerial students, or those who plan to enter the fields of social work, religious education, or eleemosynary activities. Preference will be given to the sons of clergymen or educators.

### Residence Halls Scholarship Fund

The Residence Halls Council of Lehigh University has provided four scholarships in the amount of $500 each to be awarded to a freshman, sophomore, junior and senior living in the Residence Halls of Lehigh University. The recipient of the scholarship must continue his residence throughout the term of the scholarship.

### Schlumberger Collegiate Award

The Board of Managers of the Schlumberger Foundation of Houston, Texas, has made available to Lehigh University two undergraduate scholarships in the amount of $500 each with a further matching grant of $1,000 as a contribution to the University. The Foundation has designated this scholarship and matching grant as the "Schlumberger Collegiate Award." The basic requirements state that the student be of high academic standing in his junior or senior year in electrical or mechanical engineering, physics or geology, and that his program include at least twelve hours of study in electricity.

### Milton Roy Sheen Memorial Scholarship

Through its president, Robert T. Sheen, B.S. '31, Ch.E. '36, the Milton Roy Company of Philadelphia, Pennsylvania, has established a scholarship as a memorial to the founder of the company, Milton Roy Sheen. The Milton Roy Sheen Memorial Scholarship provides an annual award of $1,200. The scholarship is to be awarded to employees or sons of employees of the Milton Roy Company. If no candidates are available, the scholarship is to be awarded to either a junior or senior enrolled in the chemical engineering or mechanical engineering curricula.

### The Alfred P. Sloan National Scholarships

The Alfred P. Sloan Foundation, Incorporated, has granted Lehigh University eight of its national scholarships. Normally each scholarship will be for an amount equal to tuition plus an allowance for other college expenses. However, the University may award a lesser or a greater amount depending upon the financial need of the recipient.

Recipients of this scholarship shall be preferably students pursuing studies in mathematics, the sciences, engineering, or business administration. They shall also meet the regular requirements of financial need, high academic achievement, good character, and promising leadership qualifications.

### Special Awards

Recognizing the need of many worthy and able students for financial aid in addition to tuition scholarship, friends of Lehigh have made grants to the University for this purpose. From this fund one or two awards are made on an annual basis to students in the College of Engineering by the Committee on Undergraduate Financial Aid in accordance with its established policies.

### The Stauffer Chemical Foundation Scholarship

The Stauffer Chemical Company, through its Foundation, has established a scholarship in the amount of $1000 for a deserving senior in chemical engineering. An unrestricted grant of $2000 is also made to the Department of Chemical Engineering in support of the scholarship. The award is made by the Committee on Undergraduate Financial Aid under the established rules governing the award of University scholarships.

### Texaco Scholarships

Texaco, Inc., has provided undergraduate scholarships available to students who have successfully completed at least two years of college work in any of several fields which would prepare them for careers in the petroleum industry. The donor also grants to the University a cost-of-education supplement. The scholarships are restricted to citizens of the United States who have proven scholastic ability and who have demonstrated qualities of leadership as well as a recognition of the values of higher education, and who give evidence of good health and financial need.

### UNIROYAL Foundation Scholarship

UNIROYAL Incorporated, through its Foundation, has established a scholarship for a student who has successfully completed at least two years of college, who has need of financial assistance, and who has demonstrated interest in a career in industry. Also, the recipient must be willing to assume a moral obligation to repay over a reasonable period of time at least 25% of the scholarship aid received as worked out with the institution. In addition the University receives a grant-in-aid for each award.

### The Western Electric Fund Scholarships

The Western Electric Fund has established at Lehigh University three annual scholarships, to a maximum of $1,200 each, two to be awarded to undergraduate students in the College of Engineering, and one to an undergraduate in either the College of Business and Economics or the College of Arts and Science. The scholarships may be granted to an upperclassman or to a first or second year student if the University desires. The recipient shall be a United States citizen without regard to color, creed, or national origin.

## DESCRIPTION OF LOAN FUNDS

### W. Appleton Aiken Memorial Loan Fund

The Residence Halls Council of Lehigh University has provided the sum of $3,000 as an undergraduate loan fund. The administration of the loan fund is under the usual University agencies. Preference in the granting of all loans to be given to students residing in the residence halls of the University.

### C. S. Albright Loan Fund

In memory of Carl Samuel Albright, E.E. '11, his family has provided the sum of $2,500 as an undergraduate loan fund. The administration of the loan fund is by the Committee on Undergraduate Financial Aid, and is for the assistance of worthy students requiring financial aid.

### The Eckley B. Coxe Loan Fund

Mrs. Eckley B. Coxe, the widow of a trustee who served Lehigh University from 1871 until his death in 1895, established this fund in 1897 and continued to make contributions to it during her lifetime. The several gifts were invested, and the income from this principal has created a revolving loan fund in excess of $170,000 which is administered for worthy and needy students by the Committee on Undergraduate Financial Aid.

### John R. W. Davis Memorial Loan Fund

This fund was established by Mrs. John R. W. Davis of

Seattle, Washington, in memory of her husband, John R. W. Davis, C. E. '91. The income from the fund is to be used to make loans to needy and worthy students in the various branches of engineering at Lehigh University. The loans are to be administered by the Committee on Undergraduate Financial Aid in accordance with the principles used in administering the other loan funds of the University.

### The Frazier and Ringer Memorial Fund

The Frazier and Ringer Memorial Fund was established in 1906 by the late Robert H. Sayre in memory of Benjamin West Frazier, A.M., Sc.D., former professor of mineralogy and metallurgy, and Severin Ringer, U.J.D., former professor of modern languages and literature and of history, each of whom served Lehigh University for one-third of a century. The income from the fund and payments made by the former borrowers are available for loans to cover the medical and surgical care of worthy students.

### The Kenneth Hankinson, Jr., Memorial Fund

Mr. and Mrs. Kenneth Hankinson established this fund in memory of their late son, Bus. '50. The principal from this fund shall be used to grant emergency loans to deserving students of Lehigh University. Administration of the fund is at the discretion of the Dean of Students of the University.

### R. L. McCann Loan Fund

Mr. R. L. McCann, E.M. '17, established this endowment fund to provide income for loans to needy students of Lehigh University.

### George F. Pettinos Memorial Fund

An endowment fund has been established by George F. Pettinos, Jr. in memory of George F. Pettinos, M.E. '87. The income earned on the principal of the fund shall be used "to grant loans to students for tuition and fees." Repayments of the principal and interest on loans to students are also to be used to grant similar loans to students.

### The Edward W. Pratt Fund

Edward Williams Pratt, M.E. '90, bequeathed to Lehigh University the sum of $1,000 to be used "as a revolving fund for loans to students" to be administered at the discretion of the Dean of Students.

### The President's Fund

The President's Fund was established during the early years of the University for the help of deserving students. As payments are made by former beneficiaries they are immediately available for the assistance of students of the University.

### The Frank Williams Fund

Frank Williams, B.S. '87, E.M. '88, bequeathed to the University the greater part of his estate as an endowment, the income of which is lent to deserving students.

## GRADUATE SCHOLARSHIPS AND FELLOWSHIPS

Candidates for scholarships or fellowships must file a completed application with the Office of Admission, Lehigh University, Bethlehem, Pa. 18015, on or before February 1 preceding his enrollment. 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 on Graduate Record Examinations or other recognized examinations are desired. Each applicant must indicate the field of graduate study he wishes to undertake. Each applicant is automatically considered for all awards for which he is eligible. See page 90 for further information.

## SCHOLARSHIP DESCRIPTIONS

### The Daniel S. Whiteman Memorial Scholarship

The Reilly-Whiteman-Walton Company of Conshohocken, Pennsylvania, makes an annual grant to support this scholarship in memory of the late Daniel S. Whiteman, E.M. '17. It is awarded to a graduate student specializing in colloid chemistry or a related field.

### Graduate Tuition Grants

The Board of Trustees has authorized the annual award to graduate students, on the basis of superior qualifications and of need, of twelve Graduate Tuition Grants. These Grants are awarded to accompany certain research fellowships and provide for the remission of graduate tuition.

### Union Bank and Trust Company Scholarships

The Union Bank and Trust Company of Bethlehem, Pennsylvania, has established four scholarships in the College of Business and Economics. Each award is in the amount of $1250 and provides for a grant-in-aid to the University of $250.

## FELLOWSHIP DESCRIPTIONS

### RESEARCH FELLOWSHIPS AND SCHOLARSHIPS

### The William C. Gotshall Scholarship

A bequest from the late William C. Gotshall provides funds for as many as six scholarships to be awarded annually to worthy graduate students in any branch of engineering offered at Lehigh University. Appointment is for one year, with an annual stipend of $2400 or more, depending on the qualifications of the applicant, plus remission of tuition fees. No duties other than graduate study are required of the holders.

### The Alumni Fund Fellowship

The Alumni Fund for 1960 established an endowment, the income from which is to provide one or two graduate fellowships in any of the departments offering graduate study.

### The C. Kemble Baldwin Research Fellowship in Aeronautics

A fund established by Mrs. C. Kemble Baldwin as a memorial to her husband, C. Kemble Baldwin, M.E., '95 provides for the appointment of a research fellow in any

branch of science having a bearing on the field of aeronautics. One or two appointments are available each year.

### The Lawrence Calvin Brink Research Fellowship
### in Civil Engineering

A fund established by the late Mrs. L. C. Brink as a memorial to her husband, Lawrence Calvin Brink, C.E., '94, provides for the occasional appointment of a research fellow in civil engineering.

### The Henry Marison Byllesby Memorial
### Research Fellowships

In 1926 Mrs. H. M. Byllesby, widow of Col. H. M. Byllesby, M.E., '78, President of the Byllesby Engineering and Manufacturing Corporation, provided an endowment fund for the establishment of the Henry Marison Byllesby Memorial Research Fellowships in Engineering. The time of the holders of these fellowships must be devoted to graduate study and research work on some problem in electrical, mechanical, or hydraulic engineering. Usually two awards are made each year.

### The William L. Heim Research Fellowship in Chemistry

A research fellowship in chemistry was established by William L. Heim, B.S. in Chem., '02.

### The Garrett Linderman Hoppes Research Fellowship
### in Civil Engineering

A fund established by the late Mrs. Maria B. Hoppes in memory of her son, the late Garrett Linderman Hoppes, C.E., '83, provides for the occasional appointment of a research fellow in civil engineering.

### The Roy R. Hornor Research Fellowship in Metallurgy
### and Inorganic Chemistry

The income from a bequest by Roy R. Hornor, B.S., '99, provides for a research fellowship in either metallurgy or inorganic chemistry, the holder of which devotes his time to research under the direction of the faculty and to graduate study. While one fellowship generally will be granted to students in each of the two departments concerned, the appointment may be determined by the qualifications of available candidates.

### The Chester W. Kingsley Memorial Fellowship

This fund is a bequest by Mrs. C. W. Kingsley in memory of her husband for the education of young men of exceptional scientific ability. An annual stipend up to $2200 plus tuition is available for graduate study in engineering or science.

### The New Jersey Zinc Company Research Fellowship

The New Jersey Zinc Company provided funds in 1924 for a research fellowship to be known as the New Jersey Zinc Company Research Fellowship in any field in which the University offers a graduate major.

### The James Ward Packard Research Fellowship

The income from a bequest made by James Ward Packard, M.E., '84, provides for a research fellowship in any field in which Lehigh University offers work for the doctorate.

### The Charles W. Parkhurst Research Fellowship

A fund established by Mrs. C. W. Parkhurst as a memorial to her husband, Charles W. Parkhurst, E.E., '93, provides for the occasional appointment of a research fellow in any field in which the University offers a graduate major.

### The Student Chemistry Foundation Fellowship

In the spring of 1927, members of the class of 1930 established the Student Chemistry Foundation in honor of Harry Maas Ullmann, A.B., Ph.D., a member of the chemistry department from 1894 to 1938 and chairman of the department from 1912 until his retirement. Subsequent classes have contributed to this fund which now provides an annual research fellowship in chemistry or chemical engineering. Only Lehigh graduates are eligible for this fellowship.

### The Katherine Comstock Thorne Fellowship in Biology

The late Gordon Comstock Thorne of the class of 1916 endowed, in memory of his mother, a fellowship in biology, to be known as the Katherine Comstock Thorne Fellowship.

## ADDITIONAL FELLOWSHIPS

Certain fellowships are supported annually by various governmental agencies, foundations, learned societies and industrial organizations. Normally the fellow devotes full time to his academic program and receives a stipend plus tuition grant. Among those national fellowships available are the following:

### National Defense Act, Title IV

Fellowships are granted by the U.S. Department of Health, Education, and Welfare for award by Lehigh University to graduate students in various fields of study. The fellowship provides tuition, $2,400 to $2,800 and dependency allowance. The standard University fellowship form serves as application.

### National Institutes of Health

A large program of fellowships for U.S. students in the medical sciences and areas of the biological, physical and behavioral sciences provides tuition plus $2,400 to $2,800 and dependency allowance. Application should be made to the Career Development Branch, Division of Research Grants, National Institutes of Health, Bethesda, Md. 20014.

### National Science Foundation Traineeships

Several fellowship grants are awarded annually to U.S. graduate students for study in the mathematical, physical, medical, biological, and engineering sciences, economics, and psychology. Awards provide tuition plus $2,400 to $2,800 and dependency allowance. The standard University, fellowship form serves as application.

### Woodrow Wilson National Fellowship Foundation

Fellowships are awarded to first-year graduate students primarily in the humanities and social sciences, pursuing teaching careers. Awards provide nine months' tuition plus $1,800. Nomination must be made by a faculty member to the appropriate regional committee. For information, contact the Woodrow Wilson Foundation, Box 642, Princeton, N.J.

## Industrial-Foundation Fellowships

Among those fellowships supported by foundations and industrial concerns are the following:

**The Air Products and Chemicals Incorporated Fellowship**
in Chemical Engineering.

**The Air Reduction Company Fellowship**
in Engineering.

**The Allegheny-Ludlum Fellowship**
in Metallurgy.

**Althouse Chemical Fellows**
in Chemistry.

**American Society for Tool and Manufacturing Engineers Fellowship**
in Industrial Engineering.

**Azoplate Corporation Fellowship**
in Chemistry.

**The Louis Calder Foundation Fellowship**
in Chemistry.

**The California Oil Company Fellowship**
in Chemical Engineering.

**The Carpenter Technology Corporation Fellowship**
in Mathematics, Science, or Engineering.

**Thomas R. Caton Fellowship**
in Chemistry.

**The Esso Foundation Fellowship**
in Chemical Engineering.

**The International Nickel Company of Canada, Ltd. Fellowship**
in Metallurgy and Materials Science

**The General Telephone and Electronics Foundation Fellowship**
in Materials Research

**The Materials Research Fellowship**
in Materials Research.

**National Printing Ink Research Institute Fellowship**
in Chemistry.

**Paint Research Institute Fellowship**
in Chemistry.

**Texaco Fellowship**
in Chemical Engineering.

**The Union Bank and Trust Company Fellowship**
in Business and Economics.

**The United States Public Health Service (Water Pollution) Fellowship**
in Biology.

**The United States Steel Foundation Fellowship**
in Engineering.

**Samuel Geltman Fellowship**
$1,000 grant to a deserving student from the Lehigh-Northampton County area.

## PRIZES AND AWARDS

Student prizes and awards are announced at commencement exercises on Founder's Day, the second Sunday in October, and on University Day in June.

### Alumni Prizes

Funds are provided by the Alumni Association for the annual award of four prizes of $25 each. Two prizes are awarded to the highest ranking juniors in the College of Engineering, one to the highest ranking junior in the College of Arts and Science, and one to the highest ranking junior in the College of Business Administration.

### Medal of the Philadelphia Chapter, American Institute of Chemists

This medal is awarded to the academically highest ranking senior majoring in chemistry or chemical engineering.

### American Society for Testing Materials Student Membership Prize

The American Society for Testing Materials awards each year four student memberships to students who in their junior year have demonstrated interest and meritorious work in the engineering courses which are related to the American Society for Testing Materials.

### Bethlehem Fabricators Award

This tuition award is made to the senior who has shown the most improvement in academic achievement over previous years.

### The Robert W. Blake Memorial Prize

The Robert W. Blake Memorial Prize is awarded annually at the Founder's Day exercises to a freshman, upon his completion of one year of studies in the College of Arts and Science, who is recommended by the faculty of the College of Arts and Science as the most outstanding in high scholastic achievement and in promise of worthy leadership.

### The John B. Carson Prize

An annual prize of $50 was established by Mrs. Helen Carson Turner, of Philadelphia, Pennsylvania, in memory of her father, John B. Carson, whose son, James D. Carson, was a graduate of the civil engineering curriculum of Lehigh University in 1876. It is awarded to that senior in civil engineering who shows the most marked excellence in the professional courses of his curriculum.

### The William H. Chandler Prizes in Chemistry

Four annual prizes of $25 each, one in each class, for excellence in the chemistry and chemical engineering curricula were established by Mrs. Mary E. Chandler, of Bethlehem, Pennsylvania, widow of Dr. William H. Chandler who was professor of chemistry at Lehigh University from 1871 until his death in 1906.

### The N. I. Stotz and D. E. Pickert Choral Cup

The Choral Cup provided by Norman I. Stotz, Jr. '53 and Donald E. Pickert '53, is awarded to the outstanding senior participating in the choral organizations of the Department of Music.

### The R. K. Burr and J. D. Kirkpatrick Concert Cup

The Concert Cup provided by Richard K. Burr '53 and J. Donald Kirkpatrick '55, is awarded to the outstanding senior(s) participating in the instrumental organizations of the Department of Music.

### The Cornelius Prize

The Cornelius Prize of $25, established by William A. Cornelius, M.E. '89, and endowed by a bequest by his widow, Mrs. Eleanor R. W. Cornelius, will be awarded annually to the senior student in mechanical engineering who is judged to have profited most by his opportunities at Lehigh University. The award will be based 70 per cent on scholarship, 20 per cent on attainment in general culture, and 10 per cent on development in personality. To be eligible for the award, a student's scholastic standing must be in the top quarter of the class in the College of Engineering.

### The Philip Francis du Pont Memorial Prize in Electrical Engineering

The Philip F. du Pont Memorial Prize Fund was established in 1929 by L. S. Horner, E.E. '98. The annual income of this fund is awarded each year in the way of prizes, two-thirds to the highest ranking senior and one-third to the second highest ranking senior in electrical engineering.

### Fraternity Alumni Advisory Council Scholarship Improvement Award

This trophy is awarded to the Lehigh Fraternity chapter whose scholastic average for the year is most improved over the average for the previous year.

### The Gold-Hansen Trophy

The Gold-Hansen Trophy, provided by Stephen R. Gold and Robert A. Hansen, both members of the Class of 1960, is awarded to a student of at least four semesters' standing with the Lehigh University Band who has shown outstanding merit in other ways than musical or marching performance.

### Malcolm J. Gordon, Jr. Physics Prize

An annual award of $40.00 is made to the highest ranking sophomore majoring in physics with some extracurricular activity.

### The Hamilton Humanities Award

The Hamilton Watch Company awards an engraved electric watch each year to the senior engineering student who has most successfully combined proficiency in his major field of study in engineering with achievements (either academic, extra-curricular, or both) in the social sciences or humanities.

### The Bill Hardy Memorial Prize

An annual award of $100 is given by Mr. and Mrs. C. Edson Hardy in memory of their son to the junior who most nearly reflects the qualities that typified Bill Hardy, who was outstanding in many activities, academic and otherwise.

### Haskins and Sells Foundation Award

An annual award of $500 is awarded to that accounting student in the College of Business Administration or the

College of Arts and Science who after three years has demonstrated excellence in scholarship, professional potential, extra-curricular activities, and moral character.

### The Harold J. Horn Prizes

The heirs of Harold J. Horn, E.E. '98, established a fund, the income of which is used in the award of a first and second prize of $40 and $20 respectively for the two highest ranking juniors in electrical engineering.

### The Andrew Wilson Knecht III Memorial Award

This award is made each year to the member of the mechanical engineering class graduating in June who has exhibited the greatest potential for applying his technical training to practical application. The award is a specially designed medallion with hand engraving and enclosed in a leather folder and presentation case.

### The McClain Award for Meritorious Painting

The McClain Award for Meritorious Painting, consisting of a trophy and a fifteen ($15) dollar purchase prize, and provided by Mr. A. V. McClain, shall be presented to the student of painting in the Department of Fine Arts studio classes who completes the most meritorious painting during the academic year.

### The McClain Progress Award

The McClain Progress Award, consisting of a trophy and a fifteen ($15) dollar purchase prize, and provided by Mr. A. V. McClain, shall be presented to that student whose progress in painting in the Department of Fine Arts studio classes during the year shall be most marked.

### Merck Index Award

A copy of the *Merck Index* is awarded by Merck and Co., Inc. to a senior in chemistry who is an outstanding student, who has been active in student society affairs and who has promise of a successful career in chemistry in the judgment of the faculty of the Department of Chemistry.

### The Elizabeth Major Nevius Award

The Elizabeth Major Nevius Award was established by Walter I. Nevius, E.E. '12, "in loving memory of his wife, who profoundly admired young men of diligence, intelligence, aggressiveness and sterling character." The award of $500 shall be made annually to that senior enrolled in any five-year combination curriculum leading to two baccalaureate degrees who, upon completion of his first four years at Lehigh University and upon graduation with his class, shall be adjudged the most outstanding of the seniors completing work for their first baccalaureate degree and continuing to a second baccalaureate degree at Lehigh University, judged upon the basis of leadership, citizenship, and scholarship.

### The Pendleton Award

This silver bowl is awarded yearly to the student who has produced the most effective contemporary painting.

### The Pennsylvania Institute of Certified Public Accountants Prize

The Pennsylvania Institute of Certified Public Accountants awards each year an Accountants' Handbook to the senior in the College of Business Administration majoring in accounting who is outstanding in academic achievement and leadership.

### Phi Sigma Kappa Scholarship Cup

A scholarship cup, to be awarded for one year to the fraternity in the interfraternity council having the highest scholastic average for the preceding year and to become the permanent property of the fraternity winning it for three successive years, was provided by an alumnus of the Nu Chapter of Phi Sigma Kappa social fraternity in 1923.

New cups, to be awarded on the same terms as the original, have been provided by the local chapter of Phi Sigma Kappa.

### The Allen S. Quier Prize in Metallurgy

An annual prize of $15 has been provided by the daughters of the late Allen S. Quier in memory of their father, to be awarded to the senior who was adjudged by the staff of the Department of Metallurgical Engineering to have made the most progress in his work in that curriculum. While high scholastic standing is a requisite, the prize is awarded on the basis of progressive achievement in scholastic work, rather than an average rating.

### Bosey Reiter Leadership Cup

This award is given to the student whose leadership shall contribute primarily to the best interest of the University. Leadership is defined chiefly as moral character and shall combine intellectual ability and common sense. High scholarship and athletic achievements shall be included as cases of leadership, but neither is necessary or sufficient alone.

### Robert Ridgeway Senior Prize

The Robert Ridgeway Senior Prize is awarded annually to the Engineering senior with the highest cumulative average.

### The Senior Band Plaque

The Senior Plaque was established by the seniors on the executive committee of The Lehigh University Band to honor a member (s) of the senior class of the Band who has given outstanding performances in both marching and concert seasons for four years and who has not served in a major administrative capacity in the Band.

### The T. Edgar Shields Cups

The Shields Cups were established by the late Dr. T. Edgar Shields, former director of music at Lehigh. They are awarded annually to the students who are considered most outstanding in vocal and instrumental activities.

### Sigma Xi Undergraduate Research Award

An award of $50.00 and associate membership in the society is made each year to an undergraduate student by the Chapter Executive Committee from departmental nominations. The basis of the award is research potential and demonstrated achievement in research.

### Bradley Stoughton Student Award

This award is given to an outstanding senior student in the Department of Metallurgy. It consists of a certificate and twenty-five dollars awarded annually.

### Thornburg Mathematics Prize

The Thornburg Mathematics Prize is made possible through a bequest by the late W. P. Tunstall ('03) in honor

of the late Professor Charles L. Thornburg. The prize, consisting of a credit slip in the amount of forty dollars to purchase books in the field of mathematics or allied disciplines at the Book Store, shall be awarded to the senior with the most outstanding record in an advanced course in mathematics.

### Trustees' Scholarship Cup

The trustees of the University have provided a scholarship cup which is awarded for one year to the living group having the highest scholarship average for the preceding year. The trustees' scholarship cup becomes the permanent property of any living group winning it for three successive years.

### University Service Award

This award is given annually to the senior who has been adjudged to have contributed most during his career at Lehigh University, to promote student body unity, campus cooperation for worthy objectives, and loyalty to the alma mater. It is expected that the student selected shall be of sound character and satisfactory scholarship.

### William Whigham, Jr. Memorial Prize

This is awarded annually to the top ranking freshman in engineering, based on accumulative average of the first two semesters.

### The Elisha P. Wilbur Prizes

A fund was established by the late E. P. Wilbur, trustee of Lehigh University from 1872 until 1910, for distribution in prizes as the faculty might determine. The income from this fund is used to provide two awards.

WILBUR MATHEMATICS PRIZES. A first and second prize of $50 and $25 respectively to be awarded annually to the two highest ranking freshman engineers in the first year of freshman engineering mathematics completed at Lehigh University, as recommended by the Department of Mathematics.

WILBUR SCHOLARSHIP PRIZE. This prize of $200 is awarded annually to the sophomore with the best semester average for the sophomore year.

### The Williams Prizes in English

The late Professor Edward H. Williams, Jr., an alumnus of the University of the Class of 1875, established prizes for excellence in English composition and public speaking. The freshman, sophomore, and junior prizes are awarded by the faculty on the recommendation of the Department of English.

FRESHMAN COMPOSITION PRIZES. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded annually for the three best compositions submitted by freshmen of regular standing as required work in their English courses.

SOPHOMORE COMPOSITION PRIZES. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded annually for the three best compositions submitted by sophomores of regular standing as required work in their English courses.

JUNIOR COMPOSITION PRIZES. A first prize of $100, a second prize of $75, and a third prize of $50 are awarded for the three best essays submitted by juniors as part of the required work in their courses in English.

### The Williams Prizes in Extempore Speaking

A first prize of $100 and a second prize of $50 are awarded annually to freshmen of regular standing who excel in a contest in extempore speaking.

A first prize of $100, a second prize of $75, and a third prize of $50 are awarded annually to the winners in a contest in extempore speaking for sophomores, juniors, and seniors. Winners of first prizes are not eligible to compete in subsequent years.

### The Williams Prizes in Intramural Debating

Sums totaling $300 are awarded annually as prizes in intramural debating. Students engaged in this activity are organized under the direction of the Department of English into teams which compete in a series of debates. The sum of $200 is divided equally between the two members of the first place team and the sum of $100 is divided equally between the two members of the second place team. Winners of first place prizes are not eligible to compete in subsequent years.

### The Williams Prize in Dramatics

A prize of $100 is awarded annually to a Lehigh undergraduate whose interpretation of a role in a production of the Mustard and Cheese Dramatics Club is judged the most outstanding.

### The Williams Prize in Interpretive Reporting

A prize of $100 is awarded annually to a Lehigh undergraduate for meritorious reporting, published or unpublished, intended to interpret the meaning of events or developments which are significant in the life of the University.

### The Williams Prize in Creative Writing

A prize of $100 is awarded annually to the author of a meritorious short story, play, or poem submitted by a Lehigh undergraduate.

### The Williams Prize in Varsity Debating

A prize of $100 is awarded annually to a Lehigh undergraduate whose performance in intercollegiate debating is judged the most outstanding.

### The Williams Senior Prizes

The Williams Senior Prizes are awarded by the faculty on the recommendation of the committee on Williams Prizes.

1. First prizes of $200, second prizes of $100, and third prizes of $50 are awarded annually in each of the five fields of economics, English, philosophy, psychology, and history and government for dissertations submitted by regular members of the senior class on or before April 15.

2. The committee on Williams Prizes publishes, before the close of the academic year, a list of recommended subjects for dissertations; but a senior may submit a dissertation upon any other subject in the respective field if the subject has received the approval of the committee.

3. Each senior entering the competition shall submit to the committee his choice of subject and plan of work by November 15.

4. The awards are made by the faculty upon recommendation of the committee, but no award is made if in any case a dissertation does not meet the standards of merit established by the committee. This standard includes such points as excellence in thought, plan, development, argument, and composition.

### The Theodore B. Wood Prize

A prize of $50 is awarded, annually, under the terms of the will of the late Theodore Wood to the mechanical engineering student who has made the greatest scholastic improvement during the first two years of his college course.

### Prizes Awarded by Student Organizations

ALPHA A. DIEFENDERFER AWARD. In recognition of Professor Emeritus A. A. Diefenderfer's long service as faculty adviser to the organization, the Lehigh University Chemical Society established this award for the highest ranking senior in analytical chemistry. Each winner is presented with an engraved certificate, and his name is inscribed on a plaque given by the Society and displayed in the Chemistry Building.

ALPHA EPSILON DELTA AWARD. Alpha Epsilon Delta places the name of the pre-medical biology freshman with the highest cumulative average on a plaque in the Department of Biology.

ALPHA KAPPA PSI KEY. The Alpha Sigma Chapter of Alpha Kappa Psi, a professional fraternity in commerce, awards annually the Alpha Kappa Psi Scholarship Key to the senior student pursuing a degree in the College of Business Administration, who has attained the highest scholastic average for three years of collegiate work at Lehigh University.

THE ALPHA PI MU PRIZE. The Alpha Pi Mu honorary fraternity in industrial engineering awards each year an industrial engineers' handbook to a high-ranking sophomore with demonstrated interest in the industrial engineering curriculum.

AMERICAN CHEMICAL SOCIETY AWARD. The Lehigh Valley Section of the American Chemical Society awards a membership in the American Chemical Society and a subcription to a journal of this society to the highest ranking junior in chemistry or chemical engineering.

AMERICAN SOCIETY OF CIVIL ENGINEERS PRIZE. The Lehigh Valley Section of the American Society of Civil Engineers offers a prize of a junior membership in the American Society of Civil Engineers to the oustanding senior in civil engineering holding membership in the student chapter.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS JUNIOR MEMBERSHIP PRIZE. The Anthracite-Lehigh Valley Section of the American Society of Mechanical Engineers awards annually a prize of the value of $10 to an outstanding member of the Lehigh Student Branch of the ASME. This prize takes the form of junior membership for one year in the parent society.

ETA KAPPA NU PRIZE. The Eta Kappa Nu honorary fraternity in electrical engineering awards a handbook in electrical engineering to the highest ranking freshman in the curriculum in electrical engineering.

PHI ETA SIGMA AWARD. The Lehigh chapter of this national freshman honor society for men offers an award to the residence halls section with the highest freshman average for the fall semester each year. The trophy is a gift from Professor Harold V. Anderson of the Department of Chemistry.

PI LAMBDA PHI JOURNALISM AWARD. This is awarded to an undergraduate for outstanding editorial or business achievement in the field of publications. The trophies are made available by the local chapter of Pi Lambda Phi Fraternity.

PI TAU SIGMA PRIZE. The Pi Tau Sigma honorary fraternity in mechanical engineering awards each year a mechanical engineers' handbook to the highest ranking sophomore in the curriculum in mechanical engineering.

WILLIAM H. SCHEMPF AWARD. This award is made annually to the freshman who has shown outstanding ability and interest beyond the requirements of a normal freshman bandsman. It is made in honor of a former head of the Music Department by the Beta Sigma Chapter of Theta Chi Fraternity.

TAU BETA PI PRIZE. The Tau Beta Pi honorary engineering fraternity awards each year a slide rule or other prize of equivalent value to the engineering sophomore having the highest scholastic average.

## BUILDINGS AND GROUNDS

Most of the University's buildings are located on 200 acres on the north side of South Mountain overlooking the city of Bethlehem. The University recently acquired additional land on the slope of South Mountain and in Saucon Valley south of Bethlehem, bringing the total acreage to almost 700.

### Alumni Memorial Building

The Alumni Memorial Building, which is used as the administration building, was erected as a memorial to 1,921 Lehigh men who served in World War I and especially to the forty-six who gave their lives. The cost of construction was raised by subscription from about 1,700 alumni.

In the south wing of the building are the offices of the President, Provost, Vice-President—Administration, Treasurer, Dean of Students, Registrar, Buildings and Grounds, and the Accounting Office. The north wing contains the offices of the Bursar, Vice-President—Development, Admission, Development, Public Information, and the Alumni Association.

The lobby of the building contains art galleries in which exhibitions are presented throughout the academic year. There is one automatic elevator in the building.

A collection of boxwood trees and shrubs, donated by the late Robert Parke Hutchinson, Class of '04, landscapes the building and the nearby President's Home.

### Arboretum

The Arboretum is a tract of about eleven acres adjoining Sayre Park. It was established by a friend of the University as a tree nursery for the purpose of furnishing illustrative specimens of American trees and of cultivating trees and shrubs for the beautifying of the park. All of the more important species of North American trees are to be found in the Sayre Park and the Arboretum. A tract of seven acres adjoining the Arboretum has been planted with a variety of trees as an exhibition of indigenous tree culture.

### Business Economics and Urban Studies Center

The Business Economics and Urban Studies Center is housed in the former Delta Chi house which is located to the west of the University Center building. The building is a three-story brick structure, 36 feet long by 34 feet wide. It contains departmental and staff offices, seminar, and library, and rooms for statistical machine calculations.

### Central Heating & Refrigeration Building

The Central Heating & Refrigeration Building is a modernistic, one story, brick-glass and steel structure which was constructed in 1968-69 and put in operation November 17, 1969.

The building is approximately 48 feet by 152 feet. Housed in the building are three Babcock & Wilcox 40,000 lbs. per hour capacity steam boilers and one 458 ton Trane chilled water centrifigal compressor. This equipment furnishes steam requirements to heat the University academic buildings and residence halls and the refrigeration for Mart Library, Sinclair Laboratory, and the Hall of Liberal Arts. The present structure provides space for additional boiler installation in the future. The Honeywell control center records fire alarm reports from nine academic buildings, control electric steam valves in ten buildings, and tempera-

ture monitoring in two buildings. This unit has the capability of handling closed circuit security T.V., audio monitoring, etc.

### Chemistry Building

The Chemistry Building is a three-story, fire-proof sandstone edifice, 259 feet long and 44 feet wide, with a wing of 62 feet long and 42 feet wide, and with a three-story extension, 60 feet long and 37 feet wide. An additional three-story wing, 116 feet long by 52 feet wide, has been added to the east of the original building.

Laboratory space and equipment are provided for qualitative and quantitative analysis, inorganic chemistry, organic chemistry, sanitary chemistry, industrial biochemistry, colloid chemistry, X-ray analysis, gas analysis, the furnace assay of ores, industrial chemistry, and research in chemistry.

The trustees of the University named this building, exclusive of the newer east wing, the William H. Chandler Chemistry Laboratory in recognition of Dr. Chandler's thirty-five years' service as professor of chemistry, 1871-1906. The east wing was named the Harry M. Ullmann Chemistry Laboratory, in recognition of Dr. Ullmann's service as head of the Chemistry Department.

A special hydrogenation building annex has been erected on the outside southwest corner of the court adjacent to the stairway, for the prevention of spark explosions. Access is from the main lobby of the Chandler building.

### Christmas-Saucon Hall

Christmas-Saucon Hall is a three-story brick and stucco building. It has historic interest as the first building of Lehigh University. Asa Packer bought it from the Moravians. It was originally a church.

Renovation of Christmas-Saucon Hall was completed in 1958. The remodeled facilities provide headquarters for the departments of English and Mathematics.

The Office of Placement occupies the east wing and the north center section of the first floor.

On the first floor west wing are the common room, statistics laboratory, waiting room, and mathematics department offices.

The second and third floors provide a lecture room, seminar and conference room, and classrooms for the departments housed in the building, as well as faculty offices.

### Coppee Hall

Coppee Hall, named for the University's first president, is a three-story stone and stucco building. It contains the recitation rooms and offices of the departments of Government, History, International Relations, Fine Arts, and Religion. There is one large lecture room for common use, two art studios, and a print-making workshop.

### Eckley B. Coxe Laboratory

The Eckley B. Coxe Laboratory is a two-story sandstone building, 100 feet long and 75 feet wide, occupied by the Materials Research Center. The building was named in memory of Eckley B. Coxe, a pioneer and leader in mining engineering in this country. He was a close associate of the founder of the University and served as a trustee from its early days until his death in 1895. His widow established an endowment fund for this building.

The portion of the building occupied by the Materials Research Center includes the Electron Microscopy Laboratory and a Crystal Growing and Zone Processing Laboratory.

## Drown Memorial Hall

Drown Memorial Hall was erected by friends and alumni as a memorial to the late Thomas Messinger Drown LL.D., fourth president of the University, who served from 1895 to 1904. The building now houses the offices, lecture rooms, classrooms, and laboratories of the College of Business and Economics.

## Education Building

The School of Education is headquartered in a two-story, five-unit building along Brodhead Avenue, across from the west entrance to the campus. The building, formerly a private residence, has been remodeled to accommodate several offices, a conference room, and a library. The department had been in a one-story, 76x30-foot wooden frame structure at the east end of Packer Hall since April, 1947. That building was razed November 18, 1964.

## Fritz Engineering Laboratory

Fritz Engineering Laboratory, headquarters for the Department of Civil Engineering, was established on the campus in 1909 by the late John Fritz of Bethlehem, known as the father of the steel industry in the United States, who served as trustee of the University for 35 years.

The original building, which was designed and erected under the personal supervision of Mr. Fritz, has been used by the department for various research and industrial projects and for laboratory instruction in mechanics of materials and hydraulics.

In October 1955, a new addition to the laboratory was dedicated. It houses the world's largest universal hydraulic testing machine capable of applying a 5,000,000-lb. load to tension or compression members up to 40 feet in length and flexure specimens up to 120 feet long.

A floor-controlled 20-ton capacity crane, 70 feet above floor level, services the new south bay and the 5,000,000-lb. testing machine. A 10-ton crane services the original north bay with its 800,000-lb. machine, 2,000,000 inch-pound torsion machine, and other machines of smaller capacity.

Research and student instructional laboratories in hydraulics, soil mechanics, concrete, structural models, and sanitary engineering, as well as a separate student laboratory for materials testing, are provided.

The concrete laboratory includes storage bins for aggregates, together with equipment for making and storing all types of plain, reinforced, and prestressed concrete specimens.

The hydraulics laboratory has three levels, with pumps, tanks, turbines, weirs, and other appropriate apparatus used both for student instruction and industrial tests. Space is available for model test of spillways, rivers, channels, etc.

The laboratory machine shop is completely equipped with lathes, millers, drill-presses, grinders, power saws, and miscellaneous tools and equipment. The welding shop provides facilities for both electric arc and gas welding.

Other facilities include photoelastic stress analysis equipment, a photographic darkroom, research library, staff offices, seminar rooms, and a conference room.

## Fritz Lab Annex

A two story stone building, 70 feet by 20 feet in plan which was the original power house was renovated in 1968. The building presently houses professors and graduate instructors for the civil engineering department.

## Eugene Gifford Grace Hall

Eugene Gifford Grace Hall, named for the donor, who served as president of the Board of Trustees from 1924 to 1956, is a stone structure 120 feet wide and 180 feet long used for sports and recreation. The building contains an athletic palestra, which also serves as an assembly hall for the University, with a seating capacity of 3,000. The second floor is a large drill floor which is available for the major University dances and receptions. In addition, there are classrooms for the Music Department, dressing rooms for athletic squads, and classrooms and offices for the departments of Aerospace and Military Science.

## Hall of Liberal Arts

The Hall of Liberal Arts (1970) is a four story building 96 feet by 139 feet of contemporary design with native South Mountain stone, brick and limestone and tinted glass windows which houses classrooms and faculty offices.

The building has a three story central gallery with sky light which separates the offices from the class rooms and seminar rooms. The first floor contains the University Book Store. The second floor, with ground level entrance on the south side, contains offices of the Dean of the College of Arts and Science, plus facilities for the departments of Religion, International Relations, and Classics. The third floor contains the departments of History and Government. The English department is on the fourth floor.

The building has a conference room, seven class rooms and six seminar rooms. Each department has its own library, or "commons" room, for the purpose of cultivating interaction between students and faculty.

## Health Services Building

The Health Center is located on University Avenue diagonally across from Taylor Hall. Built in 1955, it is a three-story building constructed of native stone with the main entrance on University Avenue.

The main floor contains a waiting lounge, record office, clinical laboratory, examining offices, dispensary, X-ray, observation rooms, and an ear and throat room. On the ground floor are the physiotherapy department, library and conference room, and administrative offices.

The second floor contains two physicians' apartments and several rooms which are used for storage and filing of inactive medical records.

## Lamberton Hall

Lamberton Hall, named after Lehigh's second president, Robert A. Lamberton, was built in 1907. Originally built as a University Commons, it was renovated in 1958. It serves as the language headquarters of the College of Arts and Science, and provides rehearsal and practice facilities for Lehigh musical organizations.

The first floor contains a modern language laboratory and a large classroom as well as the headquarters for the Department of Romance Languages. The second floor provides classrooms for all language departments and offices for the department of German.

Two indoor rifle and pistol ranges used by the military department are located in a section of the ground level. The remainder of the ground floor is used as headquarters for Mustard and Cheese, Lehigh's student dramatic organization.

### Linderman Library

Linderman Library is a five-story building of native stone, with limestone trim, in the collegiate Gothic style of architecture. It incorporates a part of the original library building, erected in 1877 by Asa Packer and named in memory of his daughter, Lucy Packer Linderman. The more modern section of the building was opened in 1929.

The main floor is occupied by the reading room, offices of the library staff, a portion of the book stack, and the large lobby, where the loan desk, reference department, and public card catalog are located. The upper floors contain seminar rooms, the Rare Book Room and the Honeyman Collection. The offices of the Office of Research are located on the ground floor, east end; and the office of the Dean of the College of Arts and Science the ground floor, west end. The Administrative Systems and University Publications offices are located on the third floor, west end. The remainder of the building is devoted to book stacks, of which there are four floors.

### The Mart Memorial Library

The Mart Library (1969) is a three story contemporary structure 130 feet long by 98 feet wide of brick trimmed with limestone and slate over a steel frame which houses the most advanced electronic devices employed in library and information sciences. The building has a book capacity of 150,000 volumes, and seating for 350.

The Mart Library includes an all night study room, Information Science Laboratory, a Programmed Learning Room, an automated circulation system, and closed circuit television accommodations.

Mrs. Leon T. Mart contributed the largest individual gift to Lehigh for the structure. The structure was named after two deceased alumni from Shawnee, Kansas. They are the late Leon T. Mart, and the late Thomas L. Mart, father and son respectively.

### The Ordnance Laboratory

The facilities of the departments of Aerospace and Military Science, located in Eugene Gifford Grace Hall, have been augmented by a temporary one-story frame structure, 60 feet long and 25 feet wide. This building contains Army and Air Force ROTC supply storage facilities and garage space.

### James Ward Packard Laboratory of Electrical and Mechanical Engineering

The late James Ward Packard, who was graduated from Lehigh University in 1884 with the degree of mechanical engineer, and was the designer of the first Packard motor car and founder of the Packard Motor Car Company of Detroit, Michigan, and of the Packard Electric Company, of Warren, Ohio, donated $1,200,000 for the erection and equipment of an electrical and mechanical engineering laboratory, which was completed in 1929.

This building, named for the donor, is a five-story steel-framed sandstone structure 225 feet long and 180 feet wide. The lobby is finished in Italian travertine. The halls throughout the building are wainscoted with Tennessee marble. An auditorium on the first floor with a seating capacity of 622 is equipped with still and motion-picture apparatus.

The western half of the building contains the offices, classrooms, research rooms, and laboratories of the Department of Electrical Engineering. The eastern half of the building houses the departments of Mechanical and Industrial Engineering with classrooms, drawing rooms, offices, research rooms, shops, laboratories, instrument rooms, and a photographic dark room.

The laboratories of the electrical engineering department include four analog computers; two small digital computers; a shielded room and facilities for noise measurement of devices and systems; a large assortment of conventional and sampling oscilloscopes, pulse and sinusoidal signal sources, analyzers and measurement equipment that span the spectrum from dc to ultra-high frequency; a large assortment of electronic components and integrated circuits; a variety of microwave generation and measurement equipment, mostly X-band; an optical spectrometer; various digital system blocks; an ac power network analyzer for the simulation of a power system with six generators, sixteen load units and sixteen transmission-line sections; an assortment of ac and dc rotating machines.

The main mechanical engineering laboratory contains a modern oil-fired steam boiler, turbo-generator sets with condensers and auxiliaries, dynamometer test stands for steam turbines and reciprocating engines, steam jet refrigeration equipment with a barometric condenser, along with various types of pumps and flow-measuring instrumentation. Equipment associated with the compression and flow of air includes two reciprocating compressors, an axial flow fan with adjustable blades on rotor and stator and dynamometer drive, ventilating fans and an air conditioning unit adaptable for extensive testing. The internal combustion engine laboratory features a supercharged variable compression engine of CFR type, completely instrumented for tests. Another variable compression CFR type engine may be adapted for either spark or compression ignition. Strain gage-type pick-ups are available for study of pressure variations. Dynamometer equipment is available for tests of engines of the automatic type. A diesel test stand has fuel-measuring facilities and a strain gage-type torque meter. An instrumentation laboratory provides means for studying the characteristics of the instruments associated with the measurements basic to mechanical engineering. For work in experimental stress analysis a 60,000 lb. universal testing machine is available along with strain gage equipment, oscilloscopes, and two polariscopes for photoelastic investigations. For vibration and balancing studies, the equipment includes vibration velocity meters, a displacement indicator, recording vibrometer, electromagnetic torque meter, and portable balancing equipment.

The manufacturing processes laboratory contains the most modern machine tools, including two 20-h.p. 16" engine lathes, a 20-h.p. turret lathe, two milling machines, large drill press, and auxiliary grinding equipment for the

maintenance of cutting tools. This laboratory is fully equipped with machinability analog computer, profilometer, dynamometers and recorders, optical comparator, and other precision measuring equipment for laboratory and experimental work in metal machining.

The Computing Center located on the ground floor has a CDC 6400 solid-state computing and information processing facility and is equipped with seminar facilities and a conference room.

## Packer Memorial Church

Packer Memorial Church in which religious services are held, was the gift of the late Mrs. Mary Packer Cummings, daughter of the founder of the University. It was built in 1887. Occasional musical recitals and the annual Bach Festivals are held in this building which contains the Starkey Memorial Organ. The Catacombs, student-operated coffee-house, is located in the basement.

## Physics Building

The Physics Building is a five-story sandstone structure, 240 feet long and 44 to 56 feet wide. In addition to offices, classrooms, and lecture rooms, there are laboratory rooms for undergraduate and graduate exercises, laboratories for research, a reading room, machine shop, glass-blowing shop, electronic shop, constant-temperature room, chemical preparation room, and dark rooms.

## Henry Reese Price Hall

Henry Reese Price Hall, named in honor of Dr. Henry Reese Price, an alumnus of the University of the Class of 1870 and late president of the board of trustees, provides offices and seminar rooms for the departments of classical languages and social relations. It formerly furnished accommodations for 35 students and was remodeled to service as an academic office building in 1966.

## Saucon Valley Fields

These facilities are located on a 550 acre tract in Saucon Valley, of which approximately 120 acres include the following: an all-weather track, lacrosse field, soccer field, nine green grass-tex composition tennis courts, freshman and varsity baseball fields, a freshman football field, varsity practice football field, one lighted field, eight intramural football fields and eight intra-mural softball fields. The fields were put into service during the 1963 fall season. The freshman baseball field is a generous gift of the Class of 1942.

## Sayre Observatory

Sayre Observatory was the gift of the late Robert H. Sayre, one of the original trustees of the University.

The observatory contains three rooms on the first floor which house animal laboratories for research and teaching in the Psychology Department.

The land upon which the observatory stands, consisting of seven acres adjoining the original grant, was presented to the University by the late Charles Brodhead of Bethlehem.

## Sayre Park

Development of the mountainside on the University grounds was effected through the donation in 1909 of the sum of $100,000 by the children of the late Robert H. Sayre, to be used in the development of Sayre Park as a memorial to their father, who was a trustee of the University from its foundation until his death in 1907.

## Sayre Park Field

Approximately $8\frac{1}{2}$ acres of intra-mural playing fields located on the top of South Mountain at the southeast corner of Sayre Park, these playing fields are completely enclosed by cyclone fence affording athletic activity to students near the fraternity houses. Area includes a one story block building with masonry veneer, 24' 2" X 16' 2" with toilet facilities and storage area, constructed in 1961. Students began using these facilities in 1962.

## Service Building

The Service Building, headquarters of the Department of Buildings and Grounds, consists of one main building, a five-story brick structure 160 feet long by 40 feet wide and an annex, a one and one-half story brick structure 160 feet long by 40 feet wide. Located at Adams and Fourth Streets, it is two blocks from the University campus.

The main building is used chiefly for the storage of maintenance materials and supplies, lumber, building materials, plumbing and heating supplies, and electrical supplies. A freight elevator 20 feet by 10 feet is used to handle materials to the various levels. The annex houses the various maintenance shops, carpenter shop, tinsmith shop, paint shop, and cement mason's shop, along with the materials used by the trades.

## Francis MacDonald Sinclair Memorial Laboratory

The Sinclair Laboratory (1970) is a three story brick, field stone and limestone structure 145 feet long by 63 feet wide containing approximately 35,000 square feet designed to serve graduate and research education.

The laboratory provides space of 70 people, including faculty, graduate students, and supporting staff with offices interconnected with laboratories. The library and conference center, auditorium (patterned after the Assembly Hall of the United Nations), seminar room, lounge, kitchen and catering facilities are located on the ground floor. The two upper floors contain research laboratories and personnel offices devoted to colloids, optics, color physics, rheology, printability, wetting, dispersion, fracture mechanics, gas absorption, calorimetry, electron spin resistance and catalysis. There are supporting facilities of shop, glass laboratory and sample preparation room.

Funds for the construction included $662,300 from the bequest of Mrs. Jennie H. Sinclair; U.S. Office of Education grant of $450,000; and $340,000 in gifts from printing ink manufacturing companies and other research sponsors and individuals.

## Taylor Field

An athletic field more than nine acres in area is provided for the accommodation of students who participate in the various outdoor sports. The stadium, located on the lower level, provides football and baseball fields, surrounded by concrete stands having a seating capacity of 12,000. New steel stands were erected in 1953 above the south concrete stands providing 4,000 more seats for a total seating capacity of 16,000. A new press box, rest rooms, and concession booths under the steel stands were erected. On the upper level there is a practice field for football, baseball, lacrosse,

and soccer; also a quarter-mile track and a 220-yard straight-away.

### Taylor Gymnasium and Field House

In 1913, Charles L. Taylor, E.M. '76, donated to the University the funds for the erection of a gymnasium and field house.

These buildings were remodeled, re-equipped, and expanded as one of the major projects of the Lehigh Progress Fund.

Taylor Gymnasium, which adjoins the athletic field, is a building 222 feet long and 73 feet wide. It has been expanded by the addition of a new swimming pool measuring 75 by 42 feet, and a new gymnasium measuring 94 by 77 feet. The new swimming pool ranges in depth from five to ten feet, and includes a large gallery for spectators, an observation room below the water line, and the latest filtration equipment.

Included in the renovation of the old buildings and in the new construction are locker facilities for 2,600 students a faculty locker room, coaches' locker room, five basketball courts, weight room, fencing room, golf practice room, wet and dry steam rooms, and a specially designed wrestling room. Also included are a well-equipped first aid room for physical education activities, corrective exercise gymnasium, trainer's room, and class meeting rooms.

Athletic, Physical Education, and business offices were incorporated in the new construction. Improved heating is furnished by electric blowers. Framed pictures of all athletics teams grace the halls of this floor and stair halls.

The former entrance way has been transformed into a trophy room measuring 26 by 55 feet as a repository for athletic prizes and awards. The third floor addition, known as the Samuel E. Berger Room, the gift of Mr. Samuel Erwin Berger, '89 has also been remodeled.

### Town Students Center

In 1969 the University building at 532 Brodhead Avenue which had served as the Delta Chi fraternity house became available as a Center for Town students. The building is operated by Town Council and serves as a hub of student activities and social life for students who live in town. The building provides social areas, study areas, meeting rooms, and recreational facilities.

### The University Center

The University Center unites the original exterior lines of Packer Hall (215 feet long, by 60 feet wide), eliminating most of the original structural wood construction, substituting steel girders, steel columns, and I beams, with a new three-story stone addition connected and running parallel with new-windowed, old Packer Hall, this addition being 185 feet long, by 53 feet wide.

The basement section of the east wing contains the offices and classroom of the Division of Journalism and the facilities of The Brown and White, The Epitome, and radio stations WLRN and WLVR.

In addition to executive and business offices for each of the publications and radio stations, the facilities include a large news room with twenty typewriters, a photographic darkroom, a teletype room, three modern, fully-equipped broadcasting studios, an engineering control room, an electronics workshop, and a library containing some ten thousand recordings and tapes.

To the west of the publications area is a large game room, a stereo listening and piano practice room, a television lounge, and the headquarters of the Student Systems Development Organization (a group interested in satellite tracking, space communications, control systems and computation, and electronics and circuit design). The basement area of the new section is taken up entirely by service areas for the Dining Services.

On the main floor, east end, of the center, are the information desk, the Student Activities Office, and the offices of the Chaplain and the Dean of Student Life. The remainder of the floor is devoted to the dining services, including the main kitchen, cafeteria, two dining rooms, each of which will accommodate approximately two hundred and seventy-five people.

The second floor houses the central files of student organizations, the office of Arcadia (the student council), and provides meeting rooms. Adjacent to the meeting rooms are the offices of the Coordinator of Community Relations and Volunteer Services (including the Volunteers Council) and an Assistant Dean of Student Life. West of this area may be found the Black Culture Center which is maintained for the University community by the Organization for the Advancement of Afromanity, and beyond this may be found the student lounge, bookstore, Snack Bar, and a room for cards and chess. There is a balcony affording a fine view of Bethlehem north of the lounge. The building may be entered on the south side at the level of this floor.

The faculty lounge, card and writing room, and a private dining room are on the third floor, east, of Packer Hall, and in the center section is the faculty and guest dining room which retains some of the architectural features of the room's initial use as the University Chapel. The third floor of the addition includes a completely equipped kitchen for service to the several dining areas on this floor, and two large multi-purpose rooms which can be used for dances, lectures, recitals, meetings, and banquets. Folding partitions permit one room to be divided into two smaller rooms and the other room into four. Both rooms are equipped with public address facilities and one has in addition projection equipment, a sound system, and a permanently installed screen for motion pictures. At the west end there is an additional meeting room which may also serve as a private dining room. There is a balcony north of one multi-purpose room, and in the tower of Packer Hall is a small, handsomely appointed, private dining room.

There is a fourth floor of Packer Hall at the east end only. The facilities here include two small meeting rooms, a large meeting room.

There are three automatic elevators in the building.

### Varsity House

The Varsity House is a two-story locker building, 121 by 82 feet in size. It contains offices for coaches, a doctor, and a trainer, a room for game officials, locker and shower rooms for home and visiting teams, and rooms for the storage and issue of equipment. This building was dedicated in June, 1963 and is the first of the buildings in the Saucon Valley Fields which will house the athletic facilities in the future.

### Whitaker Metallurgy and Chemical Engineering Laboratory

This building opened in the fall of 1965 honors Dr. Martin

D. Whitaker, the eighth president of the University. The departments of Chemical Engineering, Metallurgy and Materials Science and the Office of the Dean of the Graduate School share the 90,000 square feet of floor space. In addition to faculty offices, a classroom lecture wing, featuring an auditorium-lecture hall with a seating capacity of 225, undergraduate and graduate laboratories, and a machine shop, there are many specialized facilities. These include: for the department of Chemical Engineering—high pressure research and reaction kinetics, analog computation, process control, thermodynamics and analytical studies; and for the department of Metallurgy and Materials Science—metallographic, electron microscope, microprobe and x-ray laboratories, "solid state" materials laboratories, chemical, physical and mechanical metallurgy laboratories, and dark rooms.

### Williams Hall

Williams Hall, the donation of the late Dr. Edward H. Williams, Jr., '75, was so named by the trustees of the University in recognition not only of this gift but also of Dr. Williams' long, continued, and important service to the University as professor of mining and geology.

Originally a three-story brick building, 186 feet long and 70 feet wide, Williams Hall was rebuilt as a four-story building after it had been severely damaged by fire in January, 1956. It contains the offices, classrooms, laboratories, department libraries, and special collections of the departments of Biology, Geology, and Psychology.

Williams Hall Annex contains some of the research facilities of the departments of Biology and Psychology. This concrete and brick structure is connected to Williams Hall by a bridge passage between the third floor of the annex and the second floor of Williams Hall.

The northern portion consists of a three-story section, 35 feet long and 25 feet wide, which houses animal quarters together with aquatic-biology, virology, and bacteriology laboratories of the biology department. The entire third floor is a green house.

The southern portion, a single-story section, 35 feet long and 21 feet wide, contains the bioelectric research laboratory of the Psychology Department. This laboratory has electrically shielded and sound proofed recording and instrument rooms, an operating and work room, photographic darkroom, and an electronics shop.

### THE RESIDENCE HALLS

Six residence halls are located on the campus. These modern structures provide living accommodations for approximately 1,400 students. They are located near the center of the campus within walking distance of the Student Health Services Building, the University Center, and the classroom buildings.

### Centennial Houses

A complex of six residence halls in three three-story buildings. The Centennial Houses were occupied in September, 1965. The complex houses 264 upperclassmen. It is located just east of the Freshman Quadrangle, overlooking Taylor Stadium. Six former faculty members and administrators were honored by the naming of individual units in the Centennial Houses complex for them. The individual houses are: Charles G. Thornburg; Natt M. Emery; C. Maxwell McConn; E. Kenneth Smiley; Wray H. Congdon and H. M. Leavitt. Each unit provides the atmosphere of a small living group, accommodating 44 students in two-man sleeping and study rooms located on the second and third floors. The ground floor of each unit contains a large living room, a library, and recreation and game room areas for students living in the individual housing unit.

### Dravo House

Dravo House, a five-story fireproof residence hall completed in 1948, provides accommodations for approximately 280 students. The building was made possible by the alumni and friends of the University through their contributions to the Progress Fund. It is named in memory of Francis R. Dravo and Ralph M. Dravo, former University trustees. Each of the four-wing structures which compose the building has its own lounge, and the center unit has a lounge and reception room for visiting friends. There are rooms for one, two, and three students.

### Henry Sturgis Drinker House

Henry Sturgis Drinker House, named for the University's fifth president, was completed in 1940. It is a four-story fireproof residence hall with accommodations for 190 students. It has rooms for two and three students, and a spacious lounge.

### McClintic-Marshall House

McClintic-Marshall House was completed in 1956, providing accommodations for 296 upperclass students. The building consists of three student living floors each with 48 double rooms, two section-president rooms, a lounge, and two special purpose rooms. The ground floor holds the office of the Director of Residence Halls, the House president's and Residence Halls Council president's suite, and a large recreation room.

### Charles Russ Richards House

Charles Russ Richards House, named in honor of the sixth president of the University, was completed in 1938. It is a four-story fireproof residence hall accommodating a total of approximately 210. The building contains a spacious lounge.

### Charles Lewis Taylor Hall

Charles Lewis Taylor Hall, the gift of Mr. Andrew Carnegie, is a three-story concrete residence hall with accommodations for approximately 170 students, the majority of whom are housed in three-room suites, three to each suite. The building was named Taylor Hall by Mr. Carnegie in honor of Charles L. Taylor, his former partner in business, a graduate of the University in the Class of 1876 and a trustee of the University. The building was completed in 1907.

## ACADEMIC OBSERVANCES

BACCALAUREATE SERVICES. Baccalaureate Services were held Sunday afternoon, June 8, 1969 in Eugene Gifford Grace Hall. The sermon was delivered by the Right Reverend Dean Theodore Stevenson, S.T.D., Bishop of the Episcopal Diocese of Harrisburg.

UNIVERSITY DAY. University Day was observed Monday morning, June 9, 1969 in Eugene Gifford Grace Hall. The address to the graduating class was delivered by The Honorable Harold Everett Hughes, United States Senator from Iowa. Honorary degrees were conferred as follows: The Right Reverend Dean Theodore Stevenson, Bishop of the Episcopal Diocese of Harrisburg, Doctor of Divinity; Lido A. Iacocca, Executive Vice President, Ford Motor Company, Doctor of Engineering; Philip I. Berman, President, Hess's, Inc., Allentown, Doctor of Humane Letters; and Doctor of Laws to: Evan R. Collins, President, State University of New York at Albany; Milton Friedman, Paul Snowden Russell Professor of Economics, University of Chicago; Erling N. Jensen, President, Muhlenberg College; and Harold Everett Hughes, United States Senator from Iowa.

FOUNDER'S DAY. The ninety-first Founder's Day Exercises in honor of The Honorable Asa Packer, founder of the University, were held Sunday morning, October 12, 1969 in Eugene Gifford Grace Hall. The address to the graduating class was delivered by The Honorable Raymond Philip Shafer, Governor of the Commonwealth of Pennsylvania. Honorary degrees were conferred as follows: Barry Commoner, Director, Center for the Biology of Natural Systems, Washington University (St. Louis), Doctor of Science; Allen Corson DuBois, Partner, Wertheim & Company, and Raymond Philip Shafer, Governor of the Commonwealth of Pennsylvania, Doctor of Laws.

## ALUMNI ASSOCIATION

The Lehigh University Alumni Association which has been in existence since 1876, was incorporated in 1917. The offices of the Association are located in the Alumni Memorial Building. Along with the regular alumni activities, the Association is also concerned with the recruitment of qualified students and fund raising to help meet the needs of the University.

Over 22,000 Lehigh alumni throughout the country who maintain an active interest in the University are afforded opportunities for frequent social contact with Lehigh men of all classes through 47 alumni clubs established in areas of alumni concentration. Important outposts of the University, these clubs hold meetings and carry on activities that support the programs of the University in its cultural, social, financial, and recreation phases.

The officers of the Alumni Association for 1969-70 are: Alfred G. Blake '24, Chairman and Chief Executive Officer, Minerals & Chemical Division, Engelhard Minerals and Chemical Corporation, Menlo Park, New Jersey, President; Harold S. Mohler '48, president, Hershey Foods Corporation, Hershey, Pa. Senior Vice President; William C. Hittinger '44, president, General Instruments Corporation, New York City, Junior Vice President; John K. Con-

neen '30, assistant general manager, fabricated steel construction department, Bethlehem Steel Corporation, Bethlehem, Treasurer; James D. Mack '38, librarian, Lehigh University, Archivist; Donald W. Schmoyer '44, assistant treasurer, Lehigh University, Comptroller; Robert A. Harrier '27, Executive Secretary; James W. Niemeyer, Associate Executive Secretary; and Harry B. Ramsey '50 Assistant Executive Secretary and Editor, Lehigh Alumni Bulletin.

## ART COLLECTIONS

EHIBITIONS. FRANCIS J. QUIRK, DIRECTOR
A varied and continuing series of exhibitions are presented in the Alumni Memorial Building Galleries. Commonly the University sponsors a simultaneous display of paintings, drawings, prints or sculpture by two nationally recognized artists; one exhibits in the North and the other in the South Gallery. These exhibitions are changed every month. In the early fall, the Annual Exhibition of Contemporary American Paintings sponsored by Mr. and Mrs. Ralph L. Wilson opens the scheduled showings with individual artists' work selected from major galleries and aimed at pointing up recent trends in art. A triennial exhibition of Northeastern Pennsylvania AIA members and periodic one-man faculty exhibitions are also presented.

PERMANENT COLLECTIONS. FRANCIS J. QUIRK, DIRECTOR
The Permanent Collections comprise a group of finely chosen works presented to or acquired by the University. In the Central Gallery of the Alumni Memorial Building, Chinese Porcelains from the Franklin Baker Collection, the Sheesley Collection of Etruscan Bronzes and Roman Coins, and the La Rouchefoucald China are displayed alternately with examples of prints from the Mr. and Mrs. Charles G. Prasse, the Anna Elizabeth Wilson, and the Robert Rosenbaum collections.

American and European prints of local historical significance from the Kenneth Isaacs Collection are permanently shown in the office and library areas of Drown Hall, and framed selections from the major prints collection decorate the walls of the Cort Dining Room in the University Center. The Marian Brown Grace Collection with its French, English, Dutch, and Spanish paintings and items from the Mrs. Louis Dreyfus Collection background the faculty lounge in the University Center, while contemporary paintings from the Wilson Collection are hung in the student lounges and dining areas in the same building.

Occasionally paintings or prints are loaned to Lehigh for indefinite addition to the anonymous collection, and many of these are hung in the offices of the Dean of Arts and Science College. Other works decorate the libraries, Whitaker and Packard laboratories and many other areas of concentrated gatherings. A growing collection of prize-winning student prints, drawings, paintings, and sculpture is displayed in areas frequented by undergraduates and visiting friends.

Lehigh places its arts where people gather—in the student snack bar, cafeterias, major corridors, card rooms—in lieu of the museum concept. This serves the whole populace, all the while fine arts students have at hand original works for study or research. For example, the Muriel and Phillip

Berman Loan Collection of Japanese prints is located in the multi-purpose room and adjacent areas, backgrounding many of the innumerable meetings held in the University Center. In similar manner, paintings are displayed in several other major University buildings, and small groups from these several collections are located in reception areas and administrator's offices. As the collections grow by gift or endowment, the University adds paintings with considerable regularity. Student groups, alumni, faculty and friends contribute to the plan of providing pleasure and inspiration for campus family, valley friends, and visitors.

The Office of Exhibitions and Collections in the Hall of Liberal Arts houses the collection of etchings, lithographs, dry points, and other graphics, providing basic study material for research. From this office is available more than six-hundred framed rental reproductions for student and faculty use. Gallery talks, discussions, and lectures, may be scheduled for on-campus or visiting groups. Guide Service may be secured for groups of ten or more persons.

| Spring, 1969 | | Summer, 1969 | | Fall, 1969 | |
|---|---|---|---|---|---|
| Undergraduate Students | 3056 | Undergraduate Students | 346 | Undergraduate Students | 3198 |
| Graduate Students | 1800 | Graduate Students | 1205 | Graduate Students | 1802 |
| Special Students | 12 | | | Special Students | 35 |
| Total | 4868 | Total | 1551 | Total | 5035 |

## Students in Undergraduate Curricula Spring, 1969

| Curriculum | Seniors | Juniors | Sophomores | Freshmen | G.C.D. | Total |
|---|---|---|---|---|---|---|
| Arts and Science | 288 | 225 | 225 | 214 | — | 952 |
| Arts and Engineering | 43 | 21 | 17 | 47 | — | 128 |
| Business and Economics | 153 | 149 | 138 | 99 | — | 539 |
| Chemical Engineering | 61 | 31 | 54 | — | — | 146 |
| Chemistry | 15 | 14 | 11 | — | — | 40 |
| Civil Engineering | 40 | 27 | 43 | — | — | 110 |
| Electrical Engineering | 84 | 65 | 71 | — | — | 220 |
| Engineering Mechanics | 9 | 2 | 4 | — | — | 15 |
| Engineering Physics | 14 | 9 | 7 | — | — | 30 |
| Fundamental Science | 2 | 6 | 4 | — | — | 12 |
| Industrial Engineering | 54 | 34 | 41 | — | — | 129 |
| Mechanical Engineering | 62 | 65 | 62 | — | — | 189 |
| Metallurgy and Mat. Sci. | 30 | 36 | 22 | — | — | 88 |
| Unclassified Engineers | — | — | 12 | 439 | — | 451 |
| General College Division | — | — | — | — | 7 | 7 |
| Total | 855 | 684 | 711 | 799 | 7 | 3056 |

## Students in Undergraduate Curricula Fall, 1969

| Curriculum | Seniors | Juniors | Sophomores | Freshmen | G.C.D. | Total |
|---|---|---|---|---|---|---|
| Arts and Science | 245 | 243 | 256 | 252 | — | 996 |
| Arts and Engineering | 23 | 16 | 34 | 40 | — | 113 |
| Business and Economics | 153 | 141 | 127 | 98 | — | 519 |
| Chemical Engineering | 37 | 49 | 69 | 1 | — | 156 |
| Chemistry | 17 | 17 | 24 | — | — | 58 |
| Civil Engineering | 33 | 33 | 58 | 1 | — | 125 |
| Electrical Engineering | 64 | 75 | 94 | 2 | — | 235 |
| Engineering Mechanics | 3 | 3 | 6 | — | — | 12 |
| Engineering Physics | 12 | 6 | 24 | — | — | 42 |
| Fundamental Science | 5 | 7 | 13 | — | — | 25 |
| Industrial Engineering | 46 | 43 | 55 | 1 | — | 145 |
| Mechanical Engineering | 71 | 67 | 58 | — | — | 196 |
| Metallurgy and Mat. Sci. | 38 | 25 | 16 | — | — | 79 |
| Unclassified Engineers | — | — | 5 | 482 | — | 487 |
| General College Division | — | — | — | — | 10 | 10 |
| Total | 747 | 725 | 839 | 877 | 10 | 3198 |

## GEOGRAPHICAL DISTRIBUTION OF UNDERGRADUATE STUDENTS    Fall, 1969

| | | | | | |
|---|---|---|---|---|---|
| Alabama | 1 | Nevada | 1 | Bolivia | 1 |
| Arizona | 1 | New Hampshire | 6 | Brazil | 1 |
| California | 12 | New Jersey | 658 | Canada | 4 |
| Colorado | 5 | New Mexico | 2 | Colombia | 1 |
| Connecticut | 125 | New York | 458 | Ecuador | 1 |
| Delaware | 28 | North Carolina | 3 | El Salvador | 1 |
| District of Columbia | 9 | Ohio | 43 | Ghana | 2 |
| Florida | 9 | Oregon | 1 | Haiti | 1 |
| Georgia | 5 | Pennsylvania | 1465 | Hong Kong | 2 |
| Hawaii | 1 | Rhode Island | 12 | India | 3 |
| Illinois | 21 | Tennessee | 4 | Liberia | 1 |
| Indiana | 8 | Texas | 5 | Pakistan | 1 |
| Iowa | 3 | Vermont | 4 | Panama | 3 |
| Kentucky | 2 | Virginia | 40 | Peru | 1 |
| Louisiana | 5 | West Virginia | 7 | Philippines | 2 |
| Maine | 5 | Wisconsin | 7 | Puerto Rico | 2 |
| Maryland | 121 | Africa | 1 | Switzerland | 1 |
| Massachusetts | 64 | Arabia | 1 | Thailand | 1 |
| Michigan | 6 | Argentina | 3 | United Kingdom | 2 |
| Minnesota | 3 | Australia | 1 | Venezuela | 1 |
| Missouri | 7 | Belgium | 1 | | |
| Nebraska | 1 | Bermuda | 1 | | |

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THOMAS L. DINSMORE, M.S.
*Administrator*

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*

ROBERT BENJAMIN RUNK, 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*

ROBERT WILLIAM COUGHLIN, PH.D.
*Associate Director*

JOSEPH ROBERT MERKEL, PH.D.
*Director, Marine Biochemistry Laboratory*

ADRIAN F. RICHARDS, PH.D.
*Director, Laboratory of Geotechnical
Ocean Engineering*

SIDNEY SAMUEL HERMAN, PH.D.
*Director, Marine Biology Laboratory*

SAUL BENJAMIN BARBER, PH.D.
*Physiology of Invertebrates*

THOMAS CLEMENT CHENG, PH.D.
*Marine Symbiosis, Shellfish Pathobiology*

E. EVERETT MACNAMARA, PH.D.
*Bioenvironmental Research, Soils*

JOHN DONALD RYAN, PH.D.
*Sedimentology*

ALAN HUGH STENNING, SC.D.
*Geophysical Fluid Mechanics*

Associates

JOHN RODGER ADAMS, PH.D.
*Hydraulic Model Studies, Sanitary Engineering*

ARTHUR WILLIAM BRUNE, PH.D.
*Hydrology*

JACOB DE ROOY, M.A.
*Econometric Modeling*

ALFRED JAMES DIEFENDERFER, PH.D.
*Analytical Chemistry*

WALTER H. GRAF, PH.D.
*River and Oceanographical Hydraulics*

JOHN TERENCE HIRST, PH.D.
*Geotechnical Measurements*

MATTHEW H. HULBERT, PH.D.
*Analytical Chemistry*

ROBERT L. JOHNSON, PH.D.
*Sanitary Engineering*

SIDNEY KLEINBERG, PH.D.
*Mathematical Modeling*

RICHARD GRIFFITH MALSBERGER, PH.D.
*Viral Diseases of Fish*

JACK B. PEARCE, PH.D.
*Benthic Ecology*

THEODORE ALRED TERRY, PH.D.
*Instrument Design*

## Center for Information Science

DONALD JOHN HILLMAN, M.LITT.
*Director*

HERBERT RUBENSTEIN, PH.D.
*Associate Director, Research*

JOHN J. O'CONNOR, PH.D.
*System Evaluation*

WILLIAM ADAMS SMITH, JR., PH.D.
*Associate Director, Systems*

JOHN WILLIAM HUMES, PH.D.
*Assistant to the Director*

ROBERT FEATHERSTONE BARNES, JR., PH.D.
*Mathematical Linguistics*

ANDREW JAMES KASARDA, PH.D.
*Systems Analysis*

JAMES S. GREEN
*Library Liaison*

Associates

FRANCIS JOSEPH WUEST, PH.D.
*Behavorial Studies*

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*

JACQUELINE MARIE FETSKO, M.S.
*Administrative Assistant*

Faculty

EUGENE M. ALLEN, PH.D.
BARTUS HENDRIK BIJSTERBOSCH, PH.D.
ROBERT WILLIAM COUGHLIN, PH.D.
FREDERICK M. FOWKES, PH.D.
KAMIL KLIER, PH.D.
FORTUNATO JOSEPH MICALE, PH.D.
GARY WAYNE POEHLEIN, PH.D.
PAUL C. PARIS, PH.D.
ROBERT PEH-YING WEI, PH.D.
JOHN D. WOOD, PH.D.
ALBERT C. ZETTLEMOYER, PH.D.

Research Associates

DAVID M. FAIRHURST, PH.D.
ELSIE KELLERMAN, PH.D.
JEAN LAVELLE

## Center for Business Economics and Urban Studies

WARREN PILLSBURY, PH.D.
*Director*

JOSEPH LOGSDON, PH.D.
*History*

LEONARD RUCHELMAN, PH.D.
*Government*

LEO VAN HOEY, PH.D.
*Social Relations*

DAVID AMIDON, M.A.
*History*

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*

ARNO HOLZ, PH.D.
THOMAS R. STEEL, PH.D.
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.
NORMAN LAWS, PH.D.
BRIAN R. SEYMOUR, PH.D.
RAMAMIRTHAM VENKATARAMAN, PH.D.
*Research Associate*

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 & 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 Concrete Division*

JOHN W. FISHER, 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

JOHN R. ADAMS, PH.D.
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.

(The first date after the name indicates 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 RODGER ADAMS (1965, 1966)
*Assistant Professor of Civil Engineering*
B.S., Marquette University, 1959; M.S., Michigan State University 1961.; Ph.D. Michigan State University, 1966.

JOHN WILLIAM ADAMS (1965)
*Associate Professor of Industrial Engineering*
B.S., University of Nebraska, 1952; Ph.D., University of North Carolina, 1962.

ROLF K. ADENSTEDT (1969)
*Assistant Professor, Center for Application of Mathematics*
B.S., Brown University, 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 ALPSTEN (1967)
*Postdoctoral Research Associate in Civil Engineering*
Teknologie Licentiat—Royal, Institute of Technology, (Sweden) 1967.

CARLOS J. ALVARE (1968, 1969)
*Visiting Associate Professor of Fine Arts*
B.A., Yale University, 1947; M.C.P., University of Pennsylvania, 1952.

DAVID C. AMIDON, JR., (1965)
*Instructor in History*
B.A., Juniata College, 1957; M.A., Pennsylvania State University, 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., College of Wooster, 1969.

NORMAN CRAIG ANDERSON (1966; 1968)
*Business Manager Athletics*
B.S., Lehigh, 1960; M.S., Southern Illinois University, 1964.

CHARLES ARTHUR APPLE (1970)
*Instructor in Metallurgy and Materials Science*
B.S., Florida State University, 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, 1958)
*Associate 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 University, 1959; M.A., Stanford University, 1961; Ph.D., Clark University, 1964.

LLOYD WILLIAM ASHBY (1966, 1969)
*Professor of Education*
A.B., Hasting College, Nebraska, 1927; M.A., Columbia Teachers College, 1935; Ed.D., 1950.

LYNN ASKEW (1970)
*Instructor in Education*
B.S., Susquehanna University, 1957; M.Ed., Miami University (Oxford, Ohio), 1963.

EDWARD F. ASSMUS, JR., (1966)
*Associate Professor of Mathematics*
A.B., Oberlin College, 1953; A.M., Harvard University, 1955; Ph.D., 1958.

BETZALEL AVITZUR (1964, 1968)
*Professor of Metallurgy and Materials Science*
B.Sc. and Dip. Ing., Israel Institute of Technology, 1949; M.S., University of Michigan, 1956; Ph.D., 1960.

JOHN ROSS BAKER (1962)
*Instructor in English*
B.A., Rice University, 1952; M.A., 1954.

NICHOLAS W. BALABKINS (1957, 1966)
*Professor of Economics*
Dipl. rer. pol., Gottingen, 1949; M.A., Rutgers, 1953; Ph.D., 1956.

JAMES L. BANNON (1969)
*Assistant Professor Aerospace Studies*
B.S. Ed., Ball State, 1962; M.B.A., University of Hawaii, 1968. Captain, U.S. Air Force

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 Polytechnic Institute, 1963; M.S., Case Institute of Technology, 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., Massachusetts Institute of Technology, 1957; M.A., Dartmouth, 1959; Ph.D., University of California, 1965.

LUCILE LEWIS BARRETT (1944)
*Assistant to Director of Public Information*
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, 1966)
*Associate Professor of Government*
A.B., Ohio University, 1956; M.A., Syracuse, 1959; Ph.D., 1963.

ALLEN MERRIL BARSTOW (1967)
*Instructor in Romance Languages*
B.S., Lehigh, 1955; M.A., Pennsylvania, 1966.

SANDRA LEE BARTOLI (1970)
*Instructor in Education, Centennial School*
B.S., St. Joseph's College (Emmitsburg, Md.), 1963; M.S., Shippensburg State College, 1968.

LYNN SIMPSON BEEDLE (1947, 1957)
*Professor of Civil Engineering; Director, Fritz Engineering Laboratory*
B.S. in C.E., California. 1941; 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 (France), 1938.

CARL ROBERT BEIDLEMAN (1967)
*Assistant Professor of Management and Finance*
B.S., Lafayette, 1954; M.B.A., Drexel Institute of Technology, 1961; Ph.D., University of Pennsylvania, 1968.

•PETER BEIDLER (1963, 1968)
*Assistant Professor of English*
B.A., Earlham College, 1962; M.A., Lehigh, 1965; Ph.D., 1968.
•On leave 1969-70.

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., State University of New York, (Albany), 1952; M.S., 1960.

RUSSELL EDWARD BENNER (1962)
*Professor of Mechanical Engineering*
B.M.E., Cornell University, 1947; M.S. in M.E., Lehigh, 1951; Ph.D., 1959.

GRAHAME BENNETT (1970)
*Visiting Lecturer in Mathematics*
B.Sc., Newcastle, 1966.

LOIS REED BENSON (1955, 1958)
*Chief Nurse and Administrative Assistant, University Health Service*
B.A., Michigan, 1932; R.N., Allentown Hospital, 1939.

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 University, 1964; M.A., Princeton, 1966; Ph.D., 1969.

HANSPETER BIERI (1969)
*Visiting Assistant Professor of Mathematics*
Maturitat, Gymnasium Thun, 1962; Diploma in Mathematics, Universitat Bern, 1967.

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., Istanbul State University, 1962; M.S., Lehigh, 1964.

JEAN WRIGHT BISHOP (1968)
*Assistant to Director of University Publications*
B.A., Pennsylvania State University, 1966.

HARTWIG R. F. BLUME (1967)
*Research Associate in Physics*
Dipl. Phys., University of Freiburg (Germany), 1962; Ph.D., 1967.

PHILIP ANTHONY BLYTHE (1968)
*Associate Professor, Center for the Application of Mathematics*
B.S., University of Manchester (England), 1958; Ph.D., 1961.

GAROLD JOSEPH BORSE (1966)
*Assistant Professor of Physics*
B.S., University of Detroit, 1962; M.S., University of Virginia, 1964; Ph.D., 1966.

•HENDERSON BAMPFIELD BRADDICK (1956, 1960)
*Associate Professor of International Relations*
A.B., University of Washington, 1942; LL.B., Harvard, 1949; Ph.D., University of Washington, 1957.
•On leave, first semester, 1970.

FRANCIS MARIO BRADY, JR. (1955, 1957)
*Assistant Professor of Accounting*
B.S., Drexel Institute of Technology, 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 College, 1960; M.A., Penn State, 1965; Ph.D., Oklahoma State, 1968.

JOSEPH BRODERWAY (1969)
*Instructor in Military Science*
Master Sergeant, U.S. Army.

ARTHUR LIONEL BRODY (1957, 1963)
*Professor of Psychology*
B.A., George Washington, 1951; Ph.D., Indiana, 1956.

ADDISON C. BROSS (1967)
*Assistant Professor of English*
B.A., Davidson College, 1959; M.A., Duke University, 1960; Ph.D., Louisiana State University, 1967.

FORBES TAYLOR BROWN (SEPTEMBER, 1970)
*Professor of Mechanical Engineering*
S.B., Massachusetts Institute of Technology, 1958; S.M., 1959; Sc.D., 1962.

JOSEF MARIA BROZEK (1959, 1963)
*Research Professor of Psychology*
Ph.D., Charles (Prague), 1937.

ARTHUR WILLIAM BRUNE (1952)
*Assistant Professor of Civil Engineering*
B.S., in E.M., Missouri School of Mines, 1941; M.S. in E.M., 1946; Ph.D., Pennsylvania State, 1952; P.E., Pennsylvania, 1957.

STEPHEN D. BRYEN (1967, 1970)
*Assistant Professor of Government*
A.B., Rutgers, 1964; M.A., Tulane, 1966; Ph.D., 1970.

NATT BRYANT BURBANK (1964, 1969)
*Professor and Assistant Dean of the School of Education*
A.B., University of Vermont, 1925; M.A., Columbia, 1931; LL.D., Vermont, 1963.

JOHN JOSEPH BURBRIDGE, JR. (1962, 1964)
*Instructor in Industrial Engineering*
B.S., Lehigh, 1962; M.S., 1964.

THOMAS E. BURKE (1969)
*Instructor in English*
B.A., University of Dallas, 1964.

SIDNEY R. BUTLER (1969)
*Associate Professor of Metallurgy and Materials Science and Director, Advanced Materials Laboratory, Materials Research Center*
B.S., University of Maine, 1954; M.S., Penn State University, 1956; Ph.D., 1960.

CLARENCE BOWEN CAMPBELL (1955, 1966)
*Dean of Residence*
B.A., Temple, 1937; M.A., Lehigh, 1947.

RUDD H. CANADAY (1968)
*Visiting Lecturer in Electrical Engineering*
Ph.D., Massachusetts Institute of Technology, 1964.

BIRUTA CAP (1969)
*Assistant Professor of Romance Languages*
B.A., University of Connecticut, 1960; M.A., Rutgers University, 1961; Ph.D., 1968.

RONALD NORMAN CARON (1965)
*Instructor in Metallurgy and Materials Science*
B.S., Lehigh, 1965; M.S., 1967.

•JOHN MILLAR CARROLL (1965)
*Associate Professor of Industrial Engineering*
B.S., Lehigh, 1950; M.A., Hofstra, 1955; Ph.D., N.Y.U., 1968.
•On leave, 1969-70.

JOHN S. CARTWRIGHT (1962)
*Professor of Education*
A.B., Cornell University, 1927; M.A., New York University, 1942; Sc.D., Muhlenberg, 1954.

MICHAEL J. CARUSO (1968)
*Instructor in Physical Education*
B.A., Lehigh, 1967.

ALFRED JOSEPH CASTALDI (1964, 1966)
*Associate Professor and Director, Division of Elementary Education.*
B.S., University of Pennsylvania, 1951; M.S., 1956; Ed.D., 1964.

WATSON GARRARD CAUDILL, JR., (1968)
*Assistant Professor of Military Science*
B.S., United States Military Academy, 1964; Captain, Infantry, U. S. Army.

KALIDAS CHAKRAVARTI (1966)
*Research Associate in Chemistry*
B.Sc., University of Calcutta (India), 1957; M.Sc., 1959; Ph.D., 1964.

RANDALL M. CHAMBERS (1966)
*Adjunct Associate Professor of Psychology*
B.A., Indiana, 1948; M.A., Missouri, 1951; Ph.D., Western Reserve, 1954.

EDWARD CHARLES (1969)
*Instructor in Education*
B.A., Bluffton College, 1953; LL.B., Rutgers, 1953; M.A., Temple University, 1961.

MARVIN CHARLES (1970)
*Assistant Professor of Chemical Engineering*
B.S., Polytechnic Institute of Brooklyn, 1964; M.S., 1967; Ph.D., 1970.

JOHN MCILVAIN CHEEZUM, JR. (1964)
*Assistant Director, Office of Research*
A.B., University of Pennsylvania, 1964.

WAI-FAH CHEN (1966)
*Assistant Professor of Civil Engineering*
B.S., Cheng-Kung University, 1959; M.S., Lehigh, 1963; Ph.D., Brown University, 1966.

CHIANG-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)
*Professor of Biology*
A.B., Wayne State University, 1952; M.S., University of Virginia, 1956; Ph.D., 1958.

SHIU C. CHIU (1969)
*Research Associate in Physics*
B.S., Engineering, University of Michigan 1963; Ph.D., 1969.

YE T. CHOU (1968)
*Associate Professor of Metallurgy and Materials Science*
B.S., Chungking University (China), 1945; M.S., Carnegie Institute of Technology, 1954; Ph.D., 1957.

GLENN JAMES CHRISTENSEN (1939, 1969)
*University Distinguished Professor*
B.A., Wooster, 1935; Ph.D., Yale, 1939; LL.D., College of Notre Dame (Md.), 1966.

MARIA C. CHUN (1969)
*Post-Doctoral 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., University of Alabama, 1968.

HAROLD CLARKE (1967)
*Lecturer and Technician in Physics*

CURTIS WILLIAM CLUMP (1955, 1960)
*Professor of Chemical Engineering*
B.S., Bucknell, 1947; M.S., 1949; Ph.D., Carnegie Institute of Technology, 1954.

ALVIN COHEN (1962, 1965)
*Associate Professor of Economics*
B.A., George Washington University, 1953; M.B.A., Columbia, 1955; Ph.D., University of Florida, 1962.

ROBERT CARLTON COLE (1964)
*Assistant Director of University Publications*
A.B., Marshall University, 1959; M.A., Wake Forest University, 1964.

FRANK THOMAS COLON (1965, 1967)
*Associate Professor of Government*
A.B., Geneva College, 1954; M.A., University of Pittsburgh, 1960; Ph.D., 1963.

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 of Technology, 1948; Sc.D., Massachusetts Institute of Technology, 1952.

SAMUEL IRVIN CONNOR (1961)
*Director, Office of Public Information*
B.A., Lehigh, 1949.

ROBERT FRANCIS COOK (1968)
*Instructor in Economics*
B.S., University of Maryland, 1965; M.S., Lehigh, 1966.

PERCY ELWOOD CORBETT (1964)
*Adjunct Professor of International Relations*
M.A., McGill University (Canada), 1915; B.A., Oxford (England), 1920; M.A., 1925; LL.D. (Hon.), Melbourne (Australia), 1938; D.C.L. (Hon.), McGill, 1961.

ROBERT JOSEPH CORKHILL (1968)
*Instructor in Management and Finance*
B.S., Lehigh, 1956; M.B.A., 1958.

JOSEPH A. CORRADO (1963, 1967)
*Instructor in Civil Engineering*
B.S., University of Detroit, 1963; M.S., Lehigh, 1965.

ROBERT WILLIAM COUGHLIN (1965, 1967)
*Associate Professor of Chemical Engineering; Associate Director, Center for Marine and Environmental Studies*
B.S., Fordham University, 1956; Ph.D., Cornell University, 1961. P.E., New Jersey, 1964.

JOHN NELSON COVERT (1967)
*Assistant Professor of Physical Education, Varsity Cross Country and Track Coach*
B.S.Ed., Buffalo State University, 1953.

RAYMOND GIBSON COWHERD (1946, 1963)
*Professor of History*
A.B., William Jewell, 1933; M.A., Pennsylvania, 1936; Ph.D., 1940.

CLOYD CRISWELL (1947, 1949)
*Assistant Professor of English*
B.S. in Ed., Pennsylvania State Teachers (Millersville), 1933; M.A., New York, 1937.

MILDRED J. CROSBY (1962)
*Psychometrician, Counseling*

LINDA T. CURRAN (1969)
*Production Assistant, Office of University Publications*
B.A., Rosemont College, 1968.

CASSIUS WILD CURTIS (1946, 1948)
*Professor of Physics*
A.B., Williams, 1928; Ph.D., Princeton, 1936.

ROBERT BENJAMIN CUTLER (1954, 1962)
*Professor of Music, Chairman of the Department of Music, University Organist*
A.B., Bucknell, 1934; M.A., Columbia, 1935.

WALTER EMIL DAHLKE (1964)
*Professor of Electrical Engineering*
Diploma, University of Berlin; Ph.D., 1936; Ph.D.,
(habil), University of Jena, 1939.

JOHN HARTLEY DANIELS (1964)
*Assistant Professor in Civil Engineering*
B.S., University of Alberta (Canada), 1955; M.S., University of Illinois, 1959; Ph.D., Lehigh, 1967. P.E. Alberta,
Canada, 1955.

H. BARRETT DAVIS (1946, 1953)
*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.

PAUL L. DAVIS (1969)
*Assistant Professor of Mathematics*
A.B., West Virginia University, 1962; M.S., 1962; Ph.D.,
Carnegie-Mellon, 1969.

EDNA SOPHIA DEANGELI (1963, 1965)
*Assistant Professor of Classics*
B.S., Temple, 1938; M.A., Pennsylvania, 1960; Ph.D., 1965

JACK ANGELO DEBELLIS (1964, 1969)
*Associate Professor of English*
A.B., University of Florida, 1957; A.M., University of
California at Los Angeles, 1959; Ph.D., 1964.

MARGARET LINN DENNIS (1953, 1968)
*Assistant Librarian*
A.B., Allegheny, 1939; B.S. in L.S., Syracuse, 1940.

JACOB DE ROOY (1967, 1969)
*Assistant Professor of Economics*
A.B., Rutgers, 1963; A.M., 1965; Ph.D., 1969.

ALFRED JAMES DIEFENDERFER (1961, 1965)
*Associate Professor of Chemistry*
B.S., Pittsburgh, 1957; Ph.D., Massachusetts Institute of
Technology, 1961.

ERNEST NEVIN DILWORTH (1949, 1967)
*Professor of English*
Ph.B., Kenyon, 1933; M.A., Pittsburgh, 1937; Ph.D.,
Columbia, 1948.

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*Instructor in Government*
A.B., Brown, 1961; M.A., Lehigh, 1963.

JOHN CALVIN WHITEHEAD (1967)
*Instructor in Physical Education, Assistant Varsity Football Coach*
B.S., East Stroudsburg State College, 1950.

GARY E. WHITEHOUSE (1965, 1969)
*Associate Professor of Industrial Engineering*
B.S., Lehigh, 1960; M.S., 1962; Ph.D., Arizona State University, 1966. P.E., Pennsylvania, 1966.

LESLIE HUNTER WHITTEN, JR. (1967)
*Visiting Associate Professor of Arts*
B.S., Lehigh, 1950.

JOSEPH HARDY WHRITENOUR (1965)
*Assistant Director of Public Information*

ALBERT WILANSKY (1948, 1957)
*Professor of Mathematics*
B.A., Dalhousie (Canada), 1941; B.S., 1942; Ph.D., Brown, 1947.

ELIZABETH E. M. WILLIAMS (1969)
*Visiting Lecturer in Education*
B.A., University of London; M.A.

ROBERT CLIFFORD WILLIAMSON (1963, 1964)
*Professor of Sociology, Chairman of the Department of Social Relations*
B.A., University of California (Los Angeles), 1938; M.A., 1940; Ph.D., University of Southern California, 1951.

WILLIAM A. WOJCIECHOWSKI (1966)
*Assistant Professor Aerospace Studies*
B.S., Indiana (Pa.) University, 1958; M.Ed., Pennsylvania State College (Edinboro), 1961; Captain, U.S. Air Force.

JOHN DUDLEY WOOD (1960, 1965)
*Associate Professor of Metallurgy and Materials Science*
B.S., Case Institute of Technology, 1953; M.S., Lehigh, 1959; Ph.D., 1962.

FRANCIS JOSEPH WUEST (1961, 1965)
*Professor and Chairman of the Department of Psychology*
B.A., LaSalle College, 1951; M.A., Fordham, 1953; Ph.D., Brown, 1961.

WILLARD ROSS YATES (1955, 1963)
*Professor of Government; 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 College, 1963; Ph.D., University of Pennsylvania, 1966.

ALBERT CHARLES ZETTLEMOYER (1941, 1969)
*Provost and Vice President; Distinguished Professor of Chemistry*
B.S. in Ch.E., Lehigh, 1936; M.S., 1938; Ph.D., Massachusetts Institute of Technology, 1941; D.Sc., Clarkson, 1965.

EARL R. ZIMMERMAN (1968)
*Instructor in Education*
B.S., California State College, 1944; M.Ed., Pennsylvania State, 1954.

EMORY W. ZIMMERS JR. (1969)
*Instructor in Industrial Engineering*
B.S., I.E., Lehigh, 1966; B.S., M.E., 1967; M.S., 1967.

JEAN ZINGLER (1969)
*Instructor in Centennial School*
B.S., Kutztown State College, 1969.

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.

ALLEN JENNINGS BARTHOLD (1939)
*Professor Emeritus of Romance Languages*
B.A., Lehigh, 1921; Ph.D., Yale, 1931.

FAY CONANT BARTLETT (1917, 1956)
*Assistant Professor Emeritus of Physical Education*

FRANK SWAN BEALE (1930, 1964)
*Associate Professor Emeritus of Mathematics*
B.S., Maine, 1921; M.S., 1923; Ph.D., Michigan, 1931.

ROBERT DOMINICK BILLINGER (1923, 1965)
*Associate Professor Emeritus of Chemistry*
B.S. in Ch.E., Lehigh, 1921; M.S., 1925; Ph.D., Cincinnati, 1929.

JACOB LYNFORD BEAVER (1917, 1952)
*Professor Emeritus of Electrical Engineering*
E.E., Lehigh, 1904; M.S., 1921; Sc.D., Harvard, 1932.

FREDERICK ALDEN BRADFORD (1926, 1957)
*Professor Emeritus of Finance*
A.B., Michigan, 1921; M.A., 1923;; Ph.D., 1926.

ELMER CLARK BRATT (1929, 1968)
*Director Emeritus, Center for Business Economics*
A.B., Nebraska, 1925; A.M., 1926; Ph.D., Wisconsin, 1935; LL.D. (Hon.), Nebraska, 1955.

ALLISON BUTTS (1957, 1961)
*Professor Emeritus of Metallurgy and Materials Science*
A.B., Princeton, 1911; B.S., Massachusetts Institute of Technology, 1913.

EDWARD HUTCHINS CUTLER (1930, 1947)
*Associate Professor Emeritus of Mathematics*
A.B., Harvard, 1925; A.M., 1926; Ph.D., 1930.

ALBERT WILLIAM DE NEUFVILLE (1948, 1957)
*Associate Professor Emeritus of Mechanics*
Dipl. Ing., Berlin, 1922; M.S., Stevens Institute of Technology, 1948; Ph.D., Lehigh, 1952.

HERBERT MAYNARD DIAMOND (1927, 1964)
*Professor Emeritus of Economics*
B.A., Yale, 1914; Ph.D., 1917.

GEORGE DORMER FARNE (1927, 1945)
*Assistant Professor Emeritus of Romance Languages*
A.B., Columbia, 1926; M.A., 1927.

MERTON OTIS FULLER (1912, 1955)
*Associate Professor Emeritus of Civil Engineering*
C.E., Syracuse, 1910; M.S., Lehigh, 1934.

GEORGE DEWEY HARMON (1925, 1964)
*Professor Emeritus of American History*
B.A., Duke, 1921; M.A., 1922; Ph.D., Pennsylvania, 1930.

JOHN DOUGLAS LEITH (1945, 1964, 1966)
*Dean Emeritus of Students*
A.B., North Dakota, 1920; A.M., Columbia, 1924.

ARCHIE ROSCOE MILLER (1922, 1961)
*Professor Emeritus of Electrical Engineering*
B.S. in E.E., 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.

PERCY LEE SADLER (1946, 1962)
*Professor Emeritus in Physical Education*
Brig. Gen., Inf., U.S.A. (Ret.)

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.

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. in Chem., Lehigh, 1906; M.S., 1921.

MILTON CALEB STUART (1926, 1952)
*Professor Emeritus of Mechanical Engineering*
B.S. in M.E., Pennsylvania, 1909; M.E., 1924.

JOHN SCHRADER TREMPER (1939, 1955)
*Associate Professor Emeritus of German*
A.B., Colgate, 1928; M.A., Cornell, 1932; Ph.D., 1938.

RALPH NEWCOMB VAN ARNAM (1928, 1961)
*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.

## Retired (1969)

VORISH V. LATSHAW (1931, 1969)
*Associate Professor Emeritus of Mathematics*
B.A., Indiana, 1927; A.M., 1928; Ph.D., 1930.

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.

GATES BARNET STERN (1965)
*Professor of Military Science*
B.A., Lehigh, 1936; Colonel, Transportation Corps, U.S. Army.

## Resigned

STEPHEN D. ARMSTRONG (1966)
*Professor of Aerospace Studies*
Resigned September 1, 1969.

BRIAN GEORGE BROCKWAY (1963)
*Associate Professor of Business Law, and Chairman Department of Finance, Marketing and Law*
Resigned August 31, 1969.

CLIFFORD BURKET (1966)
*Associate Professor of Education*
Resigned August 31, 1969.

ADOLPH S. BUTKYS (1965)
*Assistant Professor of Marketing*
Resigned August 31, 1969.

COSTEL DELANO DENSON (1968)
*Visiting Associate Professor of Chemical Engineering*
Resigned August 31, 1969.

DAVID G. EISENHAUER (1967)
*Special Assistant, Office of the President; Adjunct Assistant Professor of Fine Arts*
Resigned June 30, 1969.

RONALD LEE FRIEND (1968)
*Assistant Professor of Finance*
Resigned August 31, 1969.

DORESWAMY R. IYENGAR (1967)
*Research Associate Professor of Chemistry*
Resigned October 31, 1969.

JAN KUTINA (1968)
*Visiting Professor of Geology*
Resigned August 31, 1969.

HAROLD DEAN MATHENEY (1966)
*Associate Professor in Military Science*
Resigned June 11, 1969.

MORIO OBATA (1968)
*Visiting Professor of Mathematics*
Resigned August 31, 1969.

ALBERT DEAN OTTO (1965)
*Assistant Professor of Mathematics*
Resigned August 31, 1969.

GORDON EARL PRUETT (1968)
*Assistant Professor of Religion*
Resigned August 31, 1969.

JURG RATZ (1968)
*Visiting Assistant Professor of Mathematics*
Resigned August 31, 1969.

ANNE REISSIG (1968)
*Cataloger*
Resigned August 31, 1969.

EDWARD ROSENBAUM (1966)
*Associate Professor of Economics*
Resigned August 31, 1969.

WILLIAM HENRY RUCKLE (1963, 1968)
*Associate Professor of Mathematics*
Resigned August 31, 1969.

WILLIAM DWIGHT SCHAEFFER (1956, 1966)
*Associate Director, Center for Surface and Coatings Research*
Resigned September 30, 1969.

THOMAS JOSEPH MORTON SCHOPF (1967)
*Assistant Professor of Geology*
Resigned August 31, 1969.

SHUANG YUAN SHIEH (1965)
*Assistant Professor of Physics*
Resigned June 30, 1969.

MICHAEL PETER SOLTYS (1965)
*Assistant Director of Placement*
Resigned June 30, 1969.

ARTHUR SWEETSUR (1967)
*Associate Director, Health Center*
Resigned August 31, 1969.

BLOSSOM WEISS TEPPER (1964)
*Assistant Professor in Education*
Resigned August 31, 1969.

DIANA TRACY (1968)
*Assistant Professor of Education*
Resigned August 31, 1969.

CHARLES JOSEPH VERSACCI (1958, 1965)
*Assistant Professor of Education and Supervisor of Reading and Study Clinic*
*Resigned August 31, 1969.

### Deceased

†WILLIAM THOMAS CHRISTIAN (1947, 1968)
*Ticket Manager, Athletics*
Deceased May 21, 1969.

†ROBERT PATTISON MORE (1916, 1956)
*Dean Emeritus of the College of Arts and Science*
Deceased January 24, 1970.

†HAROLD PRESCOTT THOMAS (1932, 1962)
*Professor Emeritus of Education*
Deceased July 21, 1969.

**Graduate, Teaching and Research Assistants**

EDEN M. ABAD
B.S., Far East University

PETER JOHN ACHORN
M.S., Lehigh

NEIL H. ACKERMAN
B.A. Upsala College

RODERIGO ACOSTA
Chem. Engr., University of Antioquia (Colombia, S.A.)

WILLIAM E. ADAMS
B.S., Bucknell

JEAN-PIERRE A. ADOUL
M.S., Lehigh

ALEXA A. ALBERT
B.A., Cedar Crest College

PEDRO C. ALBRECHT
Dipl. Bau. Ing., Swiss Federal Institute of Technology

STEPHEN RAY ALPERT
M.S., Lehigh

ANTHONY FRANCIS AMICO
B.S., University of Massachusetts

BARRY R. ANDERSON
B.S., State University of New York (Fredonia)

CARL ANDERSON
B.S., Lehigh

CAROLE ANDERSON
B.S., State University of New York

CRISTEL ARNOLD
Free University (Berlin)

MICHAEL ARONSON
B.S., City College of New York

TOSHIO ATSUTA
B.S., Naval Architecture, University of Tokyo

ROBERT BADALIANCE
M.S., Lehigh

CRAIG H. BAILEY
M.S., Lehigh

FELIX BARDA
M.S., Lehigh

CHARLES M. BARTISH
B.S., Villanova University

DEBABRATA BASU
M.Sc., Calcutta University

RABIH BATEL
B.S., Damascus University

ROBERT L. BATEMAN, JR.
A.B., Ursinus College

DAVID G. BECKWITH
A.B., Lehigh

GERNOT BEER
Dipl. Ing., Tech Hochschule (Graz, Austria)

PETER JOHN BEHRENS
M.Ed., Edinburg State College

HOWARD BELL
B.A., St. Peter's College

RODGER E. BERG
B.S., Muhlenberg College

JEFFREY W. BIER
B.S., Roanoke College

JOHN S. BINGMAN
B.S., Villanova University

E. DENNIS BISHOP
M.Engr., Rensselaer Polytechnic Institute

REIDAR BJORHOVDE
Lic. Techn., The Norwegian Institute of Technology

JAMES G. BOMMER
B.S., University of Scranton

JEAN-CLAUDE BOULBES
Ingénieur Arts et Metiers (France)

J. WARWICK BOULTON
B.S., London School of Economics (London)

NICHOLAS ST. J. F. BOWEN
B.Sc., London School of Economics (Britain)

JOHN ANTHONY BRESLIN
M.S., Lehigh

LAURENCE MICHAEL BRICKMAN
B.A., Lehigh

DAVID R. BROOKS
B.A., Lehigh

MARVIN BRUBAKER
M.A., Bowling Green College

J. L. BRUMBELOW
B.S., West Georgia College

EDUARDO CALABRESE
Dottore Infisica, University of Mesina (Italy)

JOHN H. CARSON
B.S., Lehigh

VICTOR M. CATANO
B.S., Drexel Institute of Technology

HUSEYIN CEKIRGE
M.S., Istanbul Technical University (Turkey)

YUNG-SHEN H. CHA
B.S., National Taiwan University (Taiwan)

NING-HUAT CHAN
B.S., National Taiwan University

ANDRIE CHEN
M.S., University of Kansas

CHIOU-HORNG CHEN
B.S., National Taiwan University (Taiwan)

TONY ER-PING CHEN
M.S., Lehigh

YAN-LIANG CHEN
M.S., Waseda University (Tokyo)

EVELYN Y. CHIU
B.S., Adamson University (Manila)

TIN HO CHIU
B.S., Chung Chi (Hong Kong)

ESTEBAN CHORNET
Ingeniero Industrial, Barcelona

SHYAN-FU CHOU
B.S., National Taiwan University (Taiwan)

SUNG H. CHOUGH
B.S., Seoul National University

JOSEPH S. CHOW
B.S., Indiana State University (Bloomington)

JANE H. CISLE
B.A., Miami University (Ohio)

MEHMET B. CIVELEK
M.S., Istanbul University (Turkey)

THEODORE R. CLINE
M.S., University of Pennsylvania

LAWRENCE M. CONAHAN
B.A., King's College

EVAN W. CONYERS
M.A., Lehigh

THOMAS A. COOK
M.S., Penn State

LEE L. COPPER
B.S., Clarion State College

FRANK P. CORCIONE
B.A., Moravian College

KEITH H. CORKUM
M.S., University of Connecticut

PAUL BRUCE CORKUM
B.S., Acadia University

SERGIO COVARRUBIAS
M.S., Universidad Nacional Autonoma De Mexico

CHARLES L. CRONAN
M.S.C., University of Southern California

JOSEPH CURRAN, JR.
B.A., Villanova

ADILSON J. CURTIUS
Eng. Quim. U.F.R.G.S. (Brazil)

HAROLD T. DALCHER
B.A., Dickinson College

NALINI R. DAS
M.S., Calcutta University

NARAYAN DAS
M.S., Calcutta University

JAMES W. DAVIS
B.S., University of Scranton

LAWRENCE JOHN DAVIS III
M.S., Lehigh

DAVID JOHN DEANGELO
B.S., Lehigh

SURESH KALANJI DESAI
M.S., Lehigh

ROBERT DEVOS
M.S., University of Pennsylvania

DANIEL J. DIMARIA
B.S., Lehigh

PETER STEFAN DOBREFF
M.S., Stanford

DOUGLAS SCHAEFFER DRUMHELLER
Ph.D., Lehigh

DAVID J. DUNN
B.S., University College (London)

DIRK P. DUPLESSIS
B.S., University of Pretoria (Africa)

ABRAHAM BAGOT EASTWOOD III
B.S., Muhlenberg College

JUDITH A. EASTWOOD
M.S., Lehigh

GEORGE TYLER EMBLEY
B.S., Lehigh

WILLIAM L. EMKEY
B.S., Penn State

ELIZABETH A. FARRIS
B.A., Dominicon College

DAVID J. FIELDING
M.S., University of Texas

WILLIAM FIVES
B.S., Mount St. Mary's College (Md.)

WILLIAM T. FLIS
B.S., Lafayette

DAMIR FRANEKIC
M.S., Zagreb University (Yugoslavia)

CLIFFORD G. FRANK
M.Ed., Penn State

KARL HEINZ FRANK
M.S., Lehigh

JEAN ELIZABETH FRIEDMAN
M.A., Lehigh

ALBERT F. FRIES, JR.
M.B.A., Lehigh

PHYLLIS W. FURST
M.A., Lehigh

JAMES GABELLO
B.S., Wilkes College

DANIEL JAMES GALLAGHER
B.A., Randolph-Macon

ISAIAS GARCIA
M.S., National University of New Mexico

JOHN J. GARHAMMER
B.S., Penn State

VINCENT JOSEPH GENTILCORE
M.S., Lehigh

WESLEY H. GEWEHR
B.S., Lehigh

BHASKAR B. GHATE
M.S., University of Illinois

MAX W. GIGER
Dipl. Tech., Technikum Winterthur (Switzerland)

JEROME GILLEN
M.A., Lehigh

MILTON H. GRANNATT III
M.B.A., Lehigh

ALAN H. GRIEP
B.S., Lehigh

CHARLES F. GROSS JR.
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BRUCE A. GRUBER
B.S., Lehigh

RAYMOND DANIEL GUMB
M.A., Emory

ELLAN GUO
B.S., National Taiwan University

RANA P. GUPTA
M.S., Punjab Engineering College (India)

VIJAY GUPTA
B. Tech. Chem. Eng. ITT, New Delhi, (India)

JAMES GUYKER
B.S., Grove City College

ANWAR HAFEEZ
B.S., Ned Government Engineering
College (Pakistan)

HOWARD CHARLES HAGENDORF
M.S., Penn State

JOHN E. HAHN
B.A., Franklin & Marshall College

SUSAN F. HAMMELL
B.A., Lycoming College

JOHN K. HAMPSON
M.S., Lehigh

SANDRA G. HAMPSON
B.A., Moravian

HUMPHREY C. HAN
B.S., Taiwan Provincial Cheng Kung
University (Taiwan)

JOHN E. HARRY
B.S., Lehigh

HENRY T. HAZLETON JR.
B.A., Lehigh

MANINDRA N. HAZRA
B.E., Bengal Engineering College (India)

ROBERT CHARLES HEISER
B.A., Lehigh

LAURENCE J. HEITZ
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ROGER M. HENDRICKSON
M.Ed., Lehigh

THERESA HERMOSO
B.A., Maryknoll College

GAIL CHADWELL HERZ
B.S., University of Nevada

GERALD M. HIGDON
B.A., Villa Madonna

MANFRED A. HIRT
Dipl. Bauingenieur, Swiss Federal Institute of Technology

PETER NAI SHIANG HO
B.A., Lincoln University

PAUL HOFFENBURG
B.S., Union College

JAMES B. HOGE
B.S., Virginia Military Institute

JOSEPH JUIN-SHYONG HUANG
B.S., National Taiwan University

VOLKER HUELCK
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E. JOHN HUGHES
B.S., London School of Economics (London)

CAROLE A. HURWITZ
B.S., Old Dominion College

RICHARD W. HUTCHINSON
M.S., Lehigh

PAUL J. HUTTA
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LEON A. HYER
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E. RUSSELL IVES JR.
M.B.A., Lehigh

ROBERT JACCARD
Diploma, Fed. Inst. of Tech., (Zurich, Switzerland)

MELVIN ROBERT JACKSON
M.S., Lehigh

KENNETH E. JONES
B.A., University of Maine

PETEE BETH JUNG
M.A., Emory Universiiy

KURT JOHN KAHLOW
M.S., Lehigh

MELVYN KAPPEPORT
B.S., Lehigh

SAMARES KAR
B.Tech., Indian Institute of Technology, Kharagpur (India)

LESTER P. KATSANIS
B.S., Lehigh

YAKOVOS J. KAZAKIA
M.S., Technical University of Istanbul

WESLEY R. KEGERISE II
B.S., Marietta College

RICHARD KELLERMAN
B.Sc., University of Manchester (England)

BRIAN J. KELLY
M.S., Lehigh

SUNG-WOO KIM
M.S., University of Utah

ROY H. KISSINGER
B.S., Bucknell

ALAN R. KLAYTON
M.S., Penn State

KENNETH L. KLENK
B.A., LaSalle College

CHEN CHANG HO KO
B.S., Chung-Yung (Taiwan, China)

RUDOLPH M. KOCH
M.S., Lehigh

FRANK W. KOKO, JR.
M.S., Lehigh

GOPALA KRISHNA
M.S., IIT Technical (Madras)

VIKRAM KUMAR
M.Sc., Allahabad University (India)

LADISLAV LAMBOJ
M.S., Czech. Tech. University, (Prague)

MILES LANDRUM LAMPSON
M.S., Lehigh

GEORGE OMER LAPIERRE, JR.
B.A., Salem (W.Va.) College

EDWARD LAREAU
M.S., Lehigh

GEORGE M. LEE
B.S., Chung Yuan Christian College (Taiwan)

JAMES H. LEHMAN
B.S., West Chester State College

MICHAEL BARRY LEIBOWITZ
M.S., Lehigh

ROBERT BATTISTA LEONESIO
M.S., Stanford

WILLIAM L. LETTINGER
B.S., Ursinus College

LEE-CHONG LIM
M. Engr. Sc., University of Sydney (Australia)

BHARTOOR LINGARAJU
B.S.M.E., Bangalore University (India)

NUNZIO LIPARI
Dottore in fisica, University of Messina (Italy)

BRUCE L. LIPPINCOTT
B.A., Colby College

TIMOTHY LO
B.A., Southern Illinois

EDWARD F. LONG
M.A., Lehigh

JOHN D. LONG
B.S., Juniata College

SALVADOR LOZANO
B.S., University of Nuevo Leon (Monterey, Mexico)

BRUCE DEY MACDONALD
M.S., Drexel Institute of Technology

RAUL G. MACHUCA
B.A., Fairleigh Dickinson

STEPHEN ANTHONY MACK
B.S., St. Francis College

JOHN H. MANCUSO
A.B., Boston College

GARY ALAN MARSHALL
M.S., Lehigh

IWAO MATSUI
M. Ch.E., Shibaura Institute of Technology (Tokyo)

DANIEL MAZAR-BARNETT
Ingeniero Electromecanico (Buenos Aires)

JAMES G. MCAULIFFE
M.S., Siena College

JANE L. MCCORMICK
M.A., Simon Fraser (Canada)

JAMES C. MCCULLAGH
B.S., Indiana State College

WILLIAM J. MCDONOUGH
B.S., State University of New York (Alfred)

HARRY I. MCHENRY
M.S., University of Texas

RENAE MEAD
B.A., Moravian

ROBERT T. MEADOWCROFT
B.S., Lehigh

SUDHIR MEHTA
M.S., Indian Institute of Technology, Kharagpur (India)

STEVEN MICHAELS
M.S., Lehigh

WILLIAM A. MILLARD
M.A., Lehigh

DONALD G. MILLER JR.
M.S., University of Illinois

JAMES H. MILLER
M.S., Lehigh

JOHN FREDERICK MILLER
M.S., Miami (Ohio) University

SITANSU S. MITTRA
M.Sc., University of Toronto

MICHAEL FRANCIS MOHR
B.A., LaSalle College

FREDERICK CARLTON MONSON
M.S., Lehigh

SHOSUKE MORINO
M.S., Kyoto University (Japan)

MICHAEL NAEDER
Guttenberg University (Mainz, Germany)

MASAHIRO NAKABAYASHI
B.S., Chuo University (Japan)

T. NARAYANAN
M.S., ITT Tech (Bombay)

DAVID NEWLIN
B.S., Lafayette College

HAROLD D. OCHO JR.
B.S., Rutgers University

Y. FRANCINE OKUDA
License d' Anglais, Universite de Strasbourg (France)

JORGEN G. OLLGAARD
Akademi Engineer, Danish Engineering Akademi

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