1971-72

The Graduate School
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<tr>
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<tr>
<td>Adams Residential Tower (NECCE)</td>
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<td>Bookstore</td>
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<td>Brackett Field</td>
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<td>Brooks House</td>
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<td>Central Receiving (location map)</td>
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<td>Christensen Hall</td>
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<td>College Woods</td>
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<td>Conant Hall</td>
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<td>Dairy Barns (location map)</td>
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<td>Pettee Hall</td>
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<td>President's House</td>
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<td>Snively Arena</td>
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<td>Stillings Dining Hall</td>
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<td>Thompson Hall</td>
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<td>Verrette House</td>
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<tr>
<td>Whittemore School of Business and Economics</td>
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<td>Wolff House</td>
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## Trustees and Officers of the University

### Trustees

<table>
<thead>
<tr>
<th>Name</th>
<th>Title and Other Information</th>
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<tr>
<td>His Excellency Walter Peterson, A.B.</td>
<td>Governor of New Hampshire</td>
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<td><em>ex officio</em></td>
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<tr>
<td>Frank T. Buckley</td>
<td>Commissioner of Agriculture</td>
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<td></td>
<td><em>ex officio</em></td>
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<tr>
<td></td>
<td><em>ex officio</em></td>
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<tr>
<td>John W. McConnell</td>
<td>President of the University</td>
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<td><em>ex officio</em></td>
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<tr>
<td>Harold E. Hyde, B.S., M.S., Ed.D.</td>
<td>President of Plymouth State College</td>
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<tr>
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<td><em>ex officio</em></td>
</tr>
<tr>
<td>Leo F. Redfern</td>
<td>B.A., M.A., M.P.A., Ph.D.</td>
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<tr>
<td></td>
<td>President of Keene State College</td>
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<td><em>ex officio</em></td>
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<tr>
<td>Fred W. Hall, Jr., B.S., LL.B.</td>
<td>Rochester (1966-1973)</td>
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<tr>
<td></td>
<td>Chairman of the Board</td>
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<tr>
<td></td>
<td>Vice Chairman of the Board</td>
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<tr>
<td>Norman S. Weeks, B.S.</td>
<td>Laconia (1965-1973)</td>
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<tr>
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<td>Secretary of the Board</td>
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<tr>
<td>J. Fred French</td>
<td>Manchester (1961-1972)</td>
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|                                          | *ex officio*                  |
|                                          | *ex officio*                  |
| Norman C. Berube, B.A., M.D.             | Manchester (1963-1971)       |
|                                          | *ex officio*                  |
| George R. Hanna, B.A., LL.B.             | Keene (1963-1971)            |
|                                          | *ex officio*                  |
| Mildred McA. Horton                      | B.A., M.A., LL.D.            |
|                                          | Randolph (1963-1971)         |
|                                          | *ex officio*                  |
|                                          | *ex officio*                  |
| George T. Gilman, B.S.                   | Farmington (1967-1971)       |
|                                          | *ex officio*                  |
|                                          | *ex officio*                  |
| Charles V. Spanos, B.A., LL.B.           | Claremont (1967-1971)        |
|                                          | *ex officio*                  |
| Lewis J. Fisher, LL.B.                   | Dover (1968-1971)            |
|                                          | *ex officio*                  |
| Frederick C. Walker, B.S., Ed.M.         | Dover (1968-1972)            |
|                                          | *ex officio*                  |
| Richard H. Keefe, A.B., LL.D.            | Dover (1968-1972)            |
|                                          | *ex officio*                  |
|                                          | *ex officio*                  |
|                                          | *ex officio*                  |
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Vice President-Treasurer

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Academic Vice President and
Professor of Psychology

Robert N. Faiman, Ph.D.
Vice President for Research and Special
Program Administration and Professor
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Agriculture and Professor of
Dairy Science

Jan E. Clee, Ph.D.
Dean of the Whittemore School and
Professor of Organizational Development

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Dean of the Graduate School and
Professor of History

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Dean of the College of Technology
and Professor of Materials

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Dean of the School of Health Studies
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Dean of Institutional Research and
Planning and Professor of Electrical
Engineering

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Associate Dean of the Graduate School,
Coordinator of Research, and Professor
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Director of the Division of Continuing
Education and Associate Professor of
Education

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Registrar

Donald E. Vincent, A.M.L.S., A.M.
Librarian
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Dean of the Graduate School,
Chairman

William H. Drew, Ph.D.
Associate Dean of the Graduate School

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Ronald R. Clark, Ph.D.
Associate Professor of Electrical Engineering

G. Alfred Forsyth, Ph.D.
Assistant Professor of Psychology

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Professor of Mathematics

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Professor of English

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Professor of Plant Science and Genetics

Michael S. Pincus, Ph.D.
Associate Professor of Spanish

Samuel R. Reid, Ph.D.
Professor of Business and Economics

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Professor of Poultry Science

Langley Wood, Ph.D.
Professor of Zoology

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Graduate Student, Mathematics

Craig Little
Graduate Student, Sociology

Martin Weinhaus
Graduate Student, Physics

Kenneth O. Freer, M.Phil.
Secretary to the Council and Assistant to the Dean

Research Council

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Coordinator of Research,
Chairman

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Professor of Electrical Engineering

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Professor of Poultry Science

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Vice President for Research

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Professor of English

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Professor of The Arts

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Professor of English

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Dean of the College of Life Sciences and Agriculture

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Professor of Microbiology

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Professor of History

J. John Uebel, Ph.D.
Associate Professor of Chemistry

Robert Seidenstadt
Graduate Student, Psychology

Bruce Smith
Graduate Student, Zoology

Dick Vogelsong
Graduate Student, Mechanical Engineering
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Dean of the Graduate School, Chairman
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Professor of Economics
Hans Heilbronner, Ph.D.
Professor of History
Richard E. Johnson, Ph.D.
Professor of Mathematics
Avery Rich, Ph.D.
Professor of Plant Pathology

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Associate Professor of English
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Professor of Biochemistry and Genetics

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Paul R. Jones, Ph.D.
Professor of Chemistry
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Assistant Professor of Mathematics
Owen M. Rogers, Ph.D.
Associate Professor of Plant Science and Genetics

Tuition Scholarship Selection Committee
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Associate Professor of Education, Chairman
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Assistant Professor of Resource Economics
Glen C. Gerhard, Ph.D.
Assistant Professor of Electrical Engineering
John J. Korbel, Ph.D.
Professor of Economics and Business
Graduate Degree Programs

Master of Science
Animal Sciences
Biochemistry
Biology
Botany
Chemical Engineering
Chemistry
Civil Engineering
Electrical Engineering
Entomology
Forest Resources
Genetics
Geology
Home Economics
Mathematics
Mechanical Engineering
Microbiology
Music Education
Physics
Plant Science
Resource Economics
Soil and Water Science
Zoology

Master of Arts
Economics
English
French
German
History
Music
Political Science
Psychology
Sociology
Spanish

Master of Arts in Teaching
Department of Education

Master of Science for Teachers
Chemistry
English
French
German
Mathematics
Physics
Spanish

Master of Occupational Education
Department of Occupational Education

Master of Business Administration
Whittemore School of Business and Economics

Master of Education
Department of Education

Master of Public Administration
Department of Political Science

Doctor of Philosophy
Biochemistry
Botany
Chemistry
Economics
Engineering
English
Genetics
History
Mathematics
Microbiology
Physics
Plant Science
Psychology
Sociology
Zoology
Graduate Education at the University of New Hampshire

Background

The University of New Hampshire began its life as the "New Hampshire College of Agriculture and the Mechanic Arts" in 1866. Originally located in Hanover, the New Hampshire College moved to Durham in 1893. Here it developed more rapidly, aided by the substantial bequest of Benjamin Thompson. In 1923 the state granted its land-grant college a new charter as the University of New Hampshire. Five years later the Graduate School was formally added to the University system. The University now includes the following colleges and schools: College of Life Sciences and Agriculture, College of Liberal Arts, College of Technology, Whittemore School of Business and Economics, the School of Health Studies, Thompson School of Applied Science, and the Graduate School. The University also includes as component parts the State Colleges located at Keene and Plymouth and the Merrimack Valley Branch at Manchester. The major thrust of graduate education is at the University campus in Durham.

Although the first Ph.D. was awarded in 1896, graduate education at the University had its formal beginnings forty years ago. The development of the graduate programs has been gradual and systematic with the quest being for academic excellence and for programming commensurate with institutional resources and regional opportunities. The Graduate school offers an environment in which the search for knowledge and understanding can be stimulated and sustained. The graduate student is expected to make use of such opportunities and to demonstrate the maturity and self-discipline on which true scholarship is based.

The Graduate School is administered by the Dean of the Graduate School in association with the Associate Dean and Coordinator for Research; the Graduate Council serves in an advisory capacity. Graduate studies at the University are supervised by the Graduate Faculty.
Few institutions of higher learning are as ideally located as the University of New Hampshire. Durham is one of the oldest towns in northern New England, and traces of its colonial past are everywhere apparent. To the south, ninety minutes away, are metropolitan Boston and all the cultural opportunities a great urban area can offer. To the north, an equal distance in time, are the White Mountains and unsurpassed skiing, hiking, and scenery. Twenty minutes to the east are the beaches and rocky coasts of New Hampshire and Maine.

The University campus in Durham is 156 acres in size. There are 35 buildings devoted to administration, instruction, and research, and 23 residence halls for men and women. Book value of the physical plant exceeds $54 million. Total University lands—including athletic fields, farms, and woodlands—comprise 3,075 acres.

Major construction projects of the past ten years include:

- University Library, housing 523,000 volumes, 4,300 periodicals, and substantial microfilm and tape collections.
- Paul Arts Center, a $2,250,000 structure with separate wings for music, drama, and the arts.
- Social Science Center, completed in 1968, houses the Graduate School offices and facilities for several departments in the Social Sciences.
- Spaulding Life Science Building, with facilities for the departments of Biochemistry, Microbiology, and Zoology.
- Physical Education Facilities, including an indoor track and pool and Snively Arena, an indoor hockey rink, have recently been completed at a cost of $3,600,000.
- Whittemore School Building, houses the business and economics departments with extensive facilities including computer equipment.
- Parsons Hall, the first phase of which was completed in 1966, provided completely new facilities for the Department of Chemistry. The second phase of construction was completed in the fall of 1970.
- Kendall Hall, a five-story building completed in the spring of 1970, is the home of the Animal Sciences Department with offices, classrooms, and laboratories. The library for the College of Life Sciences and Agriculture and for Microbiology and Zoology is located on the first floor.

Other new buildings since 1946 include the University’s engineering building, student recreation center, nutrition laboratory, thirteen residence halls, two dining halls, and housing for married students and faculty.
Teaching, Service, and Research

Student Activities

Graduate student participation in University activities is substantial. The Graduate Student Senate is an independent organization representing all departments with graduate programs. Graduate students are often consulted by departments about academic decisions. Graduate students are elected to the Graduate Council and representation also exists on the Research Council. The University's primary governing body in matters of student conduct and academic policy is the University Senate composed of 30 faculty members, 12 administrators, 5 graduate students, and 30 undergraduates—all with equal voting privileges. This reflects the increased student participation in the University governing process.

Office space has been provided in the Graduate School for graduate-student representatives. There is also a large lounge and kitchen available to students for social and academic events.

The Black Students Union participates actively in University affairs. Information and counseling are available concerning the military obligation of students.

A number of student organizations help promote religious life on the campus. There are clubs for Episcopal, Christian Science, Mormon, Jewish, Catholic, and Greek Orthodox students; a Christian Association with a full-time chaplain for protestant students; and an Inter-Varsity Fellowship.

Many of the over forty student organizations welcome graduate-student participation.

Teaching, Service, and Research

The University of New Hampshire has a teaching faculty of 620. Their main function is teaching, but many—perhaps a majority—are also deeply involved in research and service activities.

Among the University's specialized research facilities are the Space Science Center in DeMeritt Hall, the Ritzman Animal Nutrition Laboratory, and the Computation Center in Kingsbury Hall.

One of the largest research and service units is the Agricultural Experiment Station, which conducts research, publishes results, and provides testing services for New Hampshire farmers. A similar service, plus counsel on institutional problems, is provided for New Hampshire industry by the Center for Industrial and Institutional Development.
Graduate Education

The Cooperative Extension Service, operating in conjunction with the U.S. Department of Agriculture, bridges the gap between campus research and the people of the state.

Formal adult education is conducted by the Division of Continuing Education, which offers credit and non-credit courses anywhere in the state where there is sufficient demand.

The University operates New Hampshire’s educational television station, WENH-TV, broadcasting in-school programs for 110,000 young people, and, during the evening hours, cultural and educational programs.

Another major extension service of the University is the New England Center for Continuing Education. This facility houses research, conference, and service activities for the entire six-state region.

Other University units which place its resources at the service of the state: the Resources Development Center, which brings the talents and techniques of the social scientist into closer partnership with state and local governments; the Public Administration Service, which specifically aids town and city officials; the Water Resources Research Center; and the Bureau of Educational Research and Testing.

The New Hampshire State Entomologist and State Geologist are University faculty members with offices on campus.

The Engineering Design and Analysis Laboratory is an interdisciplinary faculty group predominantly from the College of Technology. EDAL-associated faculty and graduate students participate mainly in marine-oriented engineering projects.

Among the many research instruments available are a Mass Spectrometer, an Optical Rotatory Dispersion Spectrophotometer, a Nuclear Magnetic Resonance Spectrometer, a Van de Graaff Generator, an Amino Acid Analyzer, Electron Microscopes, a Gas Chromatograph, and an Electron Spin Resonance Spectrometer. Students from all disciplines may make arrangements for their use.

The Jackson Estuarine Laboratory, the University’s newest research facility, is an 8,400-square-foot structure located about five miles from the University campus on the shore of the Great Bay at Adam’s Point. The tidewater area in the Great Bay estuarine complex covers more than 15,000 acres. Tidal water enters and leaves via the Piscataqua River; some 13.5 billion gallons ebb and flow on an average tide of eight vertical feet. The continental shelf of the Gulf of Maine is approximately thirteen miles steaming distance of the Laboratory. Marine research facilities for the departments of biochemistry, botany, microbiology, zoology, and earth science are located in the Laboratory. Also included are: a circulating seawater system; a shop for maintenance of oceanographic gear; a small library-conference area; a research vessel, R/V “Jere A. Chase”; and a pier for docking research vessels.
The principal research topics of the Jackson Estuarine Laboratory are a study of the estuarine and continental shelf food-web, biotoxins from marine organisms, and pollution in the marine environment.

This project has received support from the National Science Foundation and the New England Regional Commission.

Further information about the above service activities may be obtained by writing the director of the appropriate unit, or from the Vice-President for Research, University of New Hampshire, Durham, N. H. 03824.

Cultural Activities

A substantial range of cultural activities complements the regular academic program.

An outstanding program in music each year includes concerts and opera by student groups and recitals by faculty members. The University also sponsors a “Blue and White” concert series which brings professional musicians to the campus. In recent years, this series has included the French National Orchestra, the Swingle Singers, and the Juilliad String Quartet.

Drama is offered several times during the year by the University Theater. There are professional productions in the “Allied Arts” series, which has included performances of “You’re a Good Man, Charlie Brown,” and by the Rod Rogers Dance Company and Bob Inglis in “Canterbury Tales.”

There are many public lectures at the University, by faculty and off-campus speakers. One lecture series brings outstanding men and women of arts, letters, science, and the humanities to the campus for a formal lecture and informal meetings with students. Another series concentrates on issues, and brings one or more noteworthy public figures to speak on an important topic such as Black arts, population, and pollution. Symposia on Alternative Life Styles and on Innovations in Higher Education have been offered. Recent visitors in these series have included Daniel Moynahan, James Van Allen, Stewart Udall, and Ralph Nader.

In the galleries of Paul Creative Arts Center, there is a continually changing program of exhibits to interest both the art student and the layman.

Student groups are also active in promoting cultural and educational events. Several film-series feature early movies and avant-garde and experimental works. There is also a student FM radio station. Political clubs often bring speakers of national prominence to the campus.
The Counseling and Testing Center

The Counseling and Testing Center provides, without charge and through a professionally qualified staff, psychological services to students who are experiencing personal difficulties. In addition to therapy and diagnostic testing, consultations are available for the handling of concerns one might have about another individual—roommate, fellow student, spouse, etc.

The University Health Service

The University Health Service, located in Hood House, is devoted to the protection, improvement, and maintenance of student health. Graduate students carrying nine or more credits and graduate assistants are eligible for treatment. A well equipped out-patient clinic functions for diagnosis and treatment of ambulatory patients; and an infirmary of twenty-six beds, with an isolation division for communicable diseases, is available for students who require inpatient care. During the regular academic year registered nurses are on duty at all times. Individual health guidance is given through personal conferences with the University physicians. Routine office hours of the University physicians are from 8:30 a.m. to 12:00 noon and 1:30 p.m. to 4:00 p.m. daily, except Saturdays and Sundays when emergency care is available.

The Health Service is closed when the University is officially closed for holidays, closing one hour after the dormitories, and opening at 3:00 p.m. on the day before classes resume. During the Summer Session, Hood House is open 24 hours a day with a limited staff on duty. A doctor is available during regular hours and nurses will decide when a doctor’s attention is needed after hours, usually referring the patient to the Emergency Room at Wentworth-Douglass Hospital via ambulance if necessary.

Injury and illness which require hospital confinement, service of specialists, operations, special nurse, or special prescriptions are at the expense of the student.

In addition to the health service available through Hood House, group accident and sickness insurance, providing twelve-months coverage, is available to students at the University. This insurance coverage is designed to supplement the program of the University. Complete details may be had on application to the Business Office.
The Memorial Union

The Memorial Union is a campus center for outside-the-classroom activities for the University community. It provides social, recreational, educational, and food-service facilities and serves as the headquarters for many student organizations. The Memorial Union reserves facilities for any organizations desiring to meet in the building or in other University buildings and serves as a central campus information center. A program of activities for all students is planned by the all-student board of governors of the Memorial Union Student Organization.

The original building was financed in part by the generous gifts of the citizens of New Hampshire, the alumni, students, faculty, and staff of the University. The balance of the original building and the recently completed addition are being paid for by a student fee and income from the many services provided by the Memorial Union. The building serves as a college union, a conference center, and a living memorial to the men and women of the state of New Hampshire who have given their lives in our armed services.

The University Placement Service

The objective of University Placement is to assist students in obtaining permanent employment upon graduation from the University. The office maintains contact with recruiting personnel from business, industry, government, and education, and keeps up-to-date data on positions available as well as vocational information about employing organizations. The Service provides vocational counseling as an adjunct to the faculty-student relationship. An on-campus interview program is administered by the Service which brings recruiting personnel to the campus each year between November and April.

The services of University Placement are also available to undergraduate and graduate students seeking summer employment during their years at the University.

University Placement also assists UNH alumni in their post-collegiate placement activities.

It is the policy of University Placement to provide students with information about employing organizations and to discuss particular employment opportunities with interested registrants. The final decision concerning a registrant's acceptance or rejection of an offer of employment, however, always rests with the registrant.

Registration is important and should be completed by the student while on campus, even though permanent employment is not sought immediately after graduation.
Residence and Dining Services

**Babcock House**, the graduate residence, is designed to achieve two objectives; to provide housing for single graduate students; and to provide quiet, dignified areas for graduate students to meet informally with one another and with members of the faculty.

Babcock House is located on College Road within easy walking distance of a number of major classroom areas as well as the University Library, University Theater, and the Memorial Union Building. For those students with cars, parking is provided in areas convenient to the building.

The structure includes two, six-story towers, connected at each floor by a common lounge and accommodates 180 men and women. The Hall has a large lounge with fireplace, two recreation rooms, food-vending room, coin-operated laundry, TV room, ski storage, luggage storage, individual mail boxes, and private room-telephones, if desired. The residence rooms are all single rooms, allowing complete privacy for consultation with students or faculty; and each is furnished with a bed, mattress, pillow, easy chair, desk chair, waste basket, and a built-in desk-dresser-wardrobe unit with book shelves, mirror, medicine chest, and desk lamp. The rental charge for Babcock House is $630 per student per academic year. Rooms are available on contract for the full academic year only (September-June).

A limited number of rooms in Babcock House is available to graduate students during the summer. Students interested in summer accommodations should write or call the Residence Office (603-862-2120), University of New Hampshire, Durham, N. H. 03824.

A Faculty-Member-in-Residence and his family live in a two-bedroom apartment on the ground floor. The Faculty-Member-in-Residence works in an advisory capacity within the hall on educational and social problems and with individual students on a personal level. The Faculty-Member-in-Residence with the aid of two Graduate Resident Assistants carries out the administrative responsibilities required by the students and the University and is knowledgable about University policies and personal services available.

Residents provide their own bedding. An optional linen service is available which furnishes bed linen, towels, and blankets at a minimal cost. Complete information can be obtained by writing to the Manager, Physical Facilities, Auxiliary Enterprises, Stoke Hall.

The residents of Babcock House may elect to take their meals on a contractual basis at any of the three University Dining Halls. Available to the student is a 20-meal contract at a cost of $560 per academic year, a 15-meal contract (Monday breakfast through Friday supper) at a cost of $500 per academic year, and a 12-meal-per-week contract for $440. The University Dining Services also operates a cafeteria in the Memorial
Union where meals may be obtained on an a la carte plan. There is also a pre-paid à la carte meal plan, under which a $400 coupon book may be purchased. Students are encouraged to thoroughly investigate the dining possibilities available because individual cooking facilities are not available and cooking cannot be permitted in student rooms.

As soon as a student is notified of his admission to the Graduate School, he may apply for residency in Babcock House. Assignments are made in the order in which applications are received. There are usually more applicants than there is space available, so it is important that the student return the application promptly. To obtain housing application forms, the student should write or call the Residence Office (603-862-2120), University of New Hampshire, Durham, N. H. 03824.

Married Graduate Student Housing—The University owns and operates Forest Park, a complex of 154 studio, one- and two-bedroom apartments. Residency is not limited to graduate students alone, and the demand for these apartments is great. Those interested in Forest Park are encouraged to apply a semester prior to intended occupancy. Studio apartments presently rent for $82.50 per month; one-bedroom apartments, $97.50; two-bedroom apartments, $110 and $125.

Off-Campus Housing—The University Residence Office maintains a list of off-campus rooms and apartments. The day-to-day changes in the list makes it impossible to maintain a current list for mailing. Therefore, students are encouraged to make every effort to come to the campus so that the Residence Office will be able to assist in finding suitable accommodations off-campus. The Residence Office is open Monday through Friday, 8:00 a.m. to 4:30 p.m. During the months of July and August the listings are available on Saturdays and Sundays (limited time schedule) for the convenience of those who cannot come to the campus during the week.

Alumni Association

Those individuals who have received an advanced degree from the University of New Hampshire automatically become members of the Alumni Association. The present membership of the Association exceeds 30,000, representing New Hampshire College and University of New Hampshire classes from 1897 through the present. Alumni reside in every state of the Union and many foreign countries.

Governed by a Board of Directors of 15 elected and four ex officio members, who are the elected Alumni Trustees, the alumni are organized by classes and clubs. Class reunions are held annually. An annual Homecoming in the fall provides opportunity for alumni to return to Durham while the University is in session. Other alumni gatherings on campus are also scheduled from time to time during the academic year. There are 55 UNH alumni clubs throughout the United States. Two
alternating bi-monthly publications, "The New Hampshire Alumnus" and "UNH Magazine," circulate news of students, faculty, alumni, and the University. From offices in Alumni House, the Association's activities are directed by the Director of Alumni Affairs and his staff.

Financial Information

Tuition

Full tuition is currently $810 per academic year for New Hampshire residents and $2000 for non-residents. Students enrolled for five or more credits including thesis registration will be charged full tuition. Students enrolled for four credits or less will pay a course charge of $30 per credit. Course charges in the Summer Session and the Division of Continuing Education are listed in their respective catalogs.

Doctoral candidates in residence will pay a doctoral research registration fee of $300 per semester and $150 per Summer Session in addition to course charges unless such students are paying full tuition. Master's candidates who are in residence and working on a thesis must enroll for 899. Master's Thesis, even if they are not registered for other courses.

When a student completes his degree requirements in absentia, a charge of $100 for the privilege of taking the final examination must be paid six weeks before the conferring of the degree.

A Memorial Union fee of $12.50 per semester and a student services fee of $5 per semester must be paid by each student.

Students may audit courses with the consent of their adviser and the instructor involved. Regular charges will be charged for all audits.

A student, though he may be 21, will not be recognized as a New Hampshire resident by the University unless he can clearly establish that his residence in New Hampshire is for some purpose other than the temporary one of obtaining an education at the University.

The immediate families of members of the full-time University staff may register as full- or part-time students in the Graduate School at one-half the current tuition or course rate. They are required, however, to pay the full doctoral research dissertation fee. Graduate assistants under University-supported contracts are exempted from the payment of tuition and fees.

The University reserves the right to adjust rates for tuition, charges and fees. Such rates will be held to a minimum and will be announced as far in advance as possible.
Assistantships, Scholarships, and Fellowships

Graduate Assistantships

Approximately 250 graduate assistantships are available each year. Such assistantships are awarded only to superior students. The re-appointment of a graduate assistant is contingent on the maintenance of a high level of scholarship. The service required of the graduate assistant may be in the nature of teaching or research assistance. The normal academic load is three full courses per semester.

There are four types of regular assistantships available with the possibility of additional summer employment.

Net stipends for graduate assistantships vary up to a maximum of $2,800 per academic year and $3,920 for the calendar year plus tuition waiver. The following types of graduate assistantship appointments are available:

1) Teaching Assistant—classroom teaching.
2) Laboratory Assistant—laboratory preparation or discussion section.
3) Research Assistant—assisting faculty in their research projects.
4) Project Assistant—assisting faculty in externally funded research.

As stated below a limited number of Summer Fellowships for graduate assistants is available.

Inquiries regarding assistantships should be addressed to the chairman of the department concerned.

Graduate Associates

A very limited number of appointments are available for highly qualified teaching and research personnel whose normal academic program would not exceed one full course per semester. Stipends are negotiable, up to $5,000, according to qualifications and duties.

Tuition Scholarships

Up to 50 superior students may be granted academic-year tuition scholarships. These awards are subject to the maintenance of a high scholastic record in the Graduate School. Foreign students will be considered for these scholarship awards.

Up to 30 superior students, who have been regularly admitted to the Graduate School, may be granted tuition scholarships for the Summer Session.

University of New Hampshire Fellowships

A limited number of three-year “University of New Hampshire Fellowships,” are awarded to outstanding doctoral students. Each recipient is given an opportunity to spend the first year in full-time study, the second year as a teaching assistant, and the third year as a
Graduate Education

research assistant. The stipends for this program are $2,800 for the first academic year, $3,000 for the second academic year, and $3,200 for the third academic year. In addition, the award provides $750 support for each of two summers, waiver of tuition, and an annual allotment of $500 each for up to two qualified dependents.

Traineeships

Traineeships sponsored by the National Science Foundation are available (subject to availability of federal funds) to outstanding students studying for the master’s or Ph.D. degree in the various science and engineering fields. The basic stipends (for 12 months of study) range from $2,400 to $2,800 plus free tuition and $500 per dependent—open to U.S. citizens only.

National Defense Education Act (NDEA Title IV) Fellowships

National Defense Education Act (NDEA Title IV) teaching fellowships are available (subject to availability of federal funds) to highly qualified students who are studying for the Ph.D. degree and are interested in college teaching careers. Annual (12 months) stipends range from $2,400 to $2,800 plus free tuition and $500 per dependent—open to U.S. citizens only. Graduate students also are eligible for awards granted by other national agencies and foundations.

Martin Luther King Fellowships

There are several Martin Luther King Fellowships reserved for graduate students. They are to assist members of minority groups. Stipend amounts vary according to financial need.

Dissertation Fellowships

One-year dissertation fellowships are available, providing a $3,000 stipend. Because no classes are attended, a tuition waiver is not included.

Summer Fellowships

Thirty Summer Fellowships for Teaching Assistants are available for students who have held teaching assistantships during the previous academic year. The stipend for summer study is $750.

Information and application forms for all of the above scholarships and fellowship programs may be obtained from the Dean of the Graduate School. Students wishing to apply for financial aid must submit their application for admission prior to February 15.
Regulations of the Graduate School

Admission

Admission to the Graduate School may be granted to graduates of all colleges and universities of approved standing, provided the applicant's undergraduate record is satisfactory. Factors of race, religion, color, and national origin do not enter into the admissions process.

Before entering upon graduate work the applicant must present evidence that he has had the necessary prerequisite training that will enable him to pursue the courses desired. A candidate for admission must have a superior undergraduate record. Where the department in which the candidate plans to do his work so requires, the candidate may be required to take an achievement test. In addition, there may be special requirements established by individual departments or programs. For the individual departmental requirements, see the description under the departmental offerings in this catalog.

Students wishing to enroll in the Master of Science for Teachers program must meet one of the following admission requirements: 1) education courses sufficient for certification, 2) three years' experience in teaching, or 3) current full-time participation in teaching.

All regularly enrolled graduate students must have a medical history and physical examination report on file with the Director of the University Health Service. Recent graduates of the University of New Hampshire need not file a new set of reports upon being admitted to the Graduate School. Others should return the proper forms, which will be mailed with the letter granting admission to the Graduate School.

Application Procedures

A student who desires to be admitted for graduate study must submit to the Dean of the Graduate School the official application for admission to graduate study. Forms for this purpose may be obtained by writing to the Dean of the Graduate School, University of New Hampshire, Durham, New Hampshire 03824. The application must be accompanied by two official transcripts of the student's undergraduate
work and of any previous graduate work, and by three letters of reference.

Transcripts of applicants who are admitted to graduate study become a permanent part of the University files and will not be returned. Applications to the University of New Hampshire Graduate School must be accompanied by a non-refundable $10 application fee.

Application Deadlines

Completed applications for admission to the Graduate School should be submitted before July 15 for the first semester, before November 15 for the second semester, and before April 1 for the Summer Session, to guarantee action before the respective registration days. Students wishing to apply for financial aid must submit their application for admission prior to February 15.

University of New Hampshire Seniors

Qualified senior students in the University of New Hampshire may be admitted to the Graduate School, and must have been admitted before taking courses for graduate credit.

Foreign Students

Foreign students applying for admission to the Graduate School must furnish proof of their proficiency in English by taking the "Test of English as a Foreign Language" administered by the Educational Testing Service, Princeton, New Jersey.

Unclassified Graduate Students

This category comprises students holding the baccalaureate degree who have not been admitted to the Graduate School, but who wish to register for graduate courses. These students must receive the approval of the Dean of the Graduate School and of the instructor concerned.

Credits earned in an unclassified status will be applied to a degree program on a selective basis. No more than nine hours earned in the University system in an unclassified status may be applied at a later date to the residence or credit-hour requirement for a degree. Ordinarily, the nine hours will include all courses completed or in process at the date of admission.

University of New Hampshire Faculty Members

Members of the University of New Hampshire faculty with the rank of Assistant Professor or above will not be admitted to graduate programs. This rule obtains even should the faculty member resign his position.
Honorary Fellows

Properly qualified scholars, who may temporarily desire the privileges of the library and research facilities of the University and who are not candidates for a degree, may, upon recommendation of the Dean of the Graduate School and the approval of the President of the University, be appointed Honorary Fellows without stipend. Honorary Fellows shall not be required to pay any charges except possibly the cost of unusually expensive supplies or equipment.

Degree Candidacy and Program Requirements

Admission to the Graduate School does not imply admission to candidacy for a degree. To be admitted to candidacy, a student must meet the special requirements of the department in which he is doing his graduate work; and his program must be approved by his adviser and the Dean of the Graduate School. For these special requirements see the department statements in this catalog.

A graduate student will be admitted to candidacy for a degree only after he has been in residence a sufficient length of time to enable his instructors to judge his ability to carry on graduate work. Generally this period of time shall be not less than that required for the completion of 12 credits of graduate work for the master's degree, or, for the Ph.D. degree, the passing of the qualifying examination and the completion of departmental language requirements. Admission to candidacy for a degree will be determined by the Dean upon the recommendation of the department concerned. The Dean will communicate the decision to the student.

Registration

Registration Procedure

A student admitted to graduate study must have his program approved by the chairman of his department or of his guidance committee and by the Dean of the Graduate School. Registration is held prior to the beginning of classes each semester and on the first day of Summer Session. (Consult the Calendar in this catalog for the date of registration.)

Graduate students are defined as those who meet the requirements for admission to the Graduate School and are registered for an approved program for graduate credit.
Regulations of Graduate School

The maximum graduate load allowed is 16 semester credits for a regular semester, 4 credits for a 4-week Summer Session, and 8 credits for an 8-week Summer Session. Only under unusual circumstances will extra credits be allowed, and then only with the approval of the Dean of the Graduate School.

Failure to Register
A student who is not registered during a twelve-month period and has not notified the Graduate School of his intention to continue in the degree program must reapply for admission in order to resume his graduate work.

Withdrawal Procedure
A student may withdraw from the Graduate School during any semester by obtaining a Withdrawal Form from the Registrar. This form should be signed by the student's adviser, the Dean of the Graduate School, and other appropriate University officials (e.g. the Director of Housing). When completed, the form should be filed with the Registrar's office.

Graduate Credits

Graduate credits may be earned in courses numbered from 700 through 898, and in the thesis; graduate credits will not be given in any courses so numbered which are open to freshmen or sophomores. In certain cases graduate credit may be allowed for 600-level courses in master's degree programs. (See general requirements for master's degree.)

Upon recommendation of the department, superior students may petition the Graduate School to be allowed to count credits for up to two, 800-level courses toward both a bachelor's and master's degree, provided the student has been admitted to the master's program.

Graduate students who desire to do a part of their work during the Summer Session of the University will find graduate courses offered in many departments. Credit in appropriate courses may be used in fulfilling the requirements for an advanced degree. For complete information on the Summer Session, see the Summer Session catalog.

In master's degree programs, no more than 12 credits, not including thesis, may be earned off the Durham campus. Of these 12, only six may be from another graduate school.
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Masler’s
Degree
Grades
Graduate grades are A, B+, B. Any grade below the B level (C+, C, D+, D, F) will not count toward graduate credit and will count toward the accumulation of nine failing credits, which will normally result in a student’s being required to withdraw from the Graduate School.
A grade of credit (Cr) is given for completed and approved theses and dissertations.
An incomplete grade in the Graduate School must be removed by the end of the semester following the one in which the incomplete grade was obtained. An incomplete grade automatically becomes an “F” if not removed within the allowed time period. The burden of removing the incomplete grade rests with the student. This rule does not apply to the completion of the thesis.

Requirements for Master’s Degree

General Requirements
For the degrees of Master of Arts, Master of Science, Master of Occupational Education, Master of Business Administration, and Master of Public Administration, at least 30 credits must be earned, including a minimum of eight credits in courses, not including thesis, numbered 800-898. Courses numbered 600-699 cannot be used towards these master’s degrees if the courses are given in the department awarding the degree. No more than 12 credits will be permitted in courses numbered 600-699. The major department will prescribe for its students the courses which make up the degree program. Somewhat different requirements obtain for the Master of Science for Teachers degree and it is recommended for this degree, as well as for all other master’s degrees, that the appropriate departmental section of the catalog be consulted.
A student will normally spend at least one calendar year, or the equivalent, in satisfying the requirements for the degree. No more than 12 credits, not including thesis, may be earned off the Durham campus. A student may present for credit a maximum of six credits earned at another graduate school, provided that these credits are of a grade of at least “B” or the equivalent. Credits from another graduate school will count as part of the 12 credits which may be earned off the Durham campus. These credits will be applied toward the degree only if approved by the major department and the Dean of the Graduate School.
All graduate work for any master's degree must be completed in not more than six years from the time of registration for the first work taken for the degree.

In any department or program requiring a final examination for the master's degree, the examination may be oral, written, or both. A candidate will be permitted only two opportunities to take the final examinations for the master's degree, and the time of these examinations will be at the convenience of the department concerned, except that all such examinations must be given at least two weeks before the Commencement date in the year in which the degree is to be conferred. Further regulations governing the final written examination, when required, will be made by the department concerned, subject to the approval of the Dean of the Graduate School. Oral examining committees, when required and not otherwise provided for, are appointed by the Dean of the Graduate School, upon the recommendation of the department concerned. The Dean of the Graduate School is, ex officio, a member of all examining committees.

Master's Thesis

A thesis may be required of candidates for the Master of Arts or the Master of Science degrees. Consult the departmental statement for thesis requirements. The thesis must be approved by a committee, comprising the instructor under whose direction it was written and two other members of the Graduate Faculty selected by the department chairman and approved by the Dean of the Graduate School.

Each department will determine the date when the candidate must submit for approval a statement of the subject of the thesis and the date when the thesis must be completed.

The number of thesis credits may vary from six to ten, subject to the approval of the student's adviser. No thesis credit shall be given until the completed thesis has been approved by the committee on the thesis. No letter grade shall be given for the thesis, but its satisfactory acceptance will be recorded with a "Cr" (credit).

The student should obtain from the Graduate School office the latest regulations for the form and typing of theses.

Whenever a thesis is printed, it must be designated as having been accepted as a master's thesis by the University of New Hampshire.

Two copies of the approved thesis, ready for binding, shall be submitted to the Graduate School office not less than two weeks before Commencement, together with a receipt for the binding fee from the University Bookstore. Most departments require one copy of the thesis in addition to the above-mentioned two copies. (See departmental requirements in this catalog.)
Requirements for Doctor's Degree

General Requirements

The degree of Doctor of Philosophy is conferred on qualified candidates: who have passed an oral or written examination on the subject matter of their field of study, who have completed an original investigation in this field and have embodied the results in an acceptable dissertation, and who have passed an oral examination in defense of the dissertation. The degree of Doctor of Philosophy is essentially a research degree. It is not given merely for the completion of course credits. Graduate programs leading to the degree of Doctor of Philosophy are offered in Biochemistry, Botany, Chemistry, Economics, English, Engineering, Genetics, History, Mathematics, Microbiology, Physics, Plant Science, Psychology, Sociology, and Zoology.

All resident predoctoral students must register each semester until requirements for the degree have been completed. The minimum requirement for the doctorate is three years beyond the bachelor's degree. Resident graduate work done at other universities may be counted toward the minimum requirement upon approval of the guidance committee and the Dean of the Graduate School, but one full academic year must be in residence at the University of New Hampshire. In individual cases, the major department and the Dean of the Graduate School may grant permission to pursue the research for the dissertation at another institution where access to special facilities may be advantageous.

All graduate work for the doctorate must be completed by the end of the fifth academic year following that in which the student completes the requirements for advancement to candidacy.

A student working for the Ph.D. degree must earn a passing grade in all the courses required by his guidance committee. Certain courses may be taken for audit.

Degree Candidacy

When the student declares his intention to proceed to candidacy for the degree of Doctor of Philosophy, the department of intended major concentration shall notify the Dean of the Graduate School, who then, upon recommendation of the department, will appoint a guidance committee. This committee will have the responsibility of assisting the student in outlining his program, preparing him for and administering his qualifying examination.

Upon the successful completion of the qualifying examination a doctoral committee will be appointed to supervise and pass on the dissertation and administer the final examination. This committee will be nominated by the department of major concentration and appointed
Regulations of Graduate School

by the Dean of the Graduate School. It shall consist of a minimum of five members, usually three from the major department and two from related departments, and the Dean of the Graduate School, ex officio.

The qualifying examination may be written, oral, or both. This examination will test: (1) the student’s general knowledge in his major and minor work and (2) his fitness for engaging in research, particularly in the subject proposed for the dissertation. The results of the examination will be communicated by the chairman of the major department to the Dean of the Graduate School.

The student may not be advanced to candidacy for the Ph.D. until he has passed the qualifying examination and such language or proficiency requirements as are deemed desirable by the major department. The proposed subject of the student’s dissertation must be declared at the time of application for advancement to candidacy.

Resident full-time members of the University of New Hampshire faculty with rank of Assistant Professor or higher may not be admitted to candidacy for the Ph.D. at this University.

Dissertation

The dissertation must be a contribution to knowledge, embodying the results of significant and original research, and a mature and competent piece of writing.

A copy of the completed dissertation must be made available to the Dean of the Graduate School and to the members of the examining committee two weeks before the final examination date. Following the examination and two weeks prior to Commencement, two copies of the approved dissertation, ready for binding, shall be turned in to the Graduate Office, together with a receipt for the binding fee from the University Bookstore. Publication of the dissertation by University Microfilms will be required, and the cost will be assumed by the student. If the material presented in the dissertation is published, it should be designated as having been accepted as a doctoral dissertation by the University of New Hampshire.

The final oral examination is conducted by the doctoral committee and is intended to give the candidate an opportunity to defend his dissertation. A written final examination, on subject matter not covered in the qualifying examination, may also be required. This written examination is conducted by the major department. The final examination must be completed at least two weeks prior to the date of receiving the degree. After consultation with the major department, the Dean may appoint, for participation in the final oral examination, additional members of the faculty under whom the student has worked. The doctoral committee alone shall decide on the merits of the candidate’s performance by a majority vote.
The title, in bold-face letters, and the Arabic numeral designate the particular course. Odd numerals indicate courses normally offered in the first semester; even numerals indicate courses normally offered in the second semester. Numerals enclosed in parentheses indicate that course is repeated in the semester following. Thus course 401 (401) is offered in the first semester and is repeated in the second semester. Parentheses are also used to designate courses out of semester sequence. For example, (404) indicates an even-numbered course offered in the first semester.

The course description is followed by the prerequisites, if any, and the number of semester credits the course will count in the total required for graduation. Laboratory periods are usually two and one-half hours in length, lectures either 50 minutes or 80 minutes in length.

If the course numerals are connected by a hyphen, the first semester, or its equivalent, is a prerequisite to the second semester. If the numerals are separated by a comma, properly qualified students may take the second semester without having had the first.
Regulations of Graduate School

IBM Key Codes

The following numbers are used extensively in machine-processed data to identify both undergraduate and graduate programs offered at the University. An asterisk preceding the number identifies those departments which offer graduate programs.

College of Liberal Arts
40 Liberal Arts, non-departmental
41 Biological Sciences Division
42 Educational Division
43 Humanities Division
44 Physical Sciences Division
45 Social Sciences Division
46 The Arts
*47 Microbiology
*48 Education
*49 English
50 Geography
*51 Earth Science
*52 Political Science
*53 History
55 Classics
*56 French
*57 German
58 Greek
59 Italian
60 Latin
61 Russian
*62 Spanish
*63 Music
64 Music Education
66 Philosophy
*67 Psychology
*68 Sociology and Anthropology
69 Speech and Drama
*70 Zoology

School of Health Studies
54 Nursing
65 Occupational Therapy
90 Men’s Physical Education
91 Women’s Physical Education
92 Medical Technology Program
95 Recreation and Parks

College of Life Sciences and Agriculture
20 Life Sciences and Agriculture, non-departmental

*21 Resource Economics (INER)†
*22 Occupational and Extension Education
*23 Soil and Water Science (INER)†
*25 Animal Science
*26 Biochemistry
*27 Botany
*29 Entomology
*30 Forestry (INER)†
*31 Home Economics
*32 Plant Sciences

† INER—Institute of Natural and Environmental Resources.

College of Technology
79 Technology, non-departmental
*80 Chemical Engineering
*81 Chemistry
*82 Civil Engineering
*83 Electrical Engineering
*84 Mathematics
*85 Mechanical Engineering
*86 Physics
*87 Ph.D. Engineering

Whittemore School of Business and Economics
*71 Administration
*72 Economics
73 Secretarial Studies
74 Hotel Administration

Separate Departments and Programs
93 Inter-College
*97 Genetics Program
98 Military Science
99 Aerospace Studies
Departmental Requirements and Course Descriptions

Animal Sciences  (25)

Chairman: W. C. Skoglund


Associate Professors: Alan C. Corbett, James B. Holter, James T. O'Connor, Gerald L. Smith, Samuel C. Smith

Assistant Professors: Gene B. Fuller, Larry L. Stackhouse, Thomas P. Fairchild

To be admitted to graduate study in Animal Sciences an applicant is expected to have had sufficient undergraduate training in the basic biological sciences to qualify for special work in this field. A thesis is required, and a candidate for the Master's degree shall pass an oral examination covering his graduate courses and thesis.

701. Physiology of Reproduction
A study of physiology, embryology, endocrinology, reproduction, and lactation in domestic animals. Mr. Fuller. 3 lectures; 1 laboratory; 4 credits.

705. A Review of Animal Science
The principles and practices relating to the feeding, breeding, selection, and management of beef cattle, horses, sheep, and swine. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.

706. A Review of Dairy Science
Subject matter covering the principles and practices relating to the latest information on dairy cattle breeding, feeding, and management, and the processing and marketing of milk and its products. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.

707. A Review of Poultry Science
The principles and practices relating to the latest information on poultry breeding, feeding, diseases, and management. For teachers of vocational agriculture and other students with the permission of their advisers. Staff. (Summer Session only.) Two hours daily, lecture and laboratory; 2 credits.
710. **Ruminant Nutrition**
Basic ruminant nutrition and feeding management, including the feeding of young ruminants, with the objective of economical milk production. Mr. Holter. 3 lectures; 1 laboratory; 4 credits.

711. **Animal Genetics**
Mendelian and quantitative inheritance in animals. Principles and systems of selection. Mr. Collins. Prerequisite: one course in genetics or permission of instructor. 2 lectures; 1 laboratory; 4 credits.

712. **Animal Breeding and Improvement**
Principles of population genetics and selection with emphasis on the application of these principles to effect genetic improvement in dairy cattle, livestock, and horses. Prerequisite: Animal Genetics 711 (formerly 708). Mr. Fairchild. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1971-72.)

795-796. **Investigations in Dairy, Livestock, Poultry, Light Horses**
1. **Genetics**
   Mr. Gerald Smith, Mr. Collins, Mr. Boynton.
2. **Nutrition**
   Mr. Gerald Smith, Mr. Ringrose, Mr. Colovos, Mr. Holter.
3. **Management**
   Mr. Skoglund, Mr. Gerald Smith, Mr. Boynton.
4. **Diseases**
   Mr. Allen, Mr. Corbett, Mr. Dunlop, Mr. Strout, Mr. Samuel Smith.
5. **Products**
   Mr. Gerald Smith.
6. **Light Horsemanship**
   Mrs. Briggs, Mr. O'Connor.
7. **Physiology**
   Mr. Fuller.

An opportunity is given for the student to select a special problem in any of the fields listed under the guidance of the instructor. Elective only after consultation with the instructor in charge. Hours to be arranged. 2 credits. May be repeated.

801. **Advanced Studies in Animal Breeding**
Independent study and research on modern breeding methods and newer systems of selection for quantitative traits. Prerequisite: Animal Science 712. Mr. Boynton, Mr. Collins, Mr. Fairchild, Mr. G. L. Smith. Hours to be arranged. 3 credits.

802. **Meats, Livestock Markets, and Products**
The essential factors in meat selection, cutting, curing, and smoking; study and discussion relative to the problems of livestock marketing and the procedure in the large central markets. Trips are taken to various packing plants. Mr. Gerald Smith. 3 lectures; 1 laboratory; 4 credits.

803. **Advanced Animal Nutrition**
Incidental lectures, assigned reading, and laboratory practice in methods of research with major emphasis on protein and energy metabolism. Mr. Colovos. 3 credits.

805-806. **Avian Microbiology**
The disease process (acute or chronic) in the intact host at cellular levels when invaded by viruses or virus-like agents, fungi, and protozoans. Physiological and cytopathological changes in tissue culture. Mr. Dunlop, Mr. Strout, and Mr. Corbett. Prerequisite: Animal Science 612 or the equivalent. 3 credits.
307-308. Avian Histopathology
First semester: general histopathology. Second semester: the special histopathology of common diseases with emphasis on correlation of light and electron microscopy of tumors and tumor formation. Mr. Dunlop and Mr. Strout. Prerequisite: histology or the equivalent. 3 credits.

309-310. Advanced Poultry Nutrition
Metabolism and the physiology of digestion with emphasis on nutrient needs and deficiency diseases of poultry. Analysis of recent experimental research and current feed problems. Mr. Ringrose. 3 credits.

312. Quantitative Genetics and Selection
Gene frequency, genetic and environmental variation, heritability, fitness, selection, inbreeding, outbreeding, correlated characters. Mr. Collins. Prerequisite: 1 course each in genetics and statistics. 3 credits. (Alternate years; offered 1971-72.)

351. Cell Culture
A consideration of the theory and principles fundamental to the culture cells in vitro. An introduction to the techniques of preparing and maintaining animal, plant, insect, and fish cell cultures. The application of cell culture to contemporary research in the Biological Sciences. Mr. Strout and staff: Mr. Metcalf and Mrs. Biggs. Prerequisite: Microbiology 503. General Microbiology. 2 lectures, laboratory hours arranged. 4 credits. Permission of instructor (also offered as Microbiology 851.)

397-398. Animal Science Seminar
A survey of recent literature and research in the animal sciences. Staff. 1 credit. May be repeated.

399. Thesis
Hours and credits, from 6-10, to be arranged.

Biochemistry (26)
Chairman: Edward J. Herbst

Professors: Donald M. Green, Edward J. Herbst, Miyoshi Ikawa, Douglas C. Routley, Arthur E. Teeri

Associate Professor: Samuel C. Smith

Assistant Professors: Gerald L. Klippenstein, James A. Stewart

Students admitted to graduate study in the Department of Biochemistry should have completed basic courses in chemistry, biological sciences, mathematics, and physics. The candidate for the Master of Science degree will be required to prepare a thesis, and to pass an oral examination on the thesis and on graduate courses prescribed for the degree program.

The Doctor of Philosophy degree candidate will be required to complete a dissertation on original research in biochemistry and to pass examinations supervised by the Doctoral Committee. Each candidate will be expected to demonstrate a broad basic knowledge of the field of biochemistry and to pass a reading proficiency examination based on the biochemical literature in German, French, or Russian.
Biochemistry

656. Physiological Chemistry and Nutrition
An introductory biochemistry course with emphasis on human physiological chemistry and nutrition. The laboratory includes a study of procedures basic to chemical methods used in medical diagnostic work. Mr. Teeri, Prerequisite: satisfactory preparation in organic chemistry. 3 lectures; 1 laboratory; 4 credits.

751. Principles of Biochemistry
The fundamental principles of biochemistry with emphasis on the chemistry, metabolism, and biological function of nucleic acids, proteins, carbohydrates, and lipids. Mr. Herbst, Mr. Ikawa, and staff. Prerequisite: one year of organic chemistry or permission of instructor. 4 lectures; 1 laboratory; 4 credits.

752. Topics in Biochemistry
A detailed consideration of metabolism and of current developments in biochemistry. Staff and guest lecturers. Prerequisite: Biochemistry 751. 2 lectures; 2 credits.

762. Plant Metabolism
The function, occurrence, synthesis, and degradation of plant constituents. Emphasis is placed on respiration and photosynthesis and the metabolism of nitrogenous and aromatic compounds. Biochemical mechanisms such as those involved in seed dormancy, fruit ripening, and disease resistance are discussed in relation to their roles in plant survival. Mr. Routley, Prerequisite: general biochemistry. 2 or 4 credits.

770. Biochemical Genetics
The biochemical mechanisms of storage, replication, transmission, transcription, recombination, mutation, and expression of genetic information by cells and viruses. Mr. Green. Prerequisite: Biochemistry 751 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

795, 796. Investigations in Biochemistry
Staff. Prerequisite: permission of instructor. Subject matter and hours to be arranged. 2 credits.

311. Biochemistry of Lipids
The chemistry, metabolism, and function of lipids. Mr. Smith. Prerequisite: general biochemistry. 2 credits.

331. Cell Surfaces and Exoproducts
A study of the chemical and biochemical properties of cell surfaces and extracellular products and their functions. Mr. Ikawa. Prerequisite: general biochemistry. 2 lectures; 2 credits.

342. Biochemistry of Development
An examination of the biochemical events underlying embryonic development and cellular differentiation. Special emphasis will be placed on the role of nucleic acid and protein synthesis in regulating these processes. Mr. Stewart. Prerequisite: general biochemistry. 2 lectures; 2 credits.

350. Physical Biochemistry
The physical chemistry of biological molecules with emphasis on the structure and interactions of proteins. Included will be a consideration of the physical methods commonly used in the study of proteins and nucleic acids. Mr. Klippenstein. Prerequisite: physical chemistry and general biochemistry. 2 lectures; 2 credits.
852. Advanced Biochemistry Laboratory
Application of chemical and physical techniques to the purification and characterization of proteins and nucleic acids. To be taken in conjunction with Biochemistry 850. Mr. Klippenstein. 2 laboratories; 2 credits.

897. 898. Biochemistry Seminar
Presentation and discussion of recent investigations. Mr. Herbst and staff. Prerequisite: permission of the Department Chairman. 0 credit.

899. Master of Science Thesis
To be arranged. 6-10 credits.

999. Doctoral Research

Biology (41)
Chairman of Graduate Committee: Langley Wood

The Master of Science program in the biological sciences is designed for students whose primary professional goal is to teach and who need additional training in the biological sciences. This program is administered by the Biology Committee (chairmen of the departments of Botany, Entomology, Microbiology, and Zoology), which determines, in the light of the student's objectives and deficiencies, the courses to be taken by the student. While this program is generally flexible so that it can satisfy the widest possible variety of needs, 20 of the 30 credits required must be earned in graduate courses offered by biological-science departments.

Students whose primary goal is to teach biological science in secondary school and who need certification should consider the Master of Arts in Teaching program. This program is designed for those who have a strong undergraduate science preparation but who need training that will lead to certification. This program is administered by the Department of Education with the cooperation of the Biology Committee.

641. General Ecology
Interrelationships between organisms and their physical environment; population growth, structure, and species interactions; introduction to the ecosystem; energetics, succession, and structure, with intensive study of selected examples. Mr. Franq and staff. Prerequisite: one course in biology. 4 credits.

791. Biology-Education. Problems in the Teaching of High School Biology
Objectives and methods of teaching, selection and organization of materials, preparation of visual aids, setting up of aquaria, and other projects. The use of the field trip as a tool in teaching high school biology. Mr. Schaefer. Prerequisite: two years of biological sciences and Principles of Teaching. This course is currently open only to students in the Education "Block Program" for the preparation of secondary school biology teachers. 4 credits.

For listings of other courses see: Botany, Entomology, Microbiology, and Zoology.
Botany

Botany (27)

Executive Committee: Richard Schreiber (Chairman), Arthur Mathieson, Avery Rich

PROFESSORS: Albion Hodgdon, Lorne McFadden, Avery Rich, Mathias-Richards, Richard Schreiber

ADJUNCT PROFESSOR: Alex Shigo

ASSOCIATE PROFESSORS: Arthur Mathieson, Hugh Mulligan

ASSISTANT PROFESSORS: May Biggs, Linn Bogle

Students admitted to graduate study in Botany are expected to have had adequate preparation in basic botany courses and in the physical sciences. The candidate for the Master of Science degree will be required to defend a thesis based on field or laboratory research. Students who are working toward the Doctor of Philosophy degree may be asked to demonstrate mastery of one foreign language or a knowledge of two foreign languages or of one foreign language and a cognate field, such as statistics, as an equivalent. The doctoral candidacy follows a comprehensive examination and includes the defense of thesis, which is to be a substantial contribution to knowledge. The Department's areas for graduate study include: Plant Physiology, Mrs. Biggs; Plant Ecology, Systematic Botany, Mr. Hodgdon; Phycology-Biological Oceanography, Mr. Mathieson, Mrs. Mulligan; Plant Pathology, Mr. McFadden, Mr. Pawuk, Mr. Rich and Mr. Shigo; Plant Morphology and Anatomy, Mr. Bogle; Mycology, Mr. Richards; Cell Biology, Mr. Schreiber and Mrs. Biggs.

706. Plant Physiology
Structure and properties of cells, tissues, and organs; absorption and movement of water; metabolism; growth and irritability. Botany and Plant Science staff: Mrs. Biggs (Botany) and Mr. Pollard (Plant Science). Prerequisite: Botany 411 or Botany 503 and one year of chemistry. 2 lectures; 2 laboratories; 4 credits.

721. Freshwater Phycology
Identification, classification, ecology, and life histories of the major groups of freshwater algae. Periodic field trips will be scheduled throughout the semester. Mr. Mathieson. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits. (Alternate years: not offered in 1971-72.)

722. Marine Phycology
Identification, classification, ecology, and life histories of the major groups of marine algae. Particular emphasis will be placed upon the benthonic, marine algae of New England. Laboratories will include field trips during the later portion of the course. Mr. Mathieson. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits.

723. Marine Algal Ecology
The distribution, abundance, and growth of benthonic marine algae in relation to their environment (chemical, physical, and biological). The students will be expected to attend regular, planned field trips and to conduct an independent research project. Mr. Mathieson. Prerequisite: Botany 722, Zoology 715, or permission of the instructor. 2 lectures; 1 laboratory, and field trips: 4 credits. (Alternate years: not offered in 1971-72.)
727. Introduction to Marine Phytoplankton
A study of the taxonomy and life histories of marine phytoplankton from fresh and preserved marine plankton collections. Cultural techniques and current methods for assessing standing crop and productivity will be studied. Mr. Mulligan. 2 lectures; 2 laboratories; 4 credits.

728. Marine Phytoplankton Ecology
Study of spatial and temporal distribution of phytoplankton populations in oceans and estuaries with emphasis on interactions with the physical, chemical, and biological aspects of their environment. Laboratories will cover methods of collecting and evaluating phytoplankton populations. Mr. Mulligan. 2 lectures; 2 laboratories; 4 credits.

732. Cytology
The structure, physiological behavior, and development of cells. The cellular basis of heredity. Mr. Schreiber. Prerequisite: one year each of the biological sciences and of chemistry. 3 lectures; 1 seminar; 4 credits.

735. Cell Physiology (Plant)
The integration of the molecular nature of structure with the functions of living cells. The emphasis is on plant cells. Mrs. Biggs. Prerequisites: one year general chemistry and one year of biological sciences; or permission of the instructor. 2 lectures; 2 laboratories; 4 credits.

741. Plant Antecology
The interaction of the individual plant with its environment, including such factors as earth, air, fire, and water; and the resultant processes of symbiosis, adaptation, and evolution. Prerequisite: Botany 706 or permission of instructor. 1 lecture; 1 colloquium; 1 laboratory; 4 credits. (Alternate years; not offered in 1971-72.)

742. Plant Syncology
The structure, development, and causes of distribution of plant communities. Methods of analysis and interpretation of field data. Laboratories include field trips on shared-cost basis. Prerequisite: Botany 566 (or to be taken concurrently); or Forestry 423. 2 lectures; 1 outdoor laboratory; 4 credits. (Not offered in 1971-72.)

747. Aquatic Higher Plants
A survey of flowering plants, fern relatives, and Bryophytes found in and about bodies of water in northeastern United States. Extensive field work, preparation techniques, representative collections, herbarium work, lectures, and discussions. Mr. Hodgdon. Prerequisite: Botany 566. 1 lecture; 1 colloquium; 1 half-day laboratory; 4 credits. (Alternate years; not offered in 1971-72.)

751. Plant Pathology
The nature of disease in plants; the symptomatology, etiology, and classification of plant diseases. Mr. Rich. Prerequisite: Botany 411 or Botany 503, or equivalent. 2 lectures; 2 laboratories; 4 credits.

752. Mycology
Studies of the parasitic and saprophytic fungi, their growth, reproduction, and identification. Mr. Richards. 1 lecture; 2 laboratories; 4 credits.

753. Forest Pathology
Forest and shade-tree diseases; principles, etiology, epidemiology, and control. Prerequisite: Botany 411 or Botany 503, or equivalent. 2 lectures; 2 laboratories; 4 credits.
Botany

754. Principles of Plant Disease Control
Exclusion, eradication, protection, and immunization, and the specific practical
methods used to control plant diseases. Mr. Rich. Prerequisite: Botany 751 or
753. 1 lecture; 2 laboratories; 4 credits. (Alternate years; offered in 1971-72.)

758. Plant Anatomy
The anatomy of vascular plants with special emphasis upon tissue development
and structure. Mr. Bogle. Prerequisite: Botany 411 or Botany 503. 2 lectures;
2 laboratories; 4 credits. (Alternate years; not offered in 1971-72.)

762. Morphology of the Vascular Plants
The life histories and evolution of the extinct and living vascular plants, in-
cluding comparisons of general structure and sexual organs. Mr. Bogle. Pre-
requisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits.
(Alternate years; offered in 1971-72.)

764. Microtechnique
A methods course in embedding, sectioning, and staining plant tissues, and
an introduction to microscopy. Mrs. Biggs. Prerequisite: permission of instruc-
tor. 2 lectures; 4 hours of laboratory; 4 credits.

767. Advanced Systematic Botany
The principles and rules of plant classification and nomenclature; study of
plant families, field and herbarium work. Mr. Hodgdon. Prerequisite: Botany
566. 1 lecture; 1 colloquium; 1 laboratory (full afternoon); 4 credits. (Alter-
mate years; offered in 1971-72.)

795-796. Investigations in: 1) Systematic Botany, 2) Plant Physiology, 3)
Plant Pathology, 4) Plant Anatomy, 5) Plant Ecology, 6) Mycology, 7)
Cytology, 8) Phycology, 9) Botanical Teaching, 10) Morphology, 11) Cell
Physiology
Individual projects under faculty guidance. Elective only by permission of the
appropriate instructor. Hours to be arranged. 2 or 4 credits.

799. Botany Seminar
Presentation and discussion of oral reports on research with practice in use
of visual aids. Participation by all resident departmental majors. Botany Club
in charge. 1 hour session weekly. 0 credit.

805. Advanced Plant Physiology
Plant physiological phenomena, such as absorption, permeability, mineral nutri-
tion, photosynthesis and light effects, respiration, and growth regulator effects.
Mrs. Biggs. Prerequisite: Botany 706 or equivalent, or adequate preparation in
the physical sciences. Conferences; laboratory; assigned reading; 3 or 4 credits.
(Alternate years; not offered in 1971-72.)

822. Advanced Marine Phycolgy
Classification, ecology, and life histories of marine algae considered at an
advanced level. Seminars, discussions, assigned reading, and laboratory. Mr.
Mathieson. Prerequisite: Botany 722 or its equivalent. 4 credits. (Alternate
years; not offered in 1971-72.)

830. Morphogenesis
The study of form and development as affected by internal and external
factors. Mr. Bogle. Prerequisite: Botany 758 and 762. 2 recitations of 2 hours
each. 4 credits. (Alternate years; not offered in 1971-72.)
851. Advanced Plant Pathology
Advanced theories and methods in plant pathology. Mr. McFadden. Prerequisite: Botany 751 or 753 and permission of professor. Assigned reading; conference: laboratory: 4 credits. (Alternate years: offered in 1971-72.)

861. Plant Geography
The distribution of plants, a consideration of vegetation types and floras, and problems of endemism with emphasis on North America; the major influential factors such as geologic, climatic, edaphic, and biotic, including man's activities. The major contributions from Humboldt to the present time. Mr. Hodgdon. Prerequisite: permission of professor. 1 lecture; 1 colloquium of 2 hours; field trip: 4 credits. (Alternate years: offered in 1971-72.)

Individual projects under faculty guidance. Elective only by permission of the appropriate instructor. Hours to be arranged. 2-6 credits.

899. Master of Science Thesis
6-10 credits.

999. Doctoral Dissertation

Business Administration (71)

Dean: Jan E. Clee

Professors: Robert F. Barlow, John A. Beckett, Jan E. Clee, Carroll M. Degler, Herman Gadou, John J. Korbel, Dwight R. Ladd, Donald C. Marschner, Samuel R. Reid

Associate Professors: Allan J. Braff, Allan R. Cohen, Stephen L. Fink, James O. Horrigan, James H. Schulz, Robin D. Willits, Dwayne E. Wrightman


Director of M.B.A. Programs: William E. Wetzel, Jr.

The Whittemore School day and evening programs leading to the degree of Master of Business Administration are designed to prepare graduates for professional careers in administration in both profit and not-for-profit organizations in a rapidly changing world. The MBA programs are directed toward a broad preparation in general administration through study of: 1) the increasing body of relevant knowledge drawn from the behavioral sciences, mathematics, and economics; 2) the existing and emerging processes and institutions of the functional fields of administration; and 3) the role of business and other organizations in a complex and ever-changing society.

There is a consistent emphasis on developing basic analytical skills rather than on developing extensive technical expertise. Also, the program seeks to foster the ability to utilize conceptual and theoretical material in the analysis and solution of practical problems.

Candidates for admission must possess a bachelor's degree from an accredited college or university. In addition, all candidates are expected to take the Ad-
mission Test for Graduate Study in Business (ATGSB) given by the Educational Testing Service. Details concerning the dates and locations for these examinations may be obtained from Educational Testing Service, Box 966, Princeton, New Jersey 08540.

The Whittemore School welcomes applicants with an above-average academic record in any undergraduate specialty. No previous exposure to business courses is expected. However, previous work in mathematics, economics, the behavioral sciences, and the branches of engineering are of particular relevance to graduate study in administration. Because of the increasing use of mathematical concepts, models, and notation in the practice and study of administration, applicants should normally have successfully completed one year of college mathematics, preferably including an introduction to calculus. Students lacking this background may still enroll in the program, provided they obtain adequate substitute preparation prior to beginning the program.

In all cases, the applicant's entire educational background, relevant experience, references, and professional aims will be considered in the admissions process. Exceptions may be made to any of the foregoing requirements by the Committee on Admissions.

The Whittemore School day MBA program consists of an integrated sequence of 16 four-credit courses requiring two years of study which can be started only in the fall semester. During the first year, eight required courses in the basic disciplines (quantitative analysis, economics, and behavioral science) and the functional areas of management (accounting, marketing, operations management, and financial management) are integrated into an overall study of the process of administration.

The second year of the day program continues the emphasis on overall management by requiring all students to complete the integrating course, Business Policy. Special attention is also given to the study of the modern corporation as a partly economic, partly legal, and partly social organization by requiring all students to complete the course, Conceptual Foundations of Business. In addition, with the help of a faculty adviser, the student will select the equivalent of six four-credit elective courses with some concentration in an area of special interest. Students are encouraged to select appropriate graduate-level courses offered by other colleges of the University as well as by the Whittemore School.

The evening MBA program involves completion of 16 four-credit courses offered in an integrated sequence over eight trimesters. The evening program may be begun only in the fall trimester and, because of the cumulative nature of the program, students must expect to stay on schedule with their class. The program is designed for the non-business undergraduate and is aimed at broad training rather than intensive specialization.

Further information on both the day and evening MBA programs can be obtained by writing to the Dean, Whittemore School of Business and Economics, University of New Hampshire, Durham, New Hampshire 03824.

705. Operations Research
Mathematical programming, game theory, inventory, queuing and scheduling problems, dynamic programming. 4 credits.

711. Corporations
The role of the modern corporation in the economy. Emphasis upon structure of the corporation, the corporate system, combinations, and concentration. Prerequisite: Economics 402. 4 credits.
712. Organizational Change
Examination of the process of change in organizations. Consideration of change strategies, the role of the change agent, and his relation to the client system. The bases of resistance to change and the problems encountered by internal and external change agents. Readings include theoretical material on influence, attitude change, and organizational change. Prerequisite: permission of instructor. 4 credits.

713. Interpersonal and Group Dynamics
Intensive experiential study of the dynamics of small groups through the use of the class itself as a Laboratory Study Group. Students examine their own behavior and its effects on others through use of the Laboratory Training Group (T-group) as the major learning tool. The course develops both conceptual ability and behavioral skill in this area. Prerequisite: permission of instructor. 4 credits.

717. Advanced Financial Accounting
Accounting theory and practice as they contribute to the significance and limitations of the financial statements by which business communicates financial status to interested outsiders. Prerequisite: permission of instructor. 4 credits.

718. Cost and Management
The effective use of cost accounting, cost analysis, and budgeting in planning and controlling operations. Topics considered include analysis of cost behavior, direct and absorption costing, cost-price-volume relationships, distribution costs, transfer pricing, and capital-expenditure analysis. 4 credits.

730. Investment Analysis
An evaluation of capital markets and of analytical techniques useful for security analysis. The following subjects will be covered: securities characteristics, market institutions, yield structures, price-change patterns, intrinsic value analysis, investment timing, and portfolio management. Lectures, outside readings, and security-analysis research projects are the main tools of the course. Prerequisite: some previous work in financial accounting would be extremely helpful. 4 credits.

732. Explorations in Entrepreneurial Management
The past and probable future role of the entrepreneur in the economic and social development of the U.S. is examined. Emphasis is placed upon differences between entrepreneurial and administrative management. Topics include the mythology of the "American Dream," the entrepreneur as a change agent, entrepreneurial motivation and behavior patterns, the venture-capital markets, and the role of the entrepreneur in non-profit institutions. Prerequisite: permission of instructor. 4 credits.

741. Transportation
The wide range of problems surrounding the American transportation system. The basic economic structure of the transportation industries with particular emphasis on competition among the several modes. Such public policy questions as merger of transportation enterprises and cost-benefit analysis of transportation facilities are considered. While principal emphasis in the course is on freight transportation, the problems of passenger transportation, especially in urban areas, are discussed. Limited attention is given to distribution as a specific function of business enterprise. Lectures and discussions of cases. Two or three short papers and a term paper are required. 4 credits.
747. Federal and State Taxation
Current federal income, estate, and gift taxes and their impact on corporations, partnerships, and individuals. Prerequisite: Permission of the instructor. 4 credits.

751. Advertising and Promotion
A theory of promotion: how the modern firm acts to obtain maximum efficiency and effectiveness from the use of the major tools of marketing communication (advertising, personal selling, sales promotion, direct-mail merchandising, publicity), as seen from the point of view of the marketing manager. Some emphasis is also placed upon ethical and moral problems. The course is built upon lectures, classroom discussions, some creative research, and weekly case analyses. 4 credits.

752. Marketing Research
Marketing research as a basis of formulating marketing policies and strategy. Topics include research design, methods of collecting data, planning the investigation, sampling methods, motivation research, advertising research, and consumer research. 4 credits.

753. Comparative Marketing (Innovations and Dynamic Aspects of Marketing)
The problems related to the acceptance of new products, new brands, and new services are becoming more important. The course deals with the diffusion of innovations. Factors governing the speed and ways in which products become accepted in different societies and the related dynamic aspects of competition are treated. Methods are presented for studying loyalty behavior, the acceptance process, the role of innovators, and group influence. International examples are used and emphasis is placed on the implication for marketing policies. Prerequisite: permission of instructor. 4 credits.

754. Consumer Behavior
The consumer-firm relationship studied in terms of concepts drawn from contemporary social-science findings, particularly small-group studies, as related to present and prospective marketing activities of a business organization. 4 credits.

755. Advanced Financial Management I
Financial policy of the firm with emphasis on solutions to complex problems of working-capital management. Discussion of abstract models and how they can be modified and applied to concrete situations. Cases may be used. Prerequisite: permission of instructor. 4 credits.

756. Advanced Financial Management II
A study of the long-term financial decisions of the firm, with emphasis on solutions to problems of dividend policy, optimum capital structure, and capital budgeting under conditions of uncertainty and risk. Prerequisite: permission of instructor. 4 credits.

791. Seminar in Organizations
Investigation by a restricted group of students of specific issues in organization theory and practice. The exact topic will vary from semester to semester as interests develop and opportunities for field study emerge. Prerequisite: permission of instructor. 4 credits.

798. Seminar in Business Problems
Special topics in Business Administration. This course may be repeated. Prerequisite: consent of the adviser and instructor. Credits: to be arranged.
801. Quantitative Analysis
   Calculus, difference equations, and matrix algebra with business applications, 4 credits. (Open to full-time Master of Business Administration students only.)

803. Human Behavior in Organizations
   To provide students with an understanding of behavioral science concepts and their use in the analysis of interpersonal relationships in organizations and to develop sensitivity to the range of possible human behavior in organizations, 4 credits. (Open to Master of Business Administration students only.)

804. Management Organization
   Theories of organization and analysis of contemporary forms and structure. Concern is with development of rational management processes in a dynamic society. 2 credits. (Open to Master of Business Administration students only.)

806. Financial Management
   Concepts and techniques for determining the need for, the acquisition of, and the management of, financial resources of the business. 4 credits. (Open to full-time Master of Business Administration students only.)

807. Economic Environment of Business
   To provide an understanding of national economic activity including output, income, employment, and price levels, and to provide familiarity with present knowledge of the determinants of economic growth and fluctuations. 4 credits. (Open to full-time Master of Business Administration students only.)

808. Marketing
   Identification, development, and retention of markets for the goods and services offered by the firm. Attention is given to the dynamics of demand and to the blending of the marketing mix. 4 credits. (Open to full-time Master of Business Administration students only.)

810. Production Management
   Concepts and practices in the planning, supervision, and control of activities concerned with manufacturing the goods and services of the firm. 4 credits. (Open to Master of Business Administration students only.)

811. Conceptual Foundations of Business
   Study of the modern corporation as a partly economic, partly legal, and partly social organization, including examination of widely held views about business and views of businessmen about themselves. 4 credits. (Open to Master of Business Administration students only.)

812. Business Policy
   A “capstone” course, focused on industries, companies, and other organizations in operation, and studied through case examples, with emphasis on integration of materials covered in prior courses. 4 credits. (Open to Master of Business Administration students only.)

815-816. Financial Reporting and Economic Analysis for Management I and II
   An integrated view of accounting and economic analysis. Objectives are to provide the student with some general models of the firm for planning and reviewing operations and with a wide assortment of analytical techniques for decision making. 815, 4 credits; 816, 2 credits. (Open to full-time Master of Business Administration students only.)
827. Environment of the Firm
The socio-political, economic, and legal-institutional environment in which the private enterprise firm functions and plans. (Open to evening Master of Business Administration students only.) 4 credits.

835. Financial Accounting
A general introduction to the objectives, theories, conventions, and processes for reporting and interpreting the financial status of the business enterprise. Primary emphasis on the usefulness and limitations of accounting data in decision making and in analyses of past performance. (Open to evening Master of Business Administration students only.) 4 credits.

836. Cost and Control
Emphasis is on the use of accounting data for planning and control purposes. Topics covered include (1) cost behavior and volume-profit analysis, (2) the use of standard costs and flexible budgets as a means of managerial control, (3) evaluation of management performance and the effect of accounting on human behavior, and (4) relevant cost analysis with special reference to capital budgeting problems. 4 credits. (Open to evening Master of Business Administration students only.)

837. Economic Analysis and Decision Making
A survey of micro- and macro-economic analysis. The analysis will be designed for business decision-making and business-conditions investigation. 1 credit. (Open to evening Master of Business Administration students only.)

850. Marketing Management
The practical application of the theories taught in Business Administration 308. Topics covered include the planning, organization, and control of marketing activities in large corporations and in small businesses, with special emphasis on new-product planning and development; laboratory, field, and market testing; pricing policies; selection of channels of distribution; brand management; and the interrelationships between marketing, production, and finance. Principles which underlie sound policy formulation and decision making are established through the analysis of real-life cases, several of which are based upon current marketing problems of nearby New Hampshire firms. Prerequisite: Business Administration 308 or permission of instructor. 4 credits.

861. The Philosophy of Management Science
A study of management from a systems analysis point of view. 4 credits.

895. Special Projects and Independent Study
Projects, research, and reading programs in areas required for concentration. Sixty days' advance approval of the student's plan of study by adviser and by proposed instructor required. Staff. 4 credits.

Chemical Engineering (80)
Acting Chairman: Stephen S. T. Fan

Associate Professors: R. Lee Byers, Stephen S. T. Fan
Assistant Professors: Charles B. Schriever, Gail D. Ulrich

To be admitted to graduate study in Chemical Engineering an applicant is expected to have completed a course of study substantially equivalent to that re-
versity. However, students with good undergraduate records but with deficiencies in certain areas may be admitted on condition that they complete specified courses without credit to make up for their deficiencies.

A minimum of 30 credits is required for the Master of Science degree in Chemical Engineering. A candidate for the Master of Science degree must prepare a thesis, for which up to six credits will be allowed, unless he is specifically exempted by the faculty because of previous research experience.

For students who are interested in graduate studies beyond the Master of Science degree, an interdepartmental Engineering Doctor of Philosophy Program is available which includes the following areas of specialization: Engineering System Design, Signal Processing, Theoretical and Applied Mechanics, and Transport Phenomena. For details refer to the section entitled Engineering Doctor of Philosophy Program on page 79.

Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

Permission of the instructor and consent of the student’s adviser are required for enrollment in all Chemical Engineering courses.

701. High Polymers
Principles and practice of high-polymer manufacture, including industrial polymerization methods and equipment design. Laboratory work includes typical polymerization reactions and the physical and chemical testing of various types of plastics and synthetic fibers. 3 lectures; 1 laboratory; 4 credits.

712. Introduction to Nuclear Engineering
The scientific and engineering development of nuclear reactors, including basic binding-energy physics, nuclear stability, radioactivity, the elements of nuclear-reactor theory, and the engineering problems of heat transfer, fluid flow, materials selection, and shielding. This course is intended for any interested seniors and graduate student. 4 credits.

713. Nuclear Chemical Technology
The design, construction, and operation of nuclear process equipment, including reactors and associated chemical processing facilities, and isotope separations plants. The technology of applied radiation chemistry. Intended primarily for seniors and graduate students. 3 credits.

752. Process Dynamics
A basic treatment of process dynamics, including a study of first- and second-order linear processes and their response to step and sinusoidal driving functions. Graphical analysis of the entire control system is included with special emphasis on the optimum design of a stable system. 4 credits.

762. Introduction to Optimization
Optimization techniques applied to functions not described analytically. Search techniques include Fibonacci search, golden-section search, method of steepest ascent, method of contour tangents, and the method of parallel tangents. Stochastic schemes are considered. Advanced techniques for the optimization of objective functions are considered from a qualitative viewpoint. 3 credits.

772. Engineering Aspects for Air Pollution Control
Characterization of industrial pollution according to their chemical and physical properties. Principles and techniques of sampling and control of air pollutants, including the mechanisms of inertia, diffusion, electrostatics, filtration, adsorption, and absorption. Prerequisite: calculus, physics or permission of instructor. 3 lectures; 1 laboratory; 4 credits.
813. Introduction to Fluid Dynamics
Equations of change for continuous fluids; laminar Newtonian and non-Newtonian flow; ideal fluid flow; boundary-layer methods; turbulence. 3 credits.

815. Heat Transfer
Steady-state and transient heat conduction in solids; heat convection; analytic solutions, similarity relations, boundary-layer methods; radiation. 3 credits.

816. Diffusive Mass Transfer
Emphasis on the physical aspects of diffusion; theories of diffusion in dilute gases, dense gases, liquids, and solids; surface diffusion; mixing processes. Simultaneous heat and mass transfer. 3 credits.

823. Advanced Chemical Engineering Thermodynamics
A discussion of the multicomponent open system from the engineering viewpoint; the volumetric and phase behavior of pure substances and of multicomponent systems at physical and chemical equilibrium; fugacity and activity; thermal properties of equilibrium, chemically reacting systems; introduction to statistical thermodynamics. 3 credits.

832. Advanced Chemical Engineering Kinetics
Discussion of specialized applied kinetics problems; catalysis; fast reaction and shock tubes; combustion and detonation processes; non-isothermal kinetics; heat and mass transfer in non-equilibrium, chemically reacting systems. 3 credits.

852. Advanced Process Dynamics
An advanced treatment of process dynamics, including higher order processes and nonlinear processes. Special attention is given to representing a complex process by differential equations, linearizing nonlinear elements, and adequately controlling the entire system. 3 credits.

890. Literature Report
Instruction in the use of the library for chemical engineering research. This course will culminate in the preparation of a literature report on a topic of mutual interest to the student and the chemical engineering faculty. 1 credit.

895, 896. Graduate Independent Study
Directed reading or investigation at the advanced level on topics or problems in chemical engineering. 4 credits.

897, 898. Graduate Seminar
Discussion on topics of interest to graduate students and staff; reports of research progress; invited lectures by outside speakers. 0 credit.

399. Master's Thesis
Original investigations in chemical engineering. 1-6 credits.

999. Doctoral Research
The Department of Chemistry offers programs leading to three graduate degrees: Doctor of Philosophy, Master of Science, and Master of Science for Teachers. Entering graduate students (except for those desiring the M.S.T. degree) are expected to take proficiency examinations in chemistry to assist in starting the new student's graduate work at the proper level. These examinations will be offered at the beginning of the semester in September and in February.

The faculty of the Chemistry Department feels that the experience of teaching is a valuable part of the training of the graduate student. Therefore, all graduate students who are Doctor of Philosophy or Master of Science candidates will obtain some teaching experience during their tenure.

Doctor of Philosophy Degree

Admission to this program is based upon superior work in the usual undergraduate courses in inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry, as well as the normal supporting courses in mathematics and physics. This degree requires the completion of a research problem presented in the form of a thesis.

The Ph.D. candidate will be expected to demonstrate proficiency in reading chemical literature in German and French or Russian. He will also demonstrate to his doctoral committee that he has a broad basic knowledge of the field of chemistry; (1) by completing certain fundamental graduate courses, and (2) by means of a series of examinations in his major field. The principal emphasis of the last two years will be on the research project which will constitute the dissertation. During this time the doctoral candidate will present and defend an original research proposal before his doctoral committee.

Chemical Physics and Soil and Water Chemistry Options

Doctor of Philosophy candidates in Chemistry may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Physics, or the Soil and Water Chemistry program, an interdisciplinary program offered jointly with the Department of Soil and Water Science. In these options, the doctoral student, with the advice of his guidance committee, elects courses in chemistry and in the related disciplines, and writes his dissertation on a research problem appropriate to interdisciplinary treatment.

Master of Science Degree

Admission to this program is based upon a superior undergraduate average and requires satisfactory work in the usual undergraduate courses in inorganic chemistry, analytical chemistry, organic chemistry, and physical chemistry, as well as the normal supporting courses in mathematics and physics. This degree requires the completion of a research problem presented in the form of a thesis.
Chemistry

Master of Science for Teachers Degree

This program is offered for candidates who hold a secondary-school teacher certification in chemistry. Courses leading to this degree will normally be chosen from Summer Session and Summer Institute offerings and require 30 semester hours in courses approved by the Department Chairman. Persons interested in this degree should confer with him.

Analytical Chemistry

762. Instrumental Analysis
A treatment of the theory, instrumentation, and application of methods such as emission spectrography, flame spectrometry, spectrophotometry, gas chromatography, coulometry, potentiometry, conductimetry and polarography to chemical analysis. Prerequisite: Quantitative Analysis; Chemistry 684, Elementary Physical Chemistry; as a prerequisite or concurrently or permission of instructor. 3 lectures; 2 laboratories; 4 credits. Cannot be used for graduate credit by chemistry students.

830. Advanced Optical Methods
Techniques of chemical identification and analysis utilizing optical instrumentation from the standpoint of both theory and application. Topics include NMR, ESR, X-ray fluorescence, mass spectrometry, electron beam microprobe. 3 credits.

831. Advanced Electrical Methods
Techniques of chemical identification and analysis utilizing electrical instrumentation from the standpoint of both theory and application. Topics include controlled-current coulometry, A-C polarography, chronoamperometry, cyclic voltammetry, controlled potential coulometry. 3 credits.

832. Chemical Instrumentation
The basic modules of chemical instrumentation, both electrical and optical. 3 credits.

833. Chemical Separations
The use of various separation techniques prior to analysis, and separations as a method of analysis are discussed. The application of statistics to chemical problems of analysis is covered. 3 credits.

Inorganic Chemistry

775. Inorganic Chemistry
The relationship between chemical reactions and modern concepts of inorganic chemistry on a moderate level. The applicability and limitations of the newer ideas. Prerequisite: Chemistry 683-684 or permission of instructor. 4 credits. (May not be used for graduate credit by chemistry students.)

803, 804. Advanced Inorganic Chemistry
The basic theoretical concepts necessary for an understanding of modern inorganic chemistry: atomic structure, periodicity, chemical bonding in inorganic compounds, the crystalline state, stereochemistry, redox reactions, acids and bases, elementary coordination chemistry, nonaqueous solvents, inorganic reaction mechanisms, energetics, and ionic equilibria. 3 credits.

847. Advanced Inorganic Chemistry
The chemistry of coordination compounds, their ligand field spectra, magnetic properties, and reaction mechanisms. The metal-ligand bond in crystal field and molecular orbital theories. Prerequisite: Chemistry 804 or permission of instructor. 3 credits.
848. Advanced Inorganic Chemistry
The theory and practice of X-ray diffraction and the determination of crystal structure. Prerequisite: Chemistry 804 or permission of instructor. 3 credits.

Organic Chemistry

755. Advanced Organic Chemistry
An advanced survey of methods of synthesis and determination of structure, including stereochemistry, of complex organic compounds. Structural determination will be based on chemical and spectroscopic properties, emphasis being placed on the solution of assigned problems. The laboratory will be devoted to the synthesis and structural determination of complex organic compounds, techniques for the separation and determination of purity of unknown compounds, and the identification of these unknowns by spectroscopy and chemical means. 4 credits.

801. Theoretical Organic Chemistry
The structural theories of organic chemistry, including valence-bond and molecular orbital theories. Emphasis on stereochemistry, including conformational analysis and aromaticity. 3 credits.

802. Theoretical Organic Chemistry
The mechanistic concepts of organic chemistry, including discussions of theoretical and experimental methods used in the study of reaction mechanisms. 3 credits.

811. Synthetic Organic Chemistry
Advanced discussion of heterolytic and homolytic substitution and elimination reactions of the major classes of organic compounds, with emphasis on the synthetic utility of these reactions. Permission of instructor. 3 credits.

812. Synthetic Organic Chemistry
Addition, oxidation, and reduction reactions and selected molecular rearrangements, with emphasis on the synthetic applications of these reactions. The synthesis and structure determination of complex organic compounds. Permission of instructor. 3 credits.

817, 818. Special Topics in Organic Chemistry
Specialized courses for the advanced student. Topics may include reaction mechanisms, stereochemistry, spectroscopy, molecular biochemistry, steroids, aldehydes, organic sulfur compounds, and nitrogen heterocycles. 2 or 3 credits.

Physical Chemistry

663. Introductory Radiochemical Techniques
Radiochemical techniques and laboratory practice in the use of apparatus in many fields of science which utilize radio chemical operations. Prerequisite: general inorganic chemistry and general physics. 2 lectures; 2 laboratories; 4 credits.

683-684. Elementary Physical Chemistry
The properties of gases, liquids, and solids; thermochemistry and thermodynamics; solutions, chemical equilibria, reaction rates, conductance, and electro motive force. Prerequisite: Mathematics 426 (Calculus II) and physics. Undergraduates must register for Chemistry 685-686 concurrently. 2 credits.

685-686. Physical Chemistry Laboratory
Experimental work illustrating the principles of chemistry. Emphasis is upon the measurement of thermodynamic properties, chemical kinetics, and methods
of determining the structure of matter. Prerequisite: Mathematics 426 (Calculus II) and physics. Must be taken concurrently with Chemistry 683-684. 2 laboratories; 2 credits.

776. Advanced Physical Chemistry
Foundations of quantum theory, elementary quantum mechanics, theory of spectra, statistical thermodynamics. Prerequisite: Chemistry 683-684. 4 credits.

805. 806. Advanced Physical Chemistry
Wave mechanics and quantum chemistry, spectroscopy, molecular structure; statistical thermodynamics, kinetics, and mechanism. Prerequisite: one year of physical chemistry. 3 credits.

821. Physical Chemistry—Chemical Kinetics
The kinetics of homogeneous and heterogeneous reactions in gaseous and liquid systems, including an introduction to very rapid reactions. Prerequisite: one year of physical chemistry. 3 credits.

822. Physical Chemistry—Chemical Thermodynamics
The foundations and interrelationships of the theory of thermodynamics. The methods by which the theoretical principles may be applied to practical problems. 3 credits.

826. Nuclear and Radiochemistry
Nuclear structure and reactions, particle accelerators, radioactive decay, detection of particles, and the interaction of particles with matter. Application of radiochemistry to chemical systems and research. 3 credits.

827, 828. Theoretical Chemistry I, II
The modern concepts and mathematical formalism of quantum mechanics with applications to electronic structures of atoms and molecules, spectroscopy, and the solid state. 3 credits.

829. Theoretical Chemistry III
Statistical mechanics with applications to thermodynamics of non-ideal systems, intermolecular forces, and chemical kinetics. Permission of instructor. 3 credits.

General Offerings:
Courses in which all areas of specialization participate.

708. Research Techniques
Lectures and laboratory to show experimental methods and interpretation of results. Topics include gas liquid chromatography, data handling, nuclear magnetic resonance, mass spectrometry, elementary electronics, and X-ray. 1-3 credits.

807. Introduction to Research
A course to introduce the Doctor of Philosophy student to the planning, experimental methods, and interpretation of a research problem. The student will present and defend an original research proposal before a faculty committee. Must be completed satisfactorily by all doctoral students. Cannot be used for credit by Master of Science candidates. 2 credits.

3 credits. Sections of the course may be taken to a total of 12 credits.
897, 898. Seminar
Presentation and discussion of recent investigations in chemistry. 1 credit.

899. Thesis—Problems in Chemistry
Conferences, library, and experimental work in some field of chemistry. Staff. Credits to be arranged.

999. Doctoral Research

Courses for the Master of Science for Teachers Degree
The following courses usually are offered only in the Summer Session.

781. The Teaching of High School Chemistry
Contemporary subject matter in general chemistry; choice of experiments for laboratory and lecture demonstrations; and presentation and evaluation of teaching methods which are effective in stimulating students. 4 credits.

782. Modern Inorganic Chemistry for the High School Teacher
The current concepts on such topics as fundamental particles, atomic structure, nuclear reactions, electronic configurations and orbitals, chemical bonds, the periodic table, oxidation-reduction, acids and bases, energy relationships, and ionic reactions. 4 credits.

783. Analytical Chemistry for High School Teachers
The principles of ionic equilibria in qualitative and quantitative analysis. Experimental work in qualitative analysis using the semimicro technique. The experimental work in quantitative analysis acquaints the student with the principles, techniques, and calculations of gravimetric and volumetric determinations. Some experimental work involves the use of the spectrophotometer in quantitative analysis and of the glass electrode method of measurement of pH. 8 credits.

784. Modern Approach to Organic Chemistry for High School Teachers
The structure and properties of organic compounds, including those of current interest and importance, such as natural and synthetic polymers, antibiotics, and medicinals. An understanding of the behavior of organic compounds will be based on the current theories of reactions. 8 credits.

785. Physical Chemistry for High School Teachers
The laws of chemistry and their application to physical and chemical changes. Prerequisite: college physics, algebra, and trigonometry. 8 credits.

786. Radiochemistry for High School Teachers
The theory of radioactive decay, the effects of radioactive decay upon matter, and the methods and techniques of the detection of radioactive decay. The uses of radiotracers in research. Prerequisite: general chemistry and general physics. 4 credits.

787. Laboratory Techniques in Chemistry
Modern methods for the separation, identification, and estimation of substances. Experiments will be designed to assist the teacher by providing new subjects for laboratory demonstrations and student projects. Prerequisite: analytical and organic chemistry. 4 credits.

788. Advanced Organic Chemistry for High School Teachers
Types of homolytic and heterolytic reactions of organic compounds and their relationship to organic structures, including configuration and conformation. Prerequisite: Chemistry 784 or its equivalent. 4 credits.
Civil Engineering

789. Atomic and Molecular Structure
The methods of determining atomic and molecular structure, including ultraviolet and infrared spectroscopy and radiochemistry. 4 credits.

Civil Engineering (82)
Acting Chairman: Louis H. Klotz

PROFESSOR: J. Harold Zoller
GRADUATE COORDINATOR: John P. Nielsen

A candidate for the degree of Master of Science in Civil Engineering must have completed a Baccalaureate degree in engineering, mathematics, or science. If his undergraduate work is deficient, he may be required to take undergraduate courses without graduate credit in order to present the proper prerequisites for graduate courses in the areas of his major and minor interests. In addition, other undergraduate courses may be required by his adviser in order to achieve an integrated program.

The candidate for the Master's degree may elect a Plan A or Plan B program. The Plan A program requires a minimum of 24 hours of graduate-level course work plus a thesis for which six hours of graduate credit is normally awarded. In the case of highly original and unusual work, a maximum of nine credit hours may be awarded for the thesis. The Plan B requires a minimum of 30 hours of graduate-level course work plus a written paper, which is to be written in one of the project courses not included in the 30 credit minimum. The Plan B paper is equivalent to a thesis in style and quality, but not in scope. One copy of the thesis paper is required by the Department for its files. Additional copies are usually presented to the library and the candidate's adviser. The examination committee will consist of at least two senior faculty members within the Department of Civil Engineering and an additional senior faculty member from another department within the College of Technology. The thesis or Plan B paper must be presented to an examining committee for critical review.

The Master programs in Civil Engineering are becoming increasingly interdisciplinary. Candidates may be required to complete graduate-level courses in other departments in order to enlarge their educational experience and to acquire fundamental skills expected of a master's candidate. Program areas within the Department include sanitary engineering, soil mechanics, foundation engineering, structural design, structural mechanics, and others.

Ph.D. programs are available through the Engineering Ph.D. Program within the College of Technology. The Ph.D. is awarded in Engineering, and selected candidates work within four established major program areas. Most Ph.D. candidates within the Civil Engineering area work either in the Theoretical-and-Applied-Mechanics or the Engineering-Systems-Design program areas. All interested candidates are advised to consult the graduate coordinator for the details of these programs. Additional information about the Ph.D. Engineering program is presented in the "Engineering Ph.D." section of this catalog.

Courses numbered above 700 may be offered biennially or upon demand. Courses numbered between 600 and 699 may be taken for graduate credit only by non-majors. Permission of the instructor and consent of the adviser are required for enrollment in all Civil Engineering graduate courses. With the approval of the Department Chairman and Graduate Coordinator, two graduate courses taken at
other institutions prior to admission to the University of New Hampshire Graduate School may be applied to the master's degree. Senior undergraduates interested in the dual bachelor's and master's degree programs should consult the appropriate section of this catalog under "Graduate Credits."

701. Advanced Surveying
Principles of instrumental and analytical photogrammetry. Theory of conformal mapping and the application to the State Plane Coordinate Systems. Geodetic surveying. Error theory and its application to the planning and adjustment of surveys. Application of electronic computers to surveying calculations. Prerequisite: Civil Engineering 505, Surveying. 3 lectures; 1 laboratory; 4 credits.

711. Community Planning
An introduction to Community Planning. Social, economic, and physical factors affecting community planning; content and extent of desirable community-planning programs, including purpose and scope; preliminary survey; elements of land planning; the master plan; transportation and circulation systems; street patterns and traffic; motor-vehicle parking; airport sites; public-building sites; parks and recreational facilities; zoning; control of land subdivision; neighborhood and shopping centers; housing, legal, financial, and economic problems; and redevelopment of blighted areas. Prerequisite: permission of instructor. 4 lectures; 4 credits.

714. Contracts, Specifications, and Professional Relations
The essential elements and legal requirements of engineering contracts; the purposes and content of specifications; professional conduct, relations, registration, and ethics. Construction planning and management; cost analysis based on quantity surveys and unit-cost methods. Prerequisite: permission of instructor. 4 lectures; 4 credits.

721. Pavement Design
Design of flexible and rigid pavements and bases for highways, airports, and city streets; pavement selection, construction methods, materials, specifications, and engineering cost estimates. Prerequisite: Civil Engineering 621. Highway Engineering 1. 3 lectures; 1 laboratory; 4 credits.

731. Network Planning and Scheduling
The application of Critical Path Methods (CPM) and Project Evaluation Review Technique (PERT) to the design and control of civil engineering projects. 1 lecture; 1 laboratory; 2 credits.

732. Systems Analysis
An analysis of civil engineering projects encompassing social and economic criteria as well as engineering feasibility studies. 1 lecture; 1 laboratory; 2 credits.

744. Sanitary Engineering II
An advanced treatment of water supply and waste-water disposal. Prerequisite: Civil Engineering 643, Sanitary Engineering 1. 4 lectures; 4 credits.

745. Hydrology and Hydraulics
The occurrence and physical effects of water on the earth, including meteorology, ground-water runoff, and stream-flow routing, open channel flow, reservoirs, control works, hydroelectric power, irrigation, drainage, and multipurpose projects. 4 lectures; 4 credits.

765. Foundation Engineering
Application of the principles of soil mechanics to selection of the type of substructure; determination of allowable soil bearing capacities based on rupture
Civil Engineering

and settlement theories; determination of active and passive earth pressures; and foundation construction methods. Computations by classical, numerical, and computer applied methods. Prerequisite: Civil Engineering 665, Soil Mechanics, 4 lectures; 4 credits.

782. Timber Design
Properties and characteristics of structural woods, mechanics of wood, connection methods, design of timber members and connections in beams, columns, and trusses, and glued laminates of wood. Prerequisite: Civil Engineering 682, Structural Design Concepts. 1 lecture; 1 design period; 2 credits.

784. Introduction to Matrix and Numerical Methods
Presentation of a unifying concept of basic structural-analysis theories; introduction to matrix and numerical methods of analysis and their application by linear graph concepts using computers. 3 lectures; 1 design period; 4 credits.

790. Inelastic Structural Design
A continuation of modern design theory, ultimate design of reinforced concrete, and plastic analysis of steel structures. 4 lectures; 4 credits.

793-794. Advanced Structural Design I and II
The design in steel by the elastic theory and in reinforced concrete by the working-stress method of structural elements and connections, using the appropriate controlling specifications. 3 lectures; 1 design period; 4 credits.

795. 796. Independent Study
A limited number of qualified senior and graduate students will be permitted to pursue independent studies under faculty guidance. Seniors may write terminal theses reporting the results of their investigation. 2-4 credits.

822. Highway and Airport Engineering
Design of flexible and rigid pavements and bases for highways, airports, and city streets; pavement selection, construction methods, materials, specifications, and engineering cost estimates. Prerequisite: Civil Engineering 721. 2-4 credits.

855-856. Advanced Sanitary Engineering
The application of Chemistry and Microbiology in Sanitary Engineering. The study of control and treatment systems for industrial waste. Prerequisite: Civil Engineering 744. 4 lectures; 4 credits.

863-864. Advanced Soil Mechanics I and II
The physical and mechanical properties of soil in relation to engineering structures. The theory of consolidation, shearing resistance, bearing capacity, settlement, slope stability, earth pressure, and seepage studies. Consent of instructor required for class admission. 4 lectures; 4 credits.

865. Soils Engineering
Application of soil-mechanics' principles to the selection of the type of substructure and the development of its bearing capacity, based on the theories of stability analysis and consolidation. Earth-pressure load determinations by various active and passive earth-pressure theories. Earth dam and foundation construction methods. Prerequisite: Civil Engineering 863 or equivalent. 4 lectures; 4 credits.

866. Soil Testing for Engineering Purposes
The essential tests for the physical properties: permeability, capillarity, compressibility, rate and magnitude of consolidation, and shearing resistance. Prerequisite: Civil Engineering 863 or equivalent. 24 credits.
881. Advanced Structural Analysis I
Advanced structural theory and analysis, including multi-story structures, beam columns, frames with variable moment of inertia, continuous trusses and bents, arches and curved frames, stiff rings, and closed frames. 4 lectures; 4 credits.

882. Advanced Structural Analysis II
Advanced treatment, including flexible and axially loaded flexural members, beams with variable cross-section subjected to axial loads, suspension bridges and flexible arches, and torsional problems of noncircular sections. 4 lectures; 4 credits.

883. Structural Stability
Study of the elastic and inelastic buckling behavior of structures. Topics include: stability of columns, mathematical treatment of buckling problems and buckling criteria, lateral stability of beams, buckling of trusses and framed structures, and stability of rings and curved beams. 4 lectures; 4 credits.

884. Dynamics of Structures
Analysis of structures subjected to dynamic loadings. Free and forced vibrations with one or multi-degrees of freedom. Effects of damping and inelastic action. Vibrations of beams and framed structures. Dynamic response of beams due to moving loads. 4 lectures; 4 credits.

885. Application of System Theory to Structural Analysis
Comprehensive development of the stiffness matrix of structures. Intuitive concepts of topology and linear graphs and their application to structural frameworks. Analysis of structures using linear graphs. 4 lectures; 4 credits.

886. Facility Project Engineering
A critical review of the approaches to the planning and decision processes of facilities, including: codes and specifications, concepts of engineering economy, index numbers and cost estimation procedures (including an introduction to their statistical basis), mathematical modeling concepts, and the development of design loads and criteria for specific application. 4 lectures; 4 credits.

887. Application of Linear Graphs to Civil Engineering
Concepts of topology and linear graphs and their application to civil engineering planning of transportation, water and sewage distribution, and other networks. Network planning and management systems, including Project Evaluation Review Technique (PERT), Critical Path Methods (CPM), and PERT/cost procedures. 4 lectures; 4 credits.

890. Topics in Structures
Studies of topics of special interest and need of the student in structural design, analysis, and optimization. 2-4 credits.

895-896. Civil Engineering Problems
The study and investigations of problems selected to meet the needs of the students. 2-8 credits.

899. Master's Thesis
Hours and credits, 6-9, to be arranged.
Earth Sciences

Earth Sciences (51)
Chairman: Herbert Tischler

PROFessORS: Donald H. Chapman, T. Ralph Meyers, Cecil J. Schneer, Herbert Tischler
ASSOCIATE PROFESSORS: Henri E. Gaudette, Glenn W. Stewart
ASSISTANT PROFessORS: Franz E. Anderson, Wallace A. Bothner, William J. Wiseman

The Department of Earth Sciences offers graduate work leading to the degree of Master of Science. Several options are available within the Earth Sciences program, including geochemistry, igneous and metamorphic petrology, crystallography, and oceanography. A student is expected to have adequate preparation in mathematics and the basic sciences. Students lacking these requirements may be admitted but will be required to complete certain courses which do not give graduate credit. A candidate for the master's degree shall pass an oral or written examination covering his graduate courses and his thesis.

725. Petrology-Petrography
The identification and classification of igneous, metamorphic, and sedimentary rocks in hand specimen and thin section with emphasis on mineralogic and textural relationships leading to an understanding of petrogenesis. Mr. Bothner. Prerequisite: Earth Sciences 614, Mineralogy, or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

741. Geochemistry
Applications of thermodynamics to geological processes; geochemical differentiation of the earth; the principles and processes which control the distribution and migration of elements in geological environments. Mr. Gaudette. Prerequisite: Earth Sciences 614, Mineralogy, or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

754. Sedimentation-Stratigraphy
The properties of sediments and sedimentary rocks, with emphasis on lithofacies, biofacies, principles of stratigraphic correlation, and sedimentary tectonics. Mr. Anderson and Mr. Tischler. Prerequisite: Earth Sciences 614, Mineralogy, or permission of instructor. 2 lectures; 1 laboratory; 4 credits.

758. Physical Oceanography
An introduction to the physics of the oceans in sufficient scientific and mathematical detail to permit understanding of the current oceanographic literature. Both the descriptive and dynamic concepts of physical oceanography will be treated. Mr. Wiseman. Prerequisite: permission of instructor. 3 lectures; 1 student project; 4 credits.

759. Geological Oceanography
Geologic properties of the earth that are unique to the continental shelves and ocean basins. Special emphasis will be placed on submarine geomorphology, eustatic sea level changes, crustal and subcrustal oceanic structure, and the evolution of the ocean basins. Mr. Anderson. Prerequisite: Earth Sciences 501. Introduction to Oceanography, and Earth Sciences 754. 2 lectures; 1 discussion group; 1 special project; 4 credits.

771. Economic Geology
The distribution, utilization, and geology of mineral fuels and some related materials. Mr. Meyers. Prerequisite: Earth Sciences 402, Principles of Geology 11. 4 credits.
781. Physical Geology
The materials and structures of the earth and the erosive agents that modify them are described in the lectures and are examined and studied in the laboratory and on field trips. This course is for certified elementary or high school science teachers who need an introduction to the earth sciences. (Not available for credit after completing Earth Sciences 401, Principles of Geology I, or equivalent.) 4 credits.

782. Historical Geology
The history and development of the physical features of the earth and the development of life on the earth. Fossil organisms will be briefly surveyed in the laboratory and the methods of historical geology will be illustrated in the laboratory and on field trips. Prerequisite: Earth Sciences 781 or equivalent. This course is for certified elementary or high school science teachers who need an introduction to the earth sciences. (Not available for credit after completing Earth Sciences 402, Principles of Geology II, or equivalent.) 4 credits.

Special problems by means of conferences, assigned readings, and field or laboratory work, fitted to individual needs from one of the areas listed above. Staff. 2 or 4 credits.

796. Honors Project
Independent research projects similar to Earth Sciences 795 for students with 3.0 or better average in Earth Sciences. Staff. 2 or 4 credits.

797. Geology Colloquium
Study of selected topics in both classical and modern geological thought. Designed for majors. 0 credit.

813. X-ray Crystallography
The theory and practice of diffraction of X-rays by crystals; lattices, symmetry, and structure analysis. Mr. Schneer. Prerequisite: Earth Sciences 613, Mineralogy, or Physical Chemistry or equivalent. 3 credits.

816. Mineralogy of Clays
The mineralogic composition of clays; the structure and properties of the clay minerals; origin and mode of occurrence of the clay minerals and clay materials. Prerequisite: permission of instructor. Mr. Gaudette. 3 credits. (Offered alternate years; not offered 1971-72.)

820. Advanced Igneous Petrology
Extensive readings and discussions of original sources and recent literature with reference to classical petrologic provinces. Application of thermodynamics and phase-rule chemistry to igneous petrogenesis. Mr. Buthner. Prerequisite: graduate standing and permission of instructor. 3 credits. (Offered alternate years; not offered 1971-72.)

821. Advanced Metamorphic Petrology
Extensive readings and discussions of original sources and recent literature dealing with the facies concept, equilibrium reactions, reaction kinetics, and other
chemical aspects of metamorphic petrogenesis. Mr. Bothner. Prerequisite: graduate standing and permission of instructor. 3 credits. (Offered alternate years; offered 1971-72.)

841. Analytical Geochemistry
Introduction to the theory, instrumentation, and applications of analytical methods in Geochemistry. Mr. Gaudette. Prerequisite: permission of the instructor. 3 credits. (Offered alternate years; not offered 1971-72.)

856. Estuarine and Marine Sedimentation
The unique aspects of sedimentation in marine and brackish water environments will be discussed with special emphasis placed on coastal and shelf areas and the factors that control its deposition. Deep sea marine sediment will be examined primarily for non-biogenic components. The course will include completion of a project and preparation of a report suitable for publication. Mr. Anderson. Prerequisite: permission of instructor. 3 credits.

895, 896. Topics in Geology
Advanced work on an individual or group basis under members of the graduate staff. Prerequisite: permission of department chairman and staff concerned. 1-4 credits. May be taken more than once. Sections of this course are the same as those listed under Earth Sciences 795.

897, 898. Seminar in Contemporary Geology
A review and discussion of recent geological literature. Required of graduate students in Earth Sciences. Staff. 1-3 credits.

899. Earth Sciences Master’s Thesis
6-10 credits.

Economics

Dean: Jan E. Clee

PROFESSORS: Robert F. Barlow, John A. Hogan, Manley R. Irwin, John J. Korbel, Samuel R. Reid, Sam Rosen, Kenneth J. Rothwell
ASSOCIATE PROFESSORS: George W. Betz, Allan J. Braff, James H. Schulz, Dwayne E. Wrightman
DIRECTOR OF GRADUATE STUDIES: Robert F. Barlow

Whittemore School of Business and Economics
The Economics Faculty of the Whittemore School together with the Resource Economics Faculty of the Institute of Natural and Environmental Resources offers a program leading to the degree of Doctor of Philosophy. In addition, the Economics Faculty offers a plan of study culminating in the degree of Master of Arts.

Doctor of Philosophy
Admission to this program is open to students whose undergraduate work shows evidence of superior ability and motivation and who manifest promise of serious scholarship. Normally, the appropriate undergraduate preparation will include exposure to economic reasoning and methodology, including mathematics and sta-
Economics

statistics. Those who warrant special consideration, even though their backgrounds are deficient, should be aware that remedial work may be required.

Admission requirements in addition to those established by the Graduate School include: the Graduate Record Examinations (aptitude and advanced test in economics); T.O.E.F.L. for applicants from non-English speaking countries; three letters of recommendation from those acquainted with the applicant's past academic performance, of which two shall be from those familiar with the applicant's work in his major.

The Ph.D. candidate after admission will be required to demonstrate proficiency in two research tools: 1) a reading knowledge in one foreign language which contains a substantial body of formal economics or is appropriate to an economic research field and 2) differential and integral calculus and linear algebra as related to quantitative economics. The latter may be fulfilled by prior examination, by a test conducted by the Mathematics Department, or by successful completion of the two-semester sequence of appropriate mathematics courses.

Ph.D. candidacy requires written evidence of proficiency in Economic Theory (including the Evolution of Economic Analysis and Quantitative Economics) and in three other fields of economics (or two in economics and one approved related field). In special cases, oral examinations may be required. The dissertation will be followed by an oral defense.

At the present time dissertations are confined to the following four fields: 1) International Economics and Economic Development, 2) Labor and Manpower Economics, 3) Industrial Organization, and 4) Regional Economics. Details of the doctoral program can be obtained from the Director of Graduate Economic Studies.

**Master of Arts Degree**

Admission to graduate study leading to the degree of Master of Arts is limited to students with a better than average undergraduate record. Candidates for admission are required to take the Graduate Record Examination (both the Aptitude Test and Advanced Test in Economics). The prerequisite for graduate work consists of a minimum of 24 hours of undergraduate study in Economics and related fields of which at least 12 hours shall have been in Economics. In addition, all candidates must either present six hours of undergraduate credit in statistics or mathematics, or take six hours of undergraduate work in statistics or mathematics at the University of New Hampshire without credit, or pass a proficiency test in either field.

The candidate for a master's degree must fulfill the general requirements of the Graduate School and the following major requirements:

1) 32 semester hours of graduate study or 24 semester hours and a thesis: (a) a minimum of 24 semester hours in courses numbered 700 and above, of which 8 hours may be satisfied by an acceptable thesis; at least 12 of these hours, exclusive of the thesis, must be in courses numbered 800 and above; (b) a maximum of 8 semester hours in approved courses numbered 600 and above taken in related disciplines.

2) A course grade of B or better at the graduate level as evidence of proficiency in both micro- and macro-economic analysis. 3) Evidence of proficiency, based upon a written examination, in one of the following major areas: (a) a subset in Quantitative Methods, (b) Labor Economics and Industrial Relations, (c) Public Policy Toward Business and Labor, (d) Economic Growth and Stability, (e) International Economy and Economic Development, (f) Resource Development, (g) Economic History, (h) the Evolution of Economic Analysis.
Economics

711. Economic Fluctuations
The study of recurrent movements of prosperity and depression, with emphasis upon causes and public-policy implications. Prerequisite: permission of instructor. 4 credits.

720. U. S. Economic History
The development of the United States economy from Colonial times to the present. Presentation and application of economic models and interpretation of data are stressed. The influence of capital accumulation, industrialization, foreign trade, monetary factors, and government are considered, with peripheral attention to noneconomic factors. Primarily a course in applied economic theory. 4 credits.

721. European Economic History
The development of Western European and Mediterranean economics from medieval times to the common market. Presentation and application of economic models and interpretation of data are stressed. Attention is centered on capital accumulation, technology, trade, industrialization, monetary factors, and the role of government, but the influence of noneconomic factors is discussed where relevant. 4 credits.

722. Case Studies in Economic Development
An analysis and evaluation of economic-development problems and policies in selected countries. Noneconomic factors important as initial conditions and conditioning influences for the process of economic development are emphasized. Major development-policy areas are studied, and an appraisal of national planning experience and the prospects for regional cooperation is made. 4 credits.

725. Statistical Theory
The theoretical basis of statistical methods, probability, probability distributions, statistical inference, and decisions. Prerequisite: permission of instructor. 4 credits.

727. Introduction to Econometrics
The application of statistics and mathematics to economic problems. The formulation of economic models, their measurement, and verification. Prerequisite: Economics 725 or permission of instructor. 4 credits.

728. Statistical Decision Making
The application of probability and statistics to decision problems. Special emphasis on the Bayesian approach to decisions under uncertainty. Prerequisite: permission of instructor. 4 credits.

735. Advanced Money and Banking
Emphasis on central banking, monetary policy, and monetary theory. Study of current problems and developments in banking. 4 credits.

746. International Finance
The international monetary mechanism. Analysis of private and official international capital flows. Instruments and institutions. The multi-national corporation. Exchange rates, adjustment systems, international liquidity, foreign aid. 4 credits.

750. Imperfect Competition
Extensive survey of firm behavior in imperfectly competitive market forms, such as monopoly and oligopoly. The implications for price and research performance under such market forms are examined and the relevance of the
theoretical arguments are assessed by recourse to appropriate empirical studies. 4 credits.

757. Public Policy in Social and Labor Legislation
American social and labor legislation of the recent decades and the way in which American economic and human values have been implemented and modified by law. Legislation and private industry programs in social security, reemployment, unemployment insurances, health services, training and retraining, and fair employment practice. Lectures, discussion, assigned reading, and individual student projects. Prerequisite: one year's work in economics or sociology. 4 credits.

758. Manpower and Education Planning
The flows of human beings within and between the educational and manpower sectors of the economy will be investigated. Such flows will also be related to the flows of goods and services in the industrial sector. Study of the interrelationships of these flows will be directed toward the construction of a computer simulation model for use in tracing the impact throughout the economy of manpower and educational planning decisions. 4 credits.

798. Seminar in Economic Problems
Special topics in Economics. This course may be repeated. Prerequisite: consent of adviser and instructor. 2 or 4 credits.

851. Human Relations in Industry
Labor-management relations studied as one aspect of human relations; applications of recent research in the behavioral sciences; case studies. 4 credits.

852. Economics of Collective Bargaining
Tools of economic analysis applied to collective bargaining—wages, productivity, seniority rules, job security, package bargaining. Application to cases. 4 credits.

857-858. History of Economic Thought
The evolution of economic thought. Examination and critical appraisal of the work of major economists and major schools of economists. 4 credits.

859. Government Regulation of Business
Analysis of government policy with reference to such problems as conspiracy, monopoly, mergers, unfair practices, and discrimination. This analysis includes a legal and economic appraisal of government policy alternatives. 4 credits.

861. National Economic Planning
Analysis of the functioning of various types of national economic systems. Emphasis on economic planning and development. 4 credits.

863. International Economics
Contemporary issues in international economic theory and policy. Analysis of trade theory, dynamics of world trade and exchange, and international commercial policy. 4 credits.

873. Macro-economic Theory I
Advanced analysis of such aggregates as national income, total output, employment, and the general price-level. Examination of the major aggregate models. 4 credits.
874. Macro-economic Theory II
A continuation of Macro-economic Theory I in which the dynamics of the models are stressed and growth theory receives central attention. Prerequisite: Economics 873. 4 credits.

877. Micro-economic Theory I
Topics in micro-economics with emphasis on recent developments in such areas as general equilibrium analysis, welfare economics, demand theory, and capital theory. 4 credits.

878. Micro-economic Theory II
A continuation of Micro-economic Theory I. The course will attempt to bring the student to the frontiers of contemporary research on selected problems of micro-economics. Prerequisite: Economics 877. 4 credits.

891. Seminar in Monetary Theory and Policy
Contemporary developments in monetary theory and the evaluation of policy measures. 4 credits.

892. Seminar in Public Finance—Theory and Policy
Selected topics in contemporary theoretical and policy problems of public finance. 4 credits.

894. Seminar in Economic Development
A survey of the theories of the development process and an examination of the role of various forces of economic change in developing countries. 4 credits.

895-896. Independent Study
Selected projects. Staff. 8 credits.

899. Thesis
Staff. 8 credits.

999. Doctoral Research
Staff.

Education (48)
Chairman: Roland B. Kimball


ADJUNCT PROFESSOR: Walter N. Durost

ASSOCIATE PROFESSORS: John G. Chaltas, David D. Draves, Edward D. Durnall, Bud B. Khleif, Joseph J. Petroski, M. Daniel Smith

ASSISTANT PROFESSORS: Michael D. Andrew, Charles H. Ashley, Gilbert R. Austin, Jason E. Boynton, John R. Cavanaugh, Ronald P. Curcio, Albert R. Elwell, Mary Green, Hubert A. Hardy, David D. Hebert, Edward Lawton, Judith A. Meagher, James W. Mittelstadt, Philip E. Northway, Marvin Sepersen, Deborah E. Stone, W. Dwight Webb

Admission to Graduate Standing
Admission to graduate standing in the Department of Education is granted to applicants meeting the entrance requirements of the Graduate School and accepted
by the Department. Applications must include Graduate Record Examination scores for both the aptitude test and the achievement test in the field selected by the applicant.

The Department offers courses leading to the Master of Education degree, the Master of Arts in Teaching degree, and the Certificate of Advanced Graduate Study.

**Master of Education**

Master of Education programs are offered in these areas of specialization:

- Elementary Education
- Secondary Education
- Counseling and Personnel Services
- Administration and Supervision
- School Library Science

Applicants should indicate their anticipated area of specialization on their application for admission.

Specific requirements for completion of the programs vary with the area of specialization. For information, write to the Chairman, Department of Education.

**Thesis or Comprehensive Examination**

Candidates in the Master of Education program ordinarily will be expected to complete a research thesis, or a comprehensive examination, which may be written or oral. Each candidate will plan this portion of his program in terms of his own professional needs and in consultation with his graduate adviser. There is no thesis or examination requirement for the Master of Arts in Teaching.

**Master of Arts in Teaching—Elementary and Secondary Programs**

The Master of Arts in Teaching program is designed for candidates who have completed an undergraduate degree with a strong academic major but have not followed a program of professional preparation for teaching. The Elementary Program is open also to relatively inexperienced, uncertified teachers. The Master of Arts in Teaching program will provide a balanced curriculum in teacher preparation, with strong emphasis on a supervised internship in teaching and an opportunity to complete further graduate work in the academic subjects most closely related to the candidate's teaching field.

Candidates will spend two summers and the intervening academic year in graduate study. The first summer will provide an opportunity to study and practice educational methods under the supervision of master teachers in a local summer high school and summer elementary school. During the academic year the student will be placed in a local school system as a teaching intern with a half-time load. Interns may be paid by the local school system, according to the policy of the local school board. Concurrently the intern will attend seminars on campus which extend his grasp of educational theory and method and will relate these studies to the experiences the intern encounters as a teacher in a school system. The final summer will complete the courses included in the program.

The Master of Arts in Teaching programs are open to prospective elementary school teachers and to prospective secondary school teachers of English, mathematics, the sciences, social studies, and foreign languages. For further information prospective elementary school teachers should write to Professor John Chaltas, Coordinator, M.A.T. (Elementary), Department of Education. Prospective secondary school teachers should write to Professor Roland B. Kimball, Chairman, Department of Education.
Certificate of Advanced Graduate Study

There is a post-master's degree in counselor education leading to a Certificate of Advanced Graduate Study. For further information, write to Professor Angelo V. Boy, Department of Education.

734. Children's Literature
A consideration of children's books and methods of using them, with emphasis given to intermediate grades. Practical demonstrations of how to correlate children's books with various special subjects. 4 credits.

763. Instructional Media
Introduction to instructional media and technology. Emphasis is given to theory, design, and application of instructional media systems. Prerequisite: Education 657, Psychology of Human Learning. 4 credits.

764. School Library Materials and Services
The background and development of the school library, including functions, objectives, and standards. The relationship of library services to the curriculum, classroom teacher, and students, and to the public library. 4 credits.

765. Reference Materials in the School Library I
The selection and evaluation of basic reference materials common to all libraries. An introduction to school-library informational and research techniques. 4 credits.

766. Technical Processes in the School Library I
Ordering, processing, and organizing school-library materials. Special emphasis on classification and cataloging systems. 4 credits.

767. Materials Selection for School Libraries
Techniques for building the school-library collection in all subjects. Analysis of books for children and young people. Practice in compilation of bibliographies for selected levels and interests. Prerequisite: Education 764 and 765. 4 credits.

785. Educational Tests and Measurements
An introduction to the theory and practice of educational evaluation. Emphasis is given to uses of test results in classroom teaching and student counseling. Introductory statistical techniques. Prerequisite: Education 657. 4 credits.

795, 796. Independent Study
Must be approved by appropriate faculty member. 2 or 4 credits.

800. Curriculum and Method in Elementary School Social Studies
An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary-school social studies. Prerequisite: Education 611, Teaching Elementary School Social Studies, and teaching experience. 4 credits.

801. Curriculum and Method in Elementary School Mathematics
An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary school mathematics. Prerequisite: Education 612 and teaching experience. 4 credits.

802. Curriculum and Method in Elementary School Science
An analysis of research studies, current curriculum proposals, and instructional strategies in the field of elementary-school science. Emphasis will be given to a consideration of contemporary equipment and materials for science education.
Prerequisite: Education 613, Teaching Elementary School Science, and teaching experience, 4 credits.

806. Language and Literature in the Elementary School
A study of language and literature in the elementary school including contributions of allied disciplines such as semantics and linguistics. Focus is on the processes of communication and application to elementary school curriculum. Introduction to bibliotherapy. Prerequisite: Education 610, Teaching Elementary School Language Arts, 4 credits.

807. Survey of Reading
An investigation of the research in reading and reading instruction. Emphasis is on the individual learner, the reading process, and the process of learning to read. Comparison of current diagnostic, developmental, and evaluative methods and materials. Prerequisite: Education 614, Teaching Elementary School Reading, 4 credits.

808. Diagnostic and Remedial Reading
Investigations of the nature and causes of reading disability. Study of diagnostic and remedial procedures and materials through case studies, discussions, demonstrations, and practice. Prerequisite: Education 785 and 807, 4 credits.

809. Practicum in Developmental and Remedial Reading and Language
Individual and small-group work with children will provide opportunities for clinical analysis, micro-teaching, and evaluation. Seminars will focus on the processes of reading and language and the effects of a variety of methods and materials on learning. Prerequisite: Education 808 (may be taken concurrently) and permission of instructor at least one month before beginning the course, 4 credits.

810. Reading and Study in the Secondary School
The nature of the reading process, diagnostic and developmental methods and materials, study skills, and reading in the content areas at the secondary school level. Designed for secondary school teachers who wish to foster continuous development of students' reading and study skills. Prerequisite: secondary school teaching experience, 4 credits.

820. Counseling Theory and Practice
The basic approaches to counseling are examined. Consideration is given to their theoretical foundations. Implications for practices in personnel services are emphasized, 4 credits.

821. Psychology of Vocational Development
An investigation of the psychological and informational factors which influence occupational decisions and progress, 4 credits.

822. Psychological Tests in Personnel Services
An analysis of evaluative instruments and techniques which have particular utility in personnel services. Comparisons of sample instruments in terms of psychological or factorial meanings and predictive uses. Prerequisite: Education 785, 4 credits.

823. Group Counseling
An analysis of group dynamics as they apply in group situations relevant to personnel services. Prerequisite: Education 820, 4 credits.
Education

824. Counseling and Guidance in the Elementary School
Principles and procedures of counseling and personnel services for meeting the developmental needs of elementary school pupils. Prerequisite: Education 820. 4 credits.

825. Laboratory in Counseling
Supervised application of counseling through involvement in simulated counseling situations in a laboratory setting. Prerequisite: Education 820. 4 credits.

826. Practicum in Counseling
Supervised experiences in counseling with actual clients in the usual organizational settings. Prerequisite: permission of instructor. 4 credits.

827. Organization and Administration of Personnel Services
An investigation of the organizational patterns and administrative procedures which influence the effectiveness of personnel services programs. Emphasis is on the elements of productive supervisory and staff relationships. Prerequisite: permission of instructor. 4 credits.

828. Advanced Counseling Theory and Practice
A detailed analysis of the counseling relationship: its characteristics, processes, and outcomes. Prerequisite: permission of instructor. 4 credits.

829. Advanced Practicum in Counseling
Supervised application of advanced counseling theory and practice in actual counseling situations. Samplings of counseling practices will be analyzed and evaluated. Prerequisite: Education 828 and permission of instructor. 4 credits.

830. Research in Personnel Services
A study of research design and methodology in personnel services. Prerequisite: permission of instructor. 4 credits.

831. Seminar and Practicum for Master of Arts in Teaching
(Elementary School)
Observation of reading and elementary-mathematics master teachers assigned to the University Summer Elementary School. Opportunities to teach elementary school children under supervision. Related seminars in methods of teaching reading and elementary mathematics. (Summer Session only.) Prerequisite: admission to the Master of Arts in Teaching Program. 4 credits.

832. Internship and Seminar for Master of Arts in Teaching
(Elementary School)
Internship and related seminars as follows: (a) The elementary school curriculum and methods of instruction in elementary school science, social science, music, art, and physical education will be directly related to planning instruction offered by the student as an intern teacher. (b) Half-time elementary school teaching under the supervision of the University faculty. (First semester only.) Prerequisite: Education 831. 6 credits.

833. Internship and Seminar for Master of Arts in Teaching
(Elementary School)
Internship and related seminars as follows: (a) A continuation of the seminar started in Education 832. (b) Internship. Half-time elementary school teaching under the supervision of the University faculty. (Second semester only.) Prerequisite: Education 832. 6 credits.
835. **Seminar and Practicum for Master of Arts in Teaching**

(Secondary School)
Practicum and related seminars as follows: (a) The secondary school curriculum and general methods of instruction. Candidates will make a detailed study of the secondary school curriculum and special methods of instruction in their own specific teaching field. (b) Candidates are assigned to a master teacher in their specific teaching field for observation in the University Summer High School. There will be opportunities for candidates to do supervised teaching in their subject field. (Summer Session only.) Prerequisite: admission to the Master of Arts in Teaching Program. 6 credits.

836. **Internship and Seminar for Master of Arts in Teaching**

(Secondary School)
Internship and related seminars as follows: (a) A continuation of the special methods seminar started in Education 835. Candidates elect the seminar which provides a detailed study of the secondary school curriculum and special methods of instruction in their own specific teaching field. The seminar will be directly related to planning instruction offered by the candidate as an intern teacher. (b) Half-time secondary school teaching in the candidate's major field under the supervision of the University faculty. (First semester only.) Prerequisite: Education 835. 4 credits.

837. **Internship and Seminar for Master of Arts in Teaching**

(Secondary School)
Half-time secondary school teaching in the candidate's major field under the supervision of the University faculty. (Second semester only.) Prerequisite: Education 836. 4 credits.

838. **Sociology of Education: Social Organization of Schools and Community Schools**
Schools are viewed in their socio-cultural context. Work is centered on a number of field studies of urban and suburban communities. Among the topics discussed are the following: (a) Comparative institutional analysis—what is church-like, hospital-like, factory-like, and prison-like about the school; (b) relations and perspectives of functionaries and clients in "culturally deprived" and "culturally endowed" settings; and (c) teaching as an emergent profession. 4 credits.

840. **Administration of Library-Media Centers**
The planning, organizing, and supervising of library-media centers to support the instructional needs of schools. Prerequisite: Education 766 and 767. 4 credits.

841. **Reference Materials in the School Library II**
Analysis of school-library reference services, materials, and techniques. Prerequisite: Education 765. 4 credits.

842. **Technical Processes in the School Library**
Ordering, processing, and organizing school-library materials. Opportunities for practice in technical management of books, pamphlets, periodicals, tapes, recordings, pictures, and other educational media. Prerequisite: Education 766. 4 credits.

848. **Directed Research in School Librarianship**
Prerequisite: Education 764, 767, and 841. 4 credits.

853. **Seminar in Curriculum Study**
The techniques and procedures of curriculum development and strategies for curriculum change in the public schools. Prerequisite: teaching experience. 4 credits.
858. **Analysis of Teaching**
A comparative analysis of current techniques and instrumentation for studying the process of teaching in the classroom. Consideration of substantive and procedural issues involved in planning for teaching. Prerequisite: teaching experience. 4 credits.

861. **Public School Administration**
An introductory course examining major issues in policy-making, school management, personnel, public relations, finance, and research in school administration. Prerequisite: teaching experience. 4 credits.

862. **Educational Finance and Business Management**
Principles of financing education, budgetary procedures, accounting, auditing, school indebtedness, financial reporting and business management. Experience in handling practical school finance problems will be part of the project work. Prerequisite: Education 861. 4 credits.

863. **Seminar in Educational Administration**
Cases and concepts in educational administration. Prerequisite: Education 861. 4 credits.

864. **Personnel and Communication in Educational Organizations**
The role of change-agent and the change process in education as related to school personnel will be stressed. Problems arising from the communication process will be examined and attention given to implications of group problem-solving processes. Interpersonal relations and group dynamics among students, faculty, staff, administration, and the community will be given attention. Classes will meet once weekly. Emphasis will be upon application of theories. 4 credits.

865. **Educational Supervision**
Theoretical foundations of supervisory behavior as a means of effecting changes in instructional practices; consideration of instruments and techniques based on those theoretical foundations; some opportunity for field projects utilizing instruments and techniques. Prerequisite: teaching experience. 4 credits.

867. **Legal Aspects of School Administration**
Emphasis is on federal and state laws which establish the duties, privileges, and responsibilities of school board members, superintendents, and teachers. The legal aspects of school district organization, negotiation procedures and personnel policies, fiscal operations, school building construction, compulsory attendance, pupil transportation services, and the current legal issues involved in state and federal aid to education. Prerequisite: Education 861 and 863. 4 credits.

869. **Practicum in Educational Administration**
Supervised practical experience in dealing with problems in educational administration. Prerequisite: Education 863. 4 credits.

881. **Methods and Techniques of Educational Research**
Quantitative methods employed in the investigation of educational problems. Permission of instructor. 4 credits.

883. **Advanced Psychology of Human Learning**
Special topics in the field of educational psychology with emphasis on the learning process: (a) examination of learning situations in the classroom in the light of experimental research; (b) examination and evaluation of learning situations in the light of the major theories of learning. Prerequisite: Education 657, Psychology of Human Learning. 4 credits.
Education

884. Advanced Human Development
A personal exploration of the social, psychological, and educational aspects of human development. Special emphasis on emotional growth through school practices in human encounter. Prerequisite: Education 481, An Educational Psychology of Development; Education 657, Psychology of Human Learning; or General Psychology. 4 credits.

886. Philosophy of Education
A comparative analysis of contemporary educational objectives and practices and the philosophical foundations upon which they are based. Prerequisite: Education 657, Psychology of Human Learning, and 659, Principles of Education. 4 credits.

888. Sociology of Education: The Cultures of Poverty and Affluence
The two cultures are treated as a unit; culture change is discussed. Issues of current interest are explored, e.g., poverty, school desegregation, the schooling of geographically mobile children, problems of social mobility and abundance, the rise of the counseling and healing trades, and teachers’ quest for professionalism. The education of “culturally deprived” and “culturally endowed” children receives special attention. A comparative approach is adopted; issues are examined cross-culturally and in relation to the schooling process. 4 credits.

889. Sociology of Education: Race and Ethnic Relations in Schools and Society
This course deals with ethnic stratification and inter-group processes both inside and outside the school. The public schooling of disadvantaged groups such as black, Indian, white Appalachian, and Mexican Americans receives special attention. Caste and class relations between schoolmen, parents, and pupils are examined within social contexts as slums, reservations, Levittowns, and “golden ghettos.” A socio-anthropological perspective is emphasized. 4 credits.

895. Independent Study in Education
An opportunity for intensive investigation of a special problem or issue in the field of education. Permission of instructor is required. 2-4 credits per semester. May be repeated to a maximum of 8 credits.

897. Seminar in Contemporary Educational Problems
A seminar offered by one or more members of the staff dealing with issues or problems of special contemporary significance. Normally the seminar will focus on a problem which has been the subject of recent special study by the staff member(s). Prerequisite: permission of instructor(s). 4 credits. May be repeated for different topics.

899. Thesis
Prerequisite: permission of the department. 4-8 credits.
Electrical Engineering

Electrical Engineering (83)
Chairman: Joseph B. Murdoch

PROFESSORS: Fletcher A. Blanchard, Albert D. Frost, John B. Hraba, Joseph B. Murdoch, Alden L. Winn
ASSOCIATE PROFESSORS: Ronald R. Clark, Donald W. Melvin, H. Richard Skutt, Kerwin C. Stotz

GRADUATE COORDINATOR: H. Richard Skutt

To be admitted to graduate study in Electrical Engineering a student should have completed work in his major field equivalent to that currently required of undergraduates at the University of New Hampshire.

A minimum of 30 credits is required for the Master of Science degree in Electrical Engineering. All students are required to complete two basic courses, Electrical Engineering 701 and 811, at the beginning of their program or furnish evidence of equivalent preparation. Students are further required to demonstrate the ability to do independent and creative work by taking either Electrical Engineering 899 or 891-892. With the consent of the Graduate Committee, a student who has satisfied this requirement through industrial experience may substitute approved course work.

Electrical Engineering 899 and 891-892 both involve equivalent independent theoretical and/or applied work under the guidance of a faculty member. The sequence 891-892 is to be completed in two consecutive semesters, with a letter grade given at the end of each semester. An interim report is submitted at the end of 891 and a final (oral and written) report at the end of 892. Electrical Engineering 899 requirements include the submission of a formal thesis suitable for binding. However, no two-semester time limit is imposed, and no interim or final letter grade is given. Those who intend to undertake graduate work in Electrical Engineering must consult with the department graduate adviser in order to plan their program of study, since all courses are not given each year. Normally, a minimum of 12 credits of 800-level courses is required.

An interdepartmental Engineering Ph.D. Program is also available in the following areas of specialization: Engineering System Design, Signal Processing, Theoretical and Applied Mechanics, and Transport Phenomena. Electrical Engineering students would normally work in one of the first two above areas. For details refer to the section entitled Engineering Ph.D. Program on page 79.

Permission of instructor is required for enrollment in all Electrical Engineering graduate courses.

620. Electronics and Instrumentation

A service course for those students not in engineering or physics. No attempt is made to cover the topics in mathematical or engineering detail. Emphasis is placed on making the student aware of problems which he is likely to encounter when using electronic equipment. Proper technique for using electronic instruments is pointed out in classroom demonstrations and laboratory experiments. Topics covered include D.C. and A.C. circuits, electronic amplifiers, grounding and shielding problems, transducers, electronic instruments, schematic reading, transients, noise problems, and digital techniques. 3 recitations; 1 laboratory; 4 credits.
701. Applied Electromagnetic Fields
Introduction to Maxwell's equations; boundary value problems in electrostatics and magnetostatics; plane wave propagation; reflection and refraction in isotropic media; guided wave propagation; rectangular and cylindrical wave guides; simple resonators; elements of microwave circuits, linear antennas; aperture antennas, arrays of dipoles; directivity receiving antennas and reciprocity. Prerequisite: Electrical Engineering 509, Electromagnetic Fields, or equivalent. 3 recitations; 1 laboratory; 4 credits.

706. Advanced Network Theory
Matrices, linear graph theory and the topological analysis of active and passive networks; concepts of natural frequencies and state; formulation and solution of state equations; application of linear graph and state techniques to real-world system problems. Prerequisite: Electrical Engineering 503, Electrical Circuit Theory. 4 credits.

711. Digital Systems
Generalized, systematic and practical approach to the logical design of digital systems encompassing circuit components, binary arithmetic, Boolean algebra, simplification methods, and derivation of application and input equations. Practical combinational circuits and logical arrays are emphasized in both synchronous and asynchronous applications. Logical equivalents are formulated together with the system aspects of interfacing digital communication systems, wiring and reliability considerations. Prerequisite: senior status or above within the College of Technology or approval of the instructor. 3 recitations; 1 laboratory; 4 credits.

712. Logical Design of Digital Computers
Extension of Electrical Engineering 711 to the design of both general and special purpose digital computers. The design parameters of input-output; memory; and peripheral, arithmetic, and control units are established together with complete design equations for representative digital computers. Analog and hybrid methods are presented together with error-free techniques and a survey of research trends applicable to present and next-generation computers. Prerequisite: Electrical Engineering 711 or approval of instructor. 3 recitations; 1 laboratory; 4 credits.

725. Advanced Analysis of Machinery
Theory and analysis of electromechanical energy converters as multiport devices with emphasis on their dynamic behavior. The view will be that of a systems designer wishing to incorporate a machine into a system. Machine design per se will not be considered. 4 credits.

727. Power Systems
An introduction to the modeling and planning of electric power transmission systems. Prerequisite: Electrical Engineering 503, Electrical Circuit Theory. 4 credits.

730. Direct Energy Conversion
Principle of operation and application of direct energy conversion devices. Devices studied will include fuel cells, thermoelectric and thermionic generators and magnetohydrodynamic generators and propulsion devices. Prerequisites: Mechanical Engineering 503, Thermodynamics I, or equivalent. 4 credits.

741. Fundamentals of Acoustics
The development of the acoustic wave equation for air; laws of reflection, refraction, and absorption; characteristics of acoustic sources; measurement of acoustic sources; microphones; measurement of sound level; properties of
acoustic materials, ultra-sonics, architectural acoustics. Prerequisite: Physics 408, General Physics II; Mathematics 527, Differential Equations. 3 recitations; 1 laboratory; 4 credits.

757. Fundamentals of Communications
Introduction to communications systems, Fourier analysis of signals, amplitude and frequency modulation, detection, digital and sampled data signals, noise in electrical circuits. 3 recitations; 1 laboratory; 4 credits.

758. Communication Systems
Fundamentals of the design of high frequency communication systems. RF amplification, modulators for amplitude and frequency modulation systems, receiving techniques, antennas, free space propagation, propagation characteristics of the ionosphere. Prerequisite: Electrical Engineering 509, Electromagnetic Fields; 757; or equivalent. 3 recitations; 1 laboratory; 4 credits.

762. Illumination
Radiation; color and spectra; physics of light to production; sources of ultraviolet, visible, and infrared energy; lamp circuitry; control of light; illumination design. The course will be conducted on a seminar basis with each student researching and discussing the above topics and doing a project in the application of visible or near-visible energy in business and industry, education, the ocean, agriculture, medicine, or other areas. 2 or 4 credits.

770. Integrated Circuit Design and Technology
An introduction to the principles of operation, design, processing, and technology of linear and nonlinear integrated circuits. Bipolar and unipolar structures, including surface-controlled devices, will be considered. Related topics will include thin-film hybrid circuit techniques, vacuum technology, opto-electronic devices, and microwave active circuits. Prerequisites: Electrical Engineering 505, Electronic Properties of Materials and Devices and 510, Linear Electronic Circuits. 2 recitations; 2 laboratories; 4 credits.

781. Instrumentation
Analysis and design of instrumentation systems; sensors, circuits and devices for electrical measurement and control, techniques of sampled data, telemetry, display, storage, and processing of information. Prerequisite: senior standing. 3 recitations; 1 laboratory; 4 credits.

782. Control Systems
Fundamental principles involved in the design and analysis of feedback control systems. Topics include stability criterion, time-domain analysis, frequency-domain analysis, and introduction to nonlinear systems. 3 recitations; 1 laboratory; 4 credits.

784. Bioelectronics
A study of topics in bioelectronics including biotelemetry, physiological transducers, and modeling. Animal systems such as the nervous system, circulatory system, the ear, and the eye will be studied from an engineering point of view. Prerequisite: Electrical Engineering 510, Linear Electronic Circuits, or equivalent. 4 credits.

785. Underwater Acoustics
An introduction to the field of underwater acoustics including vibrations, propagation, reflection, scattering, reverberation, attenuation, sonar equations, ray and mode theory, radiation of sound, transducers, and small and large signal considerations. Prerequisite: senior or graduate status, and permission of instructor. 4 credits.
786. Introduction to Radio Astronomy
Characteristics of electromagnetic radiation, propagation. Positional astronomy and the radio sky, discrete radio sources, source structure distribution, the sun as a radio source, flare and burst activity, planetary emissions, galactic background. Line emissions (hydrogen, hydroxyl), quasars, pulsars, techniques of observation and data reduction, radiometry, polarimeters, correlation interferometers, aperture synthesis. Prerequisite: senior or graduate status within College of Technology. 4 credits.

796. Special Topics in Electrical Engineering
New or specialized courses are presented under this listing, on sufficient demand. Independent study can be given under this course title. Prerequisite: permission of instructor. 2 or 4 credits.

801. Electromagnetic Field Theory
Review of Maxwell’s equations. Green’s function method for solution of electrostatic problems. Wave propagation in isotropic, anisotropic, and ionized media; propagation over a plane; surface waves. Prerequisite: Electrical Engineering 701. 3 credits.

802. Electromagnetic Wave Theory
Diffraction and scattering; scattering from objects with edges and without edges; introduction to wave propagation in random and turbulent media. Prerequisite: Electrical Engineering 801. 3 credits.

803. Microwave Systems
Waveguide propagation—rectangular, cylindrical, and strip-line; microwave generation devices; impedance measurements; and signal collection detection. Propagation of microwaves at centimeter and millimeter wavelengths. Prerequisite: Electrical Engineering 801. 3 credits.

804. Antennas
Radiation of electromagnetic waves, current distribution on extended structures, antenna impedance considerations. Aperture antennas, parabolic reflectors, horns, lenses. Multi-element arrays, surface wave devices, aperture synthesis, phased arrays. Prerequisite: Electrical Engineering 801. 3 credits.

811. Fundamentals of Signal Processing
Introductory probability theory, matrices and determinants, introductory graph theory. Laplace transforms and pole-zero concepts, complex variable theory, convolution, concept of state, formulation and solution of state equations. 3 credits.

812. Network Synthesis
Synthesis techniques of linear, lumped, finite, passive, bilateral networks. The positive real concept. Realizability conditions. Realization of driving point and transfer functions. RC synthesis, active network synthesis, analysis and synthesis of integrated and thin-film structures. Prerequisite: Electrical Engineering 811. 3 credits.

813. Nonlinear Networks
Introduction to basic nonlinear phenomena and methods. Study of time-varying and nonlinear passive networks including free and forced responses, jump phenomena and subharmonic generations. Circle criterion, Popov criterion and other frequency-domain stability criteria, Liapunov stability theory. Prerequisite: Electrical Engineering 811. 3 credits.
815. Linear Active Circuits
Investigation of circuits, devices, and techniques used in linear applications. Heavy emphasis is placed on design, construction, and testing of linear circuits using both discrete solid-state devices and integrated circuits. 3 credits.

816. Nonlinear Active Circuits
Investigation of circuits, devices, and techniques used in pulse and other nonsinusoidal applications. Heavy emphasis is placed on design, construction, and testing of digital circuits using both discrete solid-state devices and integrated circuits. 3 credits.

817. Network Analysis
Topological properties and analysis of networks; one to n-port networks; natural frequencies; eigen values and state variables; parts of network functions, Fourier and Hilbert transforms; the approximation problem in the time- and frequency-domains. Prerequisite: Electrical Engineering 811. 3 credits.

831. Solid State Electronics I
A study of topics in solid state electronics including semiconductor physics, crystal structure, band theory, transport phenomenon, recombination, and PN junctions. Semiconductor fabrication process theory will be introduced. Prerequisite: Electrical Engineering 505, Electronic Properties of Materials and Devices, or equivalent. 3 credits.

832. Solid State Electronics II
A continuation of Electrical Engineering 831, emphasizing the theory of semiconductor devices including bipolar, field-effect, and surface-controlled transistors, monolithic and hybrid integrated circuits, photoconductors, injection luminescent diodes, semiconductor laser and bulk effect devices, as well as selected applications and topics in theory of semiconductor technology. Prerequisite: Electrical Engineering 831. 3 credits.

833. Solid State Electronics III
A study of advanced topics in solid-state electronics either not covered in Electrical Engineering 831 and 832 or with coverage in considerable depth requiring extensive use of published literature and library resources. This course will allow and require independent study of selected topics of current interest in solid-state electronics. Prerequisite: Electrical Engineering 832. 3 credits.

839. Statistical Theory of Communications
An introduction to probability theory and random waveforms leading to a discussion of optimum receiver principles. Topics include random variables, random processes, correlation, power spectral density, sampling theory, and optimum decision rules. Prerequisite: Electrical Engineering 811. 3 credits.

840. Information Theory
A continuation of Electrical Engineering 839. Introduction of information-theory concepts. Topics include: message sources, entropy, channel capacity, fundamentals of encoding, Shannon’s theorems. Prerequisite: Electrical Engineering 839. 3 credits.

851. Advanced Control Systems I
852. **Advanced Control Systems II**  
Special topics in control theory such as multivariate and adaptive control systems; stochastic systems; Wiener and Kalman filter techniques; introduction to dynamic, linear, and nonlinear programming. Prerequisite: Electrical Engineering 851. 3 credits.

854. **Foundations of Systems Engineering**  
Introduction to function space, i.e., metric spaces, Banach spaces, Hilbert spaces, and transformations. Treat optimal control as a geometric problem on a Banach space and obtain minimum norm solutions. Sensitivity analysis of linear systems. Prerequisite: Electrical Engineering 852 or equivalent. 3 credits.

856. **Switching Theory**  
Combinational circuits—including functional decomposition, non-binary logic, and cellular networks. Sequential networks—including analysis, transient behavior, state reduction methods, state assignment, and synthesis. Prerequisite: Electrical Engineering 711. 3 credits.

891-892. **Research**  
3 credits each semester.

898. **Independent Study**  
Independent theoretical and/or experimental investigation of an electrical engineering problem under the guidance of a faculty member. 1-3 credits per semester.

899. **Master's Thesis**  
6 credits.

**Engineering Ph.D. Program** (87)  
Committee Chairman: Victor D. Azzi

**Professors**: Fletcher A. Blanchard, Robert W. Corell, Albert D. Frost, Shan S. Kuo, Joseph B. Murdoch, Godfrey H. Savage, Charles K. Taft, Alden L. Winn, Asim Yildiz


**Assistant Professors**: Robert W. Alperi, Robert J. Becherer, Glen C. Gerhard, Filson H. Glanz, David E. Limbert, John A. Wilson

**Engineering Ph.D. Committee**: Victor D. Azzi, Stephen S. T. Fan, Albert D. Frost, Charles K. Taft

An interdepartmental Engineering Program offers graduate work leading to the degree of Doctor of Philosophy and is conducted by a combined Engineering faculty. The Program consists of Areas of Specialization within an interdepartmental structure, depending principally upon strengths in engineering, the engineering sciences, mathematics, and the physical sciences. An interdepartmental program is felt to be most meaningful since many contemporary engineering and scientific problems can be solved only through the cooperation of a variety of disciplines. Further, the boundaries between the classical disciplines in engineering and science have become increasingly indistinct. The particular advantage of the non-
Engineering Ph.D. Program

departmental program structure is that improved communication and cooperation develop among faculty and students of the different disciplines and results in more meaningful academic and professional experiences.

Areas of Specialization

The Engineering Ph.D. Program includes the following four Areas of Specialization:

Engineering System Design, Charles K. Taft, Chairman

This program area provides the student with a broad spectrum of advanced course work in engineering, science, and related areas combined with a direct experience in the administrative challenges involved in the design and implementation of modern engineering systems. Concentration in an area of specific interest is combined with participation in a multi-element, design-and-development effort in which the student is eventually responsible not only for his personal contribution but the integration of related efforts into a functional and effective system.

Current research and design topics include the science and technology of utilizing the bottom resources of the continental shelf, ocean engineering, control-system design, fluidics, facility system modeling and analysis, and ski-area wind and snow control.

Signal Processing, Albert D. Frost, Chairman

This area of specialization is concerned with those analytic and experimental techniques that are involved in some aspect of the acquisition, detection, identification, or control of signals. In this context a signal is defined as any quantity which contains or conveys information. While the majority of signal processing systems are partially or wholly electrical in nature, many of the basic aspects of signal processing and utilization are common to a wide range of problems and applications in communications, biology, instrumentation, and control.

Current research topics include: network synthesis, bioelectronic telemetry, radio astronomy, ionospheric irregularities, pattern recognition, semi-conductor device fabrication, coherent signal analysis, surface-wave antennas, digital control, non-linear interacting system-control, and fluidics.

Theoretical and Applied Mechanics, Victor D. Azzi, Chairman

This area, which is treated as an engineering science, brings together those aspects of engineering, physics, and applied mathematics that are relevant to the understanding and application of the dynamical and equilibrium behavior of materials and structures. Included are the fields of solid mechanics, structural mechanics, classical and continuum mechanics, rheology, theoretil soil mechanics, biomechanics, and elastodynamics.

Current research topics include macro- and micro-mechanics of composite-material behavior, viscoelastic material properties, structural dynamics, elastodynamics, elastic wave propagation, scattering of elastic waves, theoretical soil mechanics, ocean-cable dynamics, and acoustic determination of the properties of layered media.

Transport Phenomena, Stephen S. T. Fan, Chairman

This area deals with the subjects of fluid mechanics; conductive, convective, and radiative heat transfer; and diffusive mass transfer in a generalized and coordinated approach. In addition to their fundamental role in traditional engineering activities, transport-phenomena studies are expected to make significant engineering contributions in the areas of environmental control, oceanography, space exploration, and biomedical engineering.

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Current research activities include pollution control, biomedical engineering, combustion, adsorption, simultaneous heat and mass transfer, heat transfer with phase change, liquid pumping cavitation, polymer processing, vortex flow, and flow through porous media.

Requirements

Qualified students with bachelor's or master's degrees in engineering, mathematics, or the physical sciences are eligible for admission to the Program. To be admitted a student must present evidence that he has sufficient background in the Area in which he proposes to specialize.

Following the entrance of a student into the Program, a Guidance Committee will be appointed for the student by the Dean of the Graduate School upon recommendation of the chairman of the student's Area. This committee will assist the student in outlining his program and in preparing him for his qualifying examination and may require him to take specified course work, with or without credit. The committee will also conduct an annual in-depth review of the student's progress, through written and or oral examinations.

Following the substantial completion of his course work, a student may make application for his qualifying examination. At that time a Doctoral Committee will be appointed by the Dean of the Graduate School upon recommendation of the chairman of the student's Area.

The Doctoral Committee shall supervise the qualifying and final examinations, be responsible for the language examinations, approve the dissertation, and conduct an annual review of the student's progress.

A student will normally be expected to begin his research early in his second year, at which time he will select a Dissertation Adviser.

To obtain a Ph.D. degree in Engineering a student must meet all of the general requirements as stated under Regulations of the Graduate School. A student will normally be required to demonstrate the ability to read scientific and technical literature in one approved foreign language. However, in specific cases a student's Guidance Committee may require a second language and/or a demonstrated facility in a special research technique such as digital or analog computation. To complete the Ph.D. degree in Engineering a student will normally be expected to take course work equivalent to two academic years beyond the baccalaureate and to complete a dissertation which will require at least one full-time year of study and original research. Specific course requirements have been established for each Area of Specialization. All these requirements should normally be completed before the student can be advanced to candidacy.

Course Requirements

Course work requirements will be developed on an individual basis by each student's Guidance Committee. Since each Area of Specialization has its own specific course requirements, an interested student should contact the Area Chairman to determine the particular course work and research activity that may be applicable to his educational goals.

Except for Doctoral Research (999), students will follow a program of study consisting of courses from within the Chemical, Civil, Electrical, and Mechanical Engineering Departments, many of which have been established particularly for this Program, and from related departments appropriate to the student's needs. A student should consult the Course Descriptions section of this catalog for specific course offerings and descriptions.

999. Doctoral Research
English

English (49)
Chairman: John C. Richardson


ASSOCIATE PROFESSORS: Thomas A. Carnicelli, Carl Dawson, Lewis C. Goffe, Max S. Maynard, Edmund G. Miller, John A. Yount


The Department of English offers three advanced degrees, Master of Arts, Master of Science for Teachers, and Doctor of Philosophy. Applicants are expected to have done superior work in English at the undergraduate level. Applicants for the Master of Arts and the Ph.D. degrees are advised, and may be required, to submit verbal aptitude and advanced literature scores on the Graduate Record Examinations. Applicants for the Ph.D. are normally expected to have a reading knowledge of at least one foreign language.

Master of Arts

The Master of Arts may be undertaken as a terminal degree or as preparation for a doctoral program. The program encourages students to pursue their individual interests and to correct serious deficiencies in their undergraduate training.

COURSES: A Master's candidate must pass seven four-credit courses in English and American literature and language. Five courses, including at least two graduate seminars, must be at the 800 level. Students should normally take their non-seminar courses in fields where they have had little previous experience.

LANGUAGE: A master's candidate must pass a reading examination in one of the following languages: French, German, Greek, Italian, Latin, Russian, Spanish.

THESIS: Each master's candidate must write an acceptable thesis. The thesis will normally be a scholarly paper of approximately 50 typed pages in length, and may be a development of a seminar paper. The Department occasionally accepts a body of creative writing (a novel, a collection of short stories, poems, essays) as fulfilling the thesis requirement. The complete first draft of the thesis must be submitted to the student's adviser at least two months before the degree is to be granted. The final copies must be ready for signing at least three weeks before the degree is to be granted.

Master of Science for Teachers

The Master of Science for Teachers is a terminal degree designed for the high school teacher. No foreign language is required. The student must take eight courses in English, numbered above 700, which will not be a repetition of undergraduate work. Applicants should consult the General Regulations of the Graduate School for the special admissions requirements for this program.

Doctor of Philosophy

The Ph.D. program offers professional training in the study and teaching of literature and language. The program combines the essential guidance and discipline of course work with the equally essential freedom of independent study and research. Accordingly, the first year of study lays primary stress upon courses, while the second and subsequent years encourage the student to follow a program suited to his individual interests and needs. In addition to meeting course requirements, each student must pass: 1) reading examinations in two foreign languages

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(French, German, Greek, Italian, Latin, Russian, Spanish), and 2) written qualifying examinations in five areas of English and American literature and language. He must also acquire some experience of the methods and problems of teaching, either by attending a colloquium on college teaching or by teaching under supervision for a year as a graduate assistant within the department. Finally, he must write a dissertation and defend it at a final oral examination. The program is designed to be completed within four years of full-time study. At present students will not be permitted to write dissertations in the following: English Language, Eighteenth-century British Literature, and Twentieth-century British Literature.

Graduate students should note that not all seminars are offered every year. A complete guide to the Department's graduate program is available from the chairman of the graduate committee.

701-702. Advanced Writing of Fiction and Poetry
Workshop discussions of advanced writing problems, and readings of students' fiction, poetry, or plays. Individual conferences. Mr. Williams. Written permission of instructor required for registration. 4 credits.

703-704. Advanced Nonfiction Writing
A workshop course for advanced students of writing, with discussions and individual conferences. Mr. Murray. Written permission of instructor required for registration. 4 credits.

705. English Grammar
A review of English grammar including both traditional and contemporary approaches. Mr. Goffe. 4 credits.

706. English Linguistics
A descriptive approach to modern English grammar, emphasizing the insights provided by linguistic analysis. Mr. Hunter. 4 credits.

709. Critical Analysis of Exposition
4 credits.

710. Critical Analysis of Fiction
A course designed to acquaint the student with a variety of modern approaches to the criticism of fiction, with special emphasis upon developing skills in close analysis of individual works. Mr. Briden. 4 credits.

711. Critical Analysis of Poetry and Drama
A non-historical, non-genre approach to individual poems and plays with emphasis on the works themselves. Mr. Richardson. 4 credits.

713. 714. Literary Criticism
Major critics from Plato to the present and the chief critical approaches to literature. Mr. Hapgood. 4 credits.

742. Puritanism and the Enlightenment in America
American literature and thought from the Colonial beginnings through the early republic. Mr. Duffy. 4 credits.

743. American Transcendentalists
Emerson, Thoreau, and other transcendentalists. Mr. Duffy. 4 credits.

744. American Fiction to the Civil War
Cooper, Poe, Hawthorne, Melville, and others. Mr. Goffe. 4 credits.

745. American Poetry of the Nineteenth Century
Bryant, Poe, Emerson, Whitman, Dickenson, and others. 4 credits.
English

746. American Realism and Naturalism
Twain, Henry James, Adams, Stephen Crane, Dreiser, and others. Mr. Rose. 4 credits.

747, 748. American Fiction and Drama of the Twentieth Century
Fitzgerald, Hemingway, O'Neill, Faulkner, and others. Mr. Nicoloff, Mr. Potter, Mr. Rose. 4 credits.

749. American Poetry of the Twentieth Century
Robinson, Frost, Stevens, Pound, Eliot, Jefferies, Hart Crane, Robert Lowell, and others. Mr. Nicoloff. 4 credits.

751. History of the English Language
A study of the evolution of the English language, with special emphasis upon the relation between linguistic change and literary style. Mr. Carnicelli. 4 credits.

753. Old English
An introduction to Old English language and literature through readings of selected poetry and prose. Mr. Carnicelli. 4 credits.

754. Beowulf
A reading of the poem and an introduction to the scholarship. Mr. Carnicelli. Prerequisite: English 753. 4 credits.

755, 756. Chaucer
755: Chaucer's allegorical poems and Troilus and Criseyde. 765: The Canterbury Tales. Mr. Underwood. 4 credits.

757, 758. Shakespeare
The major plays of Shakespeare. 757 surveys a number of representative plays; 758 studies a few plays more intensively. 757 is prerequisite to 758. Mr. Hapgood, Mr. Hunter, Mr. Logan, Mr. Caldwell. 4 credits.

759. Milton
Milton's life and times, all his poetry, and a selection of his prose. Mr. Hunter. 4 credits.

763, 764. English Literature in the Sixteenth Century
763: Major literary figures of the Continental Renaissance (in translation), including Petrarch, Machiavelli, Ariosto, Rabelais, Montaigne, Cervantes, and Erasmus; major English writers of the period, including More, Skelton, Wyatt, and Surrey. 764: Sidney, Drayton, and other late Elizabethans, with emphasis upon Spenser. Mr. Logan. 4 credits.

765, 766. English Literature in the Seventeenth Century
765: Major writers of prose and poetry in the first half of the century; special emphasis upon the relationships between the metaphysical and the classical modes of poetry. 766: Restoration comedy of manners, heroic drama, verse, satire; Dryden, Milton, and Bunyan. Mr. Underwood. 4 credits.

767, 768. English Literature in the Eighteenth Century
767: Addison, Steele, Defoe, Pope, and Swift. 768: Gray, Collins, the Wartons, Burke, Goldsmith, Reynolds, Johnson, Boswell, Crabbe, Burns, and Blake. Mr. Maynard. 4 credits.

769, 770. The English Romantic Period
769: Wordsworth, Coleridge, Lamb, Hazlitt, DeQuincey. 770: Byron, Shelley, Keats, Mr. Miller. 4 credits.
771, 772. Victorian Prose and Poetry
771: Carlyle, Mill, Ruskin, Newman, Tennyson, and Browning. 772: Arnold, Clough, the pre-Raphaelites, Swinburne, Hardy, Housman, and others. Mr. Miller, Mr. Pfoldresher. 4 credits.

773, 774. British Literature of the Twentieth Century
773: Survey of the novels of the period. 774: Survey of the poetry of the period. Mr. Richardson, Mr. Dawson. 4 credits.

781, 782. Introduction to English Drama
The development of English drama, exclusive of Shakespeare, from the Middle Ages to the present. 781: From the Middle Ages to the closing of the theatres in 1642. 782: From the Restoration to the present. Mr. Hapgood, Mr. Caldwell. 4 credits.

783. The English Novel of the Eighteenth Century
The rise and development of the novel through study of selected major works by Defoe, Richardson, Fielding, Smollett, Sterne, and Austen. Mr. Briden. 4 credits.

784. The English Novel of the Nineteenth Century
Representative novels from among the following authors: Austen, Scott, Dickens, Thackeray, Emily Bronte, Charlotte Bronte, Trollope, George Eliot, Hardy, and Conrad. Mr. Dawson, Mr. Miller. 4 credits.

791, 792. (English Education) Problems in the Teaching of High School English
Principles and methods of teaching literature, composition, and language in secondary schools. Mr. Goffe. Prerequisite: a grade of C or better in Education 658, Principles of Teaching. 2 credits.

795. 796. Independent Study
Individual guided study in special topics. Open to MST candidates. Open under special circumstances to MA candidates upon petition to the departmental graduate committee. Graduate faculty. 1-4 credits.

797, 798. Special Studies in Literature
The precise topics and methods of each section will vary.
1. Old English Literature
2. Medieval Literature
3. The Renaissance
4. The Seventeenth Century
5. The Eighteenth Century
6. The English Romantic Period
7. The Victorian Period
8. The Twentieth Century
9. The Drama
10. The Novel
11. Poetry
12. Non-fiction
13. American Literature
14. A Literary Problem
Graduate faculty. 4 credits.

813, 814. Literary Criticism
4 credits.

812. Puritanism and the Enlightenment in America
4 credits.

843. American Transcendentalists
4 credits.

844. American Fiction to the Civil War
4 credits.
845. American Poetry of the Nineteenth Century
4 credits.

846. American Realism and Naturalism
4 credits.

847, 848. American Fiction and Drama of the Twentieth Century
4 credits.

849. American Poetry of the Twentieth Century
4 credits.

851. History of the English Language
4 credits.

853. Old English
4 credits.

854. Beowulf
4 credits.

855, 856. Chaucer
4 credits.

857, 858. Shakespeare
4 credits.

859. Milton
4 credits.

863, 864. English Literature in the Sixteenth Century
4 credits.

865, 866. English Literature in the Seventeenth Century
4 credits.

867, 868. English Literature in the Eighteenth Century
4 credits.

869, 870. The English Romantic Period
4 credits.

871, 872. Victorian Prose and Poetry
4 credits.

873, 874. British Literature of the Twentieth Century
4 credits.

875. Seminar—Studies in Old English
Mr. Carnicelli. 4 credits.

880. Seminar—Studies in Twentieth-Century British Literature
Mr. Dawson. 4 credits.

881, 882. Introduction to English Drama
4 credits.

883. The English Novel of the Eighteenth Century
4 credits.

884. The English Novel of the Nineteenth Century
4 credits.
Entomology

885, 886. Seminar—Problems in Medieval Literature
Mr. Underwood. 4 credits.

887. Seminar—Studies in Sixteenth-Century Literature
Mr. Logan or Mr. Hunter. 4 credits.

888. Seminar—Problems in Milton Scholarship and Criticism
Mr. Hunter. 4 credits.

889. Seminar—Studies in Shakespeare
Mr. Hapgood. 4 credits.

890. Seminar—Studies in English Drama
Mr. Hapgood. 4 credits.

891. Seminar—Studies in American Literature of the Nineteenth Century
Mr. Nicoloff or Mr. Duffy. 4 credits.

892. Seminar—Studies in Restoration Literature
Mr. Underwood. 4 credits.

893. Seminar—Studies in Early Seventeenth-Century Literature
Mr. Hunter or Mr. Underwood. 4 credits.

894. Seminar—Studies in the Romantic Period
Mr. Miller. 4 credits.

895, 896. Reading and Research
Graduate Faculty. 4 or 8 credits.

897, 898. Special Studies in Literature
Graduate Faculty. 4 credits.

899. Master's Thesis
6 credits.

999. Doctoral Research

Entomology (29)
Acting Chairman: Robert L. Blickle

Professor: Robert L. Blickle
Associate Professor: R. Marcel Reeves
Assistant Professor: G. Thomas Fisher

For admission to graduate study in Entomology an applicant is expected to have adequate preparation in undergraduate Entomology and related sciences. Students lacking the necessary background courses may be required to complete certain courses which do not carry credit before they are admitted to candidacy for a degree.

The program of graduate study is designed to meet the needs of those students planning to take further work leading to a career in professional entomology.

A thesis is required of all candidates for the Master's degree.
French and Italian

704. Medical Entomology
Insects and arachnids in relation to public health. The more important disease carriers, their biology, and means of control. Adapted especially for students who are interested in public health or medicine. Elective for juniors and seniors. Mr. Blickle. 2 lectures; 1 laboratory; 4 credits.

707-708. Advanced Entomology
The anatomy and physiology of insects. Aquatic and systematic entomology. Mr. Blickle and staff. Open to other than Entomology majors by permission of department chairman. 2 lectures; 1 laboratory; 4 credits.

709-710. Advanced Economic Entomology
Problems in applied Entomology; the literature of economic Entomology. Investigational methods. Studies of the specialized phases of Entomology. Mr. Blickle and staff. Required of Entomology majors. Open to other than Entomology majors by permission of department chairman. 24 credits.

801, 802. Graduate Entomology
Concentrated studies in insect biology, systematics, and biological control or chemical control of insects. Mr. Blickle and staff. Subject matter, hours, and credits to be arranged.

899 (899). Graduate Entomology—Master’s Thesis
Mr. Blickle, Mr. Reeves, and staff. Hours and credits to be arranged. 6-10 credits.

Forest Resources
See Institute of Natural and Environmental Resources

French and Italian (56)
Chairman: Louis J. Hudon

Professor: Louis J. Hudon
Associate Professor: Samuel E. Stokes Jr.
Visiting Associate: Edna S. Hudon
Assistant Professor: Grover E. Marshall

The Department of French and Italian offers courses leading to two degrees, Master of Arts- and Master of Science for Teachers in French.

To be admitted to graduate study for the Master of Arts degree, a student must have completed an undergraduate major in French or the equivalent thereof. He must also submit scores of the Graduate Record Examination, both the Aptitude Test and the Advanced Test in French.

To satisfy requirements for the Master of Arts degree, the student must complete 8 courses and write a master's thesis. Six of the courses must be in French, four among French courses numbered 300 or above. Two of the eight courses may be taken in related departments. The thesis must embody results of independent investigation and be written in a form acceptable to the Department. It must be submitted to the thesis director six weeks before Commencement.

To be admitted to graduate study for the Master of Science for Teachers degree in French, a candidate must meet requirements as specified on page 25.

To satisfy course requirements for the Master of Science for Teachers degree, the student must complete 10 courses. Six must be in French, four from French
courses numbered 800 or above; two of the courses may be taken in related departments; and two may be transferred from an accredited NDEA institute, offering graduate courses.

The candidate for the Master of Science for Teachers degree must pass a departmental oral and written examination six weeks before the degree is to be granted.

All courses in the Department are conducted in French. Except for 899, the courses listed below are also available on the 700 level.

French

841. French Literature of the Middle Ages
   Readings in the epic, lyric poetry, and the romance. 3 credits. (Alternate years; not offered in 1971-72.)

842. French Literature of the Renaissance
   Readings in the literature of the sixteenth century. 3 credits. (Alternate years; not offered in 1971-72.)

859-860. French Literature of the Seventeenth Century
   Readings in the literature of the seventeenth century. 3 credits. (Alternate years; offered in 1971-72.)

861-862. Eighteenth Century French Literature and Thought
   Readings in the Age of Enlightenment. 3 credits. (Alternate years; not offered in 1971-72.)

867-868. Nineteenth Century French Literature
   Readings in Romantic, Parnassian, and Realistic literature of the century. 3 credits. (Alternate years; offered in 1971-72.)

(870). Introduction to Modern French Poetry
   Studies in French poetry from Baudelaire to the present. 3 credits. (Alternate years; offered in 1971-72.)

881-882. Contemporary French Novel and Theater
   Readings in the French novel and theater of the twentieth century. 3 credits. (Alternate years; not offered in 1971-72.)

(888). Seminar in French Literature
   A study of French authors chosen by the instructor. 3 credits. (Alternate years; offered in 1971-72.)

890. Advanced Language and Style
   Translation of literary texts, intensive study of the principle techniques of style, explication de textes. 3 credits.

895. 896. Special Studies in French Language and Literature
   Individual, guided study in special topics, with training in bibliography and organization of material. Examples of topics which may be selected are: the work of a major French author, specific topics in any area of French literature, such as literary criticism in a given period. Prerequisite: permission of department chairman. 4 credits.

899. Master's Thesis
   6 credits.
Genetics Program

Genetics Program (97)
Chairman: D. MacDonald Green

Professors: Walter M. Collins, Gerald M. Dunn, D. MacDonald Green, Lincoln C. Peirce, Richard W. Schreiber
Adjunct Professor: Ernst J. Schreiner
Assistant Professors: Fred T. Hickson, J. Brent Loy, Tung Tzu Kiang

The interdepartmental Genetics Program offers graduate work leading to the degrees of Master of Science and Doctor of Philosophy.

A qualified student is admitted to the program with the approval of the chairman of the department in which he has a major interest. Students will be expected to have adequate preparation in the biological and physical sciences including mathematics. Students lacking these requirements may be admitted but will be required to complete certain courses without graduate credit.

The Program is conducted by faculty members from the departments of Animal Sciences, Biochemistry, Botany, Forest Resources, Microbiology, Plant Science, and Zoology as well as other faculty from the Agricultural Experiment Station and the U. S. Forest Service, Northeastern Forest Experiment Station. Areas of specialization in the program are: the genetics of plants, animals, microorganisms, and viruses, with emphasis in physiological and quantitative genetics. All students working toward the M.S. or Ph.D. degree in Genetics are required to satisfy the core-curriculum (Genetics 703, 705 and 770) requirements unless equivalent courses have been satisfactorily completed elsewhere.

Master of Science Degree

The program for the Master of Science degree is formulated by the student with the approval of his guidance committee. Candidates for the degree will be required to complete a thesis, pass an oral examination covering graduate courses and thesis, and complete any two of the three courses of the core-curriculum.

Doctor of Philosophy Degree

The chairman of the Genetics Program, with the concurrence of the chairman of the department of major interest, will nominate the student's guidance and doctoral committees. Specific course requirements will be developed by the student and his guidance committee, and will include the courses in the core-curriculum. Students must complete a dissertation on original research in genetics.

A student must satisfy a foreign language requirement by demonstrating proficiency in one language through successful completion of an E.T.S. Language Exam.

703. General and Comparative Genetics
Comparative analysis of genetic systems with emphasis given to diploids and the role of gene and chromosome mutations in their evolution. Evolution of dominance and sex determination. Laboratory emphasizes general analysis of diploid inheritance with experimental and statistical approaches. Mr. Hoornbeek, Mr. Kiang. Prerequisite: Zoology 604, Principles of Genetics, or equivalent. 4 credits. (Alternate years; offered fall 1971.)

705. Population Genetics
The distribution of genes in populations; factors affecting gene frequency such as mode of inheritance, departures from random mating, mutation, genetic drift,
linkage disequilibrium, migration, selection, and fitness. Prerequisite: Zoology 604. Principles of Genetics, or equivalent or permission of instructor. 4 credits.

770. Biochemical Genetics
The biochemical mechanism of storage, replication, transmission, transcription, recombination, mutation, and expression of genetic information by cells and viruses. Mr. Green. Prerequisite: Biochemistry 751 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

802. Design of Experiments
The philosophy of experimental design and how it relates to standard statistical designs. Topics include the roles of replication and randomization, factorially arranged treatments, latin squares, incomplete non-factorial designs, fractional replication and confounding, and crossover designs. Mr. Urban. Prerequisite: Forest Resources 711 and Mathematics 410, Digital Computer Systems, or permission of instructor. 3 credits. (Alternate years; offered in 1971-72.)

812. Advanced Statistical Methods
Methods and techniques for handling typical problems which arise in the analysis of data. Topics include the multiple comparison of means, analysis of unweighted means, proportional subclass numbers, weighted squares of means, orthogonal polynomials, and least squares. Mr. Urban. Prerequisite: Forest Resources 711 and Mathematics 410, Digital Computer Systems, or permission of instructor. 3 credits. (Alternate years; not offered in 1971-72.)

821. Biometrical Genetics
Statistical aspects of estimating genetic parameters associated with quantitative traits. The theory underlying estimation of components of variance from various experimental designs, phenotypic and genotypic correlations, construction of selection indices, and the use of collateral and ancestral relatives to estimate breeding value. Mr. Urban. Prerequisite: Genetics 812, Mathematics 410, Digital Computer Systems, and either Animal Science 703 or Plant Science 774. 3 credits. (Alternate years; not offered in 1971-72.)

(898) 898. Genetics Seminar
Presentation and discussion of selected genetic topics. Staff. 1 credit. May be repeated.

899. Master's Thesis
6-10 credits.

999. Doctoral Research

Courses Available in the Cooperating Departments
These courses are fully described below and under the course descriptions of the appropriate department for the convenience of the student.

Animal Sciences (25)

708. Animal Genetics
Mendelian and quantitative inheritance in animals. Principles and systems of selection. Mr. Collins. Prerequisite: one course in genetics or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

811. Quantitative Genetics and Animal Improvement
Gene frequency, genetic and environmental variation, heritability, fitness, selection, inbreeding, outbreeding, and correlated characters. Mr. Collins. Prerequisite: one course each in genetics and statistics. 3 credits.
Genetics Program

Botany (27)
732. Cytology
The structure, physiological behavior, and development of cells. The cellular basis of heredity. Mr. Schreiber. Prerequisite: one year each in the biological sciences and in chemistry. 3 lectures: 1 seminar; 4 credits.

765. Microtechnique
A methods course in embedding, sectioning, and staining plant tissues, and an introduction to microcopy. Mrs. Biggs. Prerequisite: Botany 411 or 503. 2 lectures; 4 hours of laboratory; 4 credits. (Alternate years; not offered in 1971-72.)

Forest Resources (30)
711. Statistical Methods II
An intermediate course in statistics. Topics include basic concepts of sampling, linear models and analyses for one-way and multi-way classification, factorial arrangement of treatments, multiple regression, and covariance. Mr. Barrett. Prerequisite: Forest Resources 528 or equivalent. 4 credits.

720. Forest Tree Improvement
The genetics of forest tree improvement with emphasis on variation in natural populations, the basis for selection for desired characters, and the fundamentals of controlled breeding. The application of principles will be directed toward silviculture, management, and utilization. Mr. Hocker. Prerequisite: permission of instructor. 2 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1971-72.)

Microbiology (47)
804. Microbial Genetics
An introduction to genetic principles and methodology applicable to microorganisms; fine structure of genetic material, mutation, selection, adaptation, recombination, transformation, and transduction. Mr. Hickson. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

Plant Science (32)
773. Methods and Theory of Plant Breeding
Theory and use of plant breeding systems with emphasis on improving quantitative traits. Mr. Pierce. Prerequisites: Genetics, Statistics. 4 credits. (Alternate years; not offered 1971-72.)

832. Developmental Genetics
Relation to protein, RNA, and DNA synthesis in development, chromosome differentiation, nuclear-cytoplasmic interactions, genic and non-genic control of subcellular organization, cellular continuity, cell associations, experimental embryology, hormones and postembryonic development, gene regulation in development, and neoplastic growth. Mr. Loy. Prerequisite: permission of instructor. 3 credits. (Alternate years; not offered 1971-72.)

851. Plant Genetics
Linkage, euploidy, aneuploidy, cytoplasmic inheritance, mutation, and genetics of disease resistance. Mr. Dunn. Prerequisite: Genetics. 3 credits. (Alternate years; offered in 1971-72.)

853. Cytogenetics
German and Russian

Chairman: Marron C. Fort

ASSOCIATE PROFESSORS: Marron C. Fort, Helmut F. Pfanner
ASSISTANT PROFESSORS: Guenter Herr, James L. Sherman
DIRECTOR OF GRADUATE STUDIES: Helmut F. Pfanner
DIRECTOR OF STUDIES ABROAD: James L. Sherman

The Department of German and Russian offers a program of graduate study in German leading to the degrees of Master of Arts and Master of Science in teaching.

To be admitted to graduate study, a student must have completed an undergraduate major in German comparable to that offered at the University of New Hampshire. It is expected that the student will have a superior command of spoken and written German and will be able to demonstrate his knowledge of a second modern foreign language.

To satisfy the requirements for the degree of Master of Science in Teaching, a candidate must complete 10 courses approved by the Department, including one seminar and two courses in Education. The candidate must also pass the departmental comprehensive examination which is based on the Master's reading list. This reading list, which covers the entire field of German literature from the beginnings to the present, is available at the offices of the Department.

To satisfy the requirements for the degree of Master of Arts, the student must (a) successfully complete 10 courses including two seminars or (b) complete 8 courses successfully and write a master's thesis. The candidate must also pass the departmental comprehensive examination based upon the Master's reading list.

A student may do part of his graduate study at the University of Marburg. To this end he should consult with the Department Chairman.

Courses numbered 700-799 are for graduates and advanced undergraduates.

Courses numbered 800-899 are open only to graduate students. In rare instances, an undergraduate may be admitted with the permission of the instructor and the department chairman. Graduate students must take a minimum of three courses at the 800 level.

726. German Culture and Civilization
A survey of the historical, social, artistic, and folkloristic developments in German-speaking countries from the beginnings to the present. 4 credits.

751-752. The Civilization of the Low Countries
A survey of the literature, art, history, and social structure of the Netherlands and Flanders from the beginnings to the present. This course is conducted in Dutch and English. 4 credits.

756. German Enlightenment Literature
German literature from the end of the Baroque to the period of Storm and Stress with the emphasis on the works of Lessing and Wieland. 4 credits.

757, 758. The Age of Goethe
The German literature of the Storm and Stress and the Classical Period; Wagner, Klinger, Lenz, Schiller, and Goethe. 4 credits.
German and Russian

761. Kleist—Holderlin—Jean Paul
   Outstanding authors outside the Romantic School. 4 credits.

762. German Romanticism
   German Literature from 1780-1830. Critical analysis and interpretation of prose, drama, and poetry from Wackenroder to Eichendorff. 4 credits.

771. German Literature of Biedermeier, Junges Deutschland, and Vormarz
   A study of the works of Grillparzer, Morike, Stifter, Heine, Buchner, and other writers of the post-Romantic period. 4 credits.

772. The Age of Realism
   The outstanding prose and lyrics of Keller, Meyer, Storm, Fontane, and others. 4 credits.

777-778. Bibliography and Advanced Stylistics
   A study of the methods of bibliographical research including a thorough grounding in the techniques of German stylistics. Students will prepare an extensive bibliography and submit research papers. 4 credits.

781. History and Development of the German Language
   The changes in the sounds, structure, and vocabulary of the German language from the earliest records to the present. 4 credits.

783. Modern German Drama
   Critical readings and discussion of works by Hauptmann, Schnitzler, Hofmannsthal, Brecht, Dürrenmatt, and others. 4 credits.

791. Methods of the Teaching of German
   A critical study of modern language teaching at all levels from the elementary school through college. The course emphasizes the use of the most modern equipment, including films, tapes, and other audio-visual aids. 4 credits.

795, 796. Special Studies in German Culture and Civilization
   Presuming a sound background in Germanic studies, this course allows the student to investigate independently and in depth a vast range of subjects. Barring duplication of material, this course may be repeated for credit. 4 credits.

841-842. Old Icelandic
   An introduction to the Norse sagas and poetry as they are preserved in the literature of Medieval Iceland. Special attention is given to the poems of the Older Edda. 3 credits.

843. Introduction to Middle High German
   The phonology and grammar of Middle High German. The reading of selected texts. 3 credits.

844. Old High German
   A linguistic analysis of Old High German grammar, phonology, morphology, and syntax. Reading of selected texts with emphasis on dialectical distribution. 3 credits.

855. German Baroque Literature
   German literature between the Reformation and the Age of Enlightenment. 3 credits.

861. Modern German Prose
   Critical reading of selected prose works by Mann, Hesse, Kafka, Broch, and others. 3 credits.
862. German Post-War Literature
Discussion of major writers and their works from 1945 to the present: Boll, Frisch, Dürrenmatt, Grass, Weiss, and others. 3 credits.

864. Modern German Poetry
Analysis and interpretation of selected lyrical works by Rilke, George, Hofmannsthal, Benn, Trakl, and others. 3 credits.

879. The Phonology of German
A contrastive analysis of the sounds of English and German. Phonetics, morphophonemics, and distinctive features. 3 credits.

880. The Structure of Modern German
A grammatical analysis of modern German employing structural, tagmemic, and transformational models. 3 credits.

885-886. Graduate Studies Abroad
A program of studies at the University of Marburg (West Germany) for students who have been admitted to the Graduate School of the University of New Hampshire. Students should consult with the Department Chairman.

886. Special Studies in German Language and Literatures
Presuming a sound background in Germanic studies, this course allows the student to investigate independently and in depth a vast range of subjects. Barring duplication of material, this course may be repeated for credit. 3 credits.

899. Master's Thesis
6-10 credits.

History (53)
Chairman: William R. Jones


Associate Professors: Charles E. Clark, Robert C. Gilmore, Marion E. James, Douglas L. Wheeler, Donald J. Wilcox

Assistant Professors: Thomas M. Kemnitz, Allen B. Linden, Robert M. Mennel, Marc L. Schwarz, John O. Voll

Director of Graduate Studies: Darrett B. Rutman

The Department of History offers programs leading to the degree of Master of Arts and Doctor of Philosophy. The Department considers that a substantial foundation in history is prerequisite to beginning work on the graduate level. Consequently it usually requires completion on an undergraduate level of the equivalent of a history major at this University (8 semester courses in history) and
History

some preparation in other areas of the humanities and social sciences. The Department also recommends, although it does not absolutely require, that a beginning graduate student have some training in a foreign language. Students who wish to participate in a seminar or reading course in European history, however, must have a reading knowledge of at least one foreign language appropriate for that particular course. Exemptions from this requirement may be made by the course instructor in special situations. Applicants for admission to graduate study in history must submit aptitude and history scores on the Graduate Record Examinations. Applicants intending the Ph.D. degree should include with their application a personal letter indicating their reason for and intentions in undertaking graduate study.

Master of Arts

The Master's degree may be undertaken as a terminal degree or as preparation for a Ph.D. program. A successful candidate shall complete with grades of B or better at least 8 semester courses in history numbered above 700, of which a minimum of 4 shall be numbered between 800 and 898. In addition, the candidate will complete a thesis satisfactory to his thesis committee. Upon the recommendation of the Department, a student may substitute two additional semester courses for the thesis. (The preparation of the thesis is considered to be the equivalent of two semester courses each bearing the designation History 899 for the purpose of meeting the general regulations of the Graduate School as stated earlier in this Bulletin.) The completed thesis must be submitted by April 1 of the year in which the degree is to be granted. A final examination is not required. Students intending a Ph.D. degree normally include as part of their work either or both of the following which they have not completed as undergraduates: Language training to the extent of competence in one foreign language; and surveys of American and European historiography, equivalent of History 723 and 774.

Doctor of Philosophy

The degree of Doctor of Philosophy is not essentially a course-related degree. It is awarded in recognition of high attainment and ability in history as shown by performance in qualifying examinations (covering one major field of history with emphasis upon that subfield of specialization in which the student will prepare his dissertation, two subfields outside the major field, and a cognate field outside of history or a field of non-western history) and by the preparation of a dissertation. At present dissertations are limited to the major field of American history with the subfields Early America (to ca. 1815) and Modern America (since ca. 1815). Prior to admission to a doctoral program the student is required to demonstrate competence in one foreign language; prior to admission to qualifying examinations he is required to demonstrate competence in a second language or a special research technique.

Apprenticeship

The Department considers that graduate work in history, and particularly doctoral work, is professional training. All entering graduate students intending a Ph.D. are, consequently, required (and all others are urged) to participate on a continuing basis in History 801, Pro-seminar: History as a Profession. Moreover, the Department recognizes the dual concerns of the historian's life—research and teaching. All doctoral students, consequently, are expected to undertake teaching assistantships in the Department during a part of their residence. Participation in pro-seminar and as a teaching assistant constitutes an apprenticeship conjunctive with, but apart from, formal study.
A complete guide to the Department's graduate regulations and practices is available from its Director of Graduate Studies.

703. The Colonial Period of American History
Anglo-America from the late sixteenth century to the mid-eighteenth century, encompassing a general and interpretative view of the development of an Anglo-American culture along the eastern seaboard of North America. Mr. Clark, Mr. Colbourn, Mr. Gilmore, Mr. Rutman. 4 credits.

704. Sources and Methods of Colonial American History
An introduction to the materials and methodology of the historian of Anglo-America, structured around a series of problems underlying the interpretations considered in 703; specific approaches to these materials; and what historians have done with the materials. Mr. Rutman. Prerequisite: History 703 and (for graduate students) permission of instructor. 4 credits.

705, 706. America in the Eighteenth Century and the Revolution
American Colonial and Revolutionary history during the period from 1740 through the adoption of the Constitution and the establishment of Washington's first administration. Mr. Gilmore. 4 credits.

711, 712. Nineteenth Century America
The historical factors, both domestic and international, involved in the development of the American Republic, its institutions and people, from the inception of the new nation in 1789 to the emergence of the United States as a world power in 1900. Mr. Jellison. 4 credits.

715, 716. Twentieth Century America
United States history since 1896, from the triumph of industrialism on the national scene to the emergence of America as a world power in the nuclear age. Political, economic, and diplomatic developments. Mr. Greenleaf. 4 credits.

719, 720. The Foreign Relations of the United States
Primarily the history of American diplomacy, with attention given to the nondiplomatic aspects of foreign relations. Mr. Long. 4 credits.

721, 722. History of American Thought
An examination of the ideas, considered in their social context, of significant American thinkers. First semester, 1600 to 1860. Second semester, 1860 to the present. Mr. Clark, Mr. Mennel. 4 credits.

723. American Historiography
The principal writing of American historians from the colonial period to the present time. Emphasis will be given to those works that pertain mainly to the American people and their immediate neighbors. Mr. Jellison. Prerequisite: permission of instructor. 4 credits.

724. American Urban History
The development of urban society in America from colonial times to the present. Lectures will also explore the comparative histories of European and American cities. Mr. Mennel. 4 credits.

725, 726. Afro-American History
Basic historical problems, with reference to the economic, political, and social conditions of black Americans, from the early slave-trade period to recent radical confrontations and the Black Power movement. 4 credits.
739, 740. Three Medieval Civilizations
The demise of classical antiquity in the lands bordering the Mediterranean and the genesis and fruition of three new cultural traditions: the Latin Christian, the Islamic, and the Byzantine. Religious, literary, and scholarly survivals and innovations from 400 A.D. to 1400 A.D. Mr. Jones. 4 credits.

741. The Age of the Renaissance
The Renaissance from 1300 to 1600. The course will stress intellectual and cultural history and will concentrate on events in Italy, though aspects of the Renaissance in northern Europe will also be covered. Mr. Wilcox. 4 credits.

742. The Age of Reformation
The course will cover the period from 1300 to 1600 in northern Europe, stressing the intellectual and cultural aspects of the European Reformation. While the course will concentrate on the events of the sixteenth century, important trends in the fourteenth and fifteenth centuries will be given considerable attention. Mr. Wilcox. 4 credits.

747. The Age of Absolutism
The theory and practice of absolutism from its origin in the seventeenth century to its apogee in enlightened despotism. 4 credits.

749. The Age of Revolution
Revolution as a socio-political phenomenon in its historical setting. Comparative approach to Puritan, American, and French revolutions with reference to contemporary movements. Mr. Gilmore. 4 credits.

756. Twentieth Century Europe
The background of World War I, the inter-war period, the rise of European totalitarianisms, World War II, and the attempts to solve the conflicts of modern society in the post World War II period. Mr. Heilbronner. 4 credits.

(759). History of Modern Spain and Portugal
The Iberian states and their peoples from the coming of liberalism to the present. Why Iberian liberalism and liberal government failed to triumph will be a featured theme. Political and social change will be emphasized and imperial and intellectual movements. In the study of two modernizing countries with persistent traditions, influences of Western European thought and activity will be included. Mr. Wheeler. 4 credits.

761, 762. England in the Tudor and Stuart Periods
An examination of the political, religious, socio-economic, and intellectual forces for change at work in England from the accession of Henry VII to the Revolution of 1688-89. Mr. Schwarz. 4 credits.

763, 764. History of Russia
The development of the Russian state from its foundation to its present status as a world power. The course is designed to increase the understanding of the present in terms of the past. Political developments, foreign relations, and intellectual and ideological currents. Mr. Heilbronner. 4 credits.

767, 768. History of Germany
Germany and the various German states from the Reformation to the Third Reich and the presently divided Germany. The course will emphasize the relationship and importance of Germany to the rest of Europe. Mr. Lentz. 4 credits.
771. 772. Modern England
The history of England from 1760 to the present. Emphasis is placed on the social, intellectual, economic, and political transformation of the country as it developed into a major industrial nation. Mr. Kemnitz. 4 credits.

774. European Historiography
The development of historical writing from the Greeks to the twentieth century. The course will stress means of evaluating various types of historical writing, the intellectual context of the historians considered and the effect of this on their work. Readings will be from selected historians. The course is neither a methodology course nor one in the philosophy of history, and these problems will not be directly treated. Mr. Wilcox. 4 credits.

777. 778. The Hellenistic-Roman World
History of the Ancient World from the death of Alexander in 323 B.C. to the end of Constantine’s reign in 337 A.D. Major political, economic, and social developments, and consideration of artistic, scientific, philosophical, and religious trends, with particular emphasis on the rise of Christianity and the transformation of the classical world. Miss James. 4 credits.

(781). History of Modern China. 1850-1950
The modernization of China. The political, social, and cultural changes which have occurred in China from its early contacts with the West to the establishment of the Communist regime. Mr. Linden. 4 credits.

784. History of Southern Africa Since 1820
The struggle for political and economic control in the only region of Africa where European groups remain in power. Special attention is given to the development of European hegemony. The course will trace the impact of European imperialism, European settler nationalism, African nationalism, racial conflict, economic competition and industrialization, Apartheid, and assimilation. Included will be a discussion of official American policy in this region. Mr. Wheeler. 4 credits.

785. The Modern Middle East
A history of the Middle East from the eighteenth century to the present time, with special attention given to the problems created by modernization and reform of the traditional society, the conservative reaction to reform, the impact of nationalism, and the appearance of new ideologies. Mr. Voll. 4 credits.

(787). Black Consciousness and Protest
A survey of the origins and cause of the rising consciousness and consequent activism of the peoples of Negro descent in the New World and in Africa from the early nineteenth century to the present. The course includes: lectures; discussions; and panels on protest literature, black nationalism, Pan-Negroism, Pan-Africanism, negritude, the Nation of Islam, and separatist religious sects in the Americas and Africa. The framework will be cross-cultural and multidisciplinary. Mr. Wheeler. 4 credits.

(789). Seminar in the History of Science
Selected topics, conducted through special lectures, individual study, and oral and written reports. The subject will vary from year to year. This course is the same as Physical Science (789). Cannot be used for credit in History without permission of the History Department. Mr. Schneer. Prerequisite: permission of adviser and instructor. 4 credits.
History

791. History-Education. Problems in the Teaching of High-School History and Other Social Studies
Bibliography and new interpretations of history; the social-studies curriculum, past and present; aims and objectives in the social studies; selection and organization of teaching material; teaching and testing techniques. Special emphasis on teaching American history and the problems of American democracy. Open to students who have satisfactorily completed History 503, 504; six credits in other history courses, exclusive of History 501, 502; six credits from American Government, Principles of Economics, or Principles of Sociology; and Principles and Problems of Teaching in the Secondary School. Mr. Draves. 4 credits.

(793). World History
History from the perspective of the experience of the whole human community. The histories of separate areas will be examined in terms of their relationship to the general historical experience of man. Problems of interpretation, interrelationships, similarities, and differences in the development of the major traditions of civilization. Students will present oral and written reports as a basis for discussions. Mr. Voll. Prerequisite: permission of instructor. 4 credits.

(797). Colloquia in History
Selected topics in American, European, and non-Western history. Staff. Prerequisite: permission of instructor. 4 credits.

Graduate Readings and Seminars
Note that in any given semester any number of sections of a general seminar course (819 through 860) may be offered, the content and direction of a specific section depending upon the research interests of the faculty member directing the section. General seminar and readings courses, and particular sections, can be repeated as the section content changes. A full description of the current direction and content of each section offered in a given semester is available shortly before the semester from the Department's Director of Graduate Studies.

(801). Proseminar: History as a Profession
Entering graduate students intending the doctorate and all advanced graduate students serving as research, program, or teaching assistants in the department meet periodically to discuss the obligations and mechanics of the historian's profession, including teaching, scholarship, university and college structures, and the role of the faculty therein. No credit.

(819, 820). Seminar in Early American History
(1) Mr. Clark (Social and Cultural), (2) Mr. Colbourn (Intellectual), (3) Mr. Gilmore (Revolution), (4) Mr. Rutman (Anglo-American Society). Prerequisite: permission of instructor. 3 credits.

(823, 824). Seminar in American National History
(1) (Afro-American), (2) Mr. Greenleaf (Twentieth Century), (3) Mr. Jellison (Nineteenth Century and Biography), (4) Mr. Mennel (Social). Prerequisite: permission of instructor. 3 credits.

(839, 840). Seminar in Medieval History
(1) Mr. Jones (Ecclesiastical History). Prerequisite: permission of instructor. 3 credits.

(843, 844). Seminar in Early Modern European History
(1) Mr. Wilcox (Renaissance). Prerequisite: permission of instructor. 3 credits.
(855, 856). Readings in Modern European History
(1) Mr. Heilbrunner (Modern Russia), (2) Mr. Lentz (Germany), (3) Mr. Wheeler (Spain and Portugal). Prerequisite: permission of instructor. 3 credits.

(859, 860). Seminar in English History
(1) Mr. Kemnitz (Nineteenth Century), (2) Mr. Schwarz (Tudor-Stuart). Prerequisite: permission of instructor. 3 credits.

(895, 896). Tutorial Reading and Research in History

(899). Master’s Thesis

(999). Doctoral Research

Home Economics (31)

Chairman: Marjory A. Wybourn

Professor: Marjory A. Wybourn
Associate Professors: Earl O. Goodman Jr., Mary Holder, Elizabeth M. Rand, James L. Spangenberg
Assistant Professor: Linda C. Boehme

Graduate work is offered leading to the degree of Master of Science in Home Economics, with major emphasis in areas which strengthen professional competence in family, community, and educational services.

Each student’s program will be planned to achieve personal and professional objectives of the individual and be based on specific interests, ability, and undergraduate preparation. Selection of courses from the social sciences and other university departments will be encouraged.

Students admitted to the graduate program in Home Economics are expected to have had an undergraduate degree in Home Economics or a related field. If there are deficiencies in the undergraduate program, students may be admitted on condition that they complete specified prerequisites.

A candidate for a Master of Science degree in Home Economics is expected to fulfill the general requirements of the Graduate School and the following departmental requirements:

1. Home Economics—a minimum of 12 semester credits, including one course in each of the following areas: management-decision-making and family development.

2. A minimum of 8 semester credits selected from the liberal arts or other areas which support the major.

Home Economics

707. Practicum with Children and Families
A planned, supervised experience with children or families at both participating and observing levels. The practicum is designed to increase the students' awareness and understanding of the ways human beings grow and behave and the dynamics of the family and community settings. Weekly class discussions will be combined with individual and small-group supervisory conferences. Students have the opportunity to choose a focus for their practicum from among the following: 1) young children—preschool program, 2) school-age children, 3) adolescents, 4) children and parents, and 5) low-income families—management experiences. Limited to Home Economics majors. Prerequisite: Home Economics major and permission of department. One or more semesters, 2 or 4 credits, maximum of 6 credits in one area.

715. Clothing in Relation to Human Behavior
The analysis of research and theory in the social-psychological aspects of clothing. An exploration and study of clothing behavior of individuals and groups. Special emphasis given to stages of the life cycle, development of the self, and the phenomenon of fashion. 4 credits.

725. Preschool Programs
A study of the organization and operation of programs for young children. Theoretical knowledge about children and educational techniques will be related to the curriculum, facilities, and administration in a variety of group programs for young children. Field trips will be planned. Prerequisite: Home Economics 627, Creative Activities in Preschool Programs, or equivalent. Limited to Home Economics majors, or permission of instructor. 4 credits.

754. Personal and Family Finance
A study of major financial alternatives available to individuals and families during the various stages of the family life-cycle. 4 credits.

774. Nutrition and Disease
Application of the principles of normal nutrition to clinical problems, with a description of altered nutrient requirements in human disease. Diet therapy as an applied aspect of clinical nutrition is considered. A practicum in a field situation will be a part of the experience. Prerequisite: Home Economics 573, Human Nutrition, or equivalent. 4 credits.

776. Nutrition—A World View
Study of the major nutritional problems facing the world today. Consideration of protein-calorie malnutrition, obesity, nutritional status of adolescents, and special nutritional problems of pregnancy, infancy, childhood, and the aging. An exploration of concepts and methodologies for nutrition education. Prerequisite: Home Economics 573, Human Nutrition, or equivalent. 4 credits.

786. Dynamics of Family Change
An examination of the theories and supporting research of the intervention techniques used to effect changes in family behavior. Prerequisite: Home Economics 683, Family Relations, and Psychology 545, Clinical Approaches to Human Behavior, or permission of instructor. 4 credits.

793. Sex Education in Home, School, and Community
An exploration of human sexuality and of programs, materials, and methods for sex education in home, school, and community. Issues, community mores, goals, and values will be examined. Planned for school personnel, parents, and others working with children, youth, and families. 4 credits.
883. Human Sexual Behavior
An exploration of contemporary opinion and research on human sexual behavior and development. The implications for social welfare and education will be examined in light of available research and other scholarly studies. 4 credits.

892. Methods in Family Relation Education
A study of the methods and materials used in family relations education in high schools, colleges, churches, and social agencies. The methods will be applied through role play and field experience. The course assumes mastery of the basic principles of family relations, human development, and theories of intervention. 4 credits.

895. Seminar and Special Problems
The seminars are open to graduate students with sufficient background for in-depth study in any of the following areas: 1) clothing and textiles, 2) consumer education, 3) family relations, 4) food and nutrition, 5) home economics education, 6) management and family finance, and 7) human development. The student will contribute to a selective review and critical evaluation of the research and current literature and an examination of issues and trends. Independent projects may be a part of the experience. These seminars will not be scheduled every semester. One or more semesters, maximum of 4 credits in one area, 2 to 4 credits.

897. Research Seminar
Survey, evaluation, and use of research in the field of home economics. An introduction to methods and techniques used in defining a problem for study, collecting data, analyzing, and writing a report. 2 credits.

898. Research Project
A study or project which may be selected in lieu of a thesis. To be taken concurrently with or following Home Economics 897. 2-4 credits.

899. Thesis
6 credits.

Institute of Natural and Environmental Resources
Director: Otis F. Hall

ADJUNCT PROFESSORS: George E. Frick, Ernst J. Schreiner
ADJUNCT ASSOCIATE PROFESSORS: C. Anthony Federer, Nelson L. LeRay, Robert S. Pierce
ASSISTANT PROFESSORS: Chauncey T. K. Ching, Glendon W. Gee, Robert D. Harter, William W. Mautz, Sherrill B. Nott
ADJUNCT ASSISTANT PROFESSORS: Peter W. Garrett, William B. Leak

103
Master of Science Programs Offered

Forest Resources
Natural Resource Management
Forest Marketing
Wood Industry Management
Forest Mensuration
Forest Tree Improvement
Wood Science and Technology

Resource Economics
Agricultural Economics
Rural and Community Development
Regional Economics
Land and Water Economics
Rural Manpower and Population
Economics of Outdoor Recreation

Soil and Water Science
Hydrology
Hydrochemistry
Ground Water Hydrology
Evapo-transportation
Soil and Water Conservation

Soils
Soil Physics
Soil Chemistry
Soil Classification and Genesis
Soil-Plant Relationships

Wildlife Management

The Institute of Natural and Environmental Resources has the responsibility for supervising the masters' programs for Forest Resources, Resource Economics, Soil and Water Science, and Wildlife Management. Students admitted to a program in these fields are expected to have completed either an undergraduate degree in the field in which they plan to specialize or adequate preparation in the basic support courses of the field. Students with good undergraduate records who lack a background in a particular field will be admitted to a program, provided they are prepared to correct deficiencies in their background in order to enter graduate-level courses at the proper level of preparation.

Students entering the Forest Resources programs are generally expected to have completed a bachelor's degree in forestry equivalent to that obtained at a school accredited by the Society of American Foresters. Students planning a program in Resource Economics will need satisfactory undergraduate training which includes two or more courses in economics or resource economics and a total of four or more courses in the social sciences. Entering students in Soil and Water Science are required to have adequate preparation in chemistry, physics, mathematics, and the biological or earth sciences. Students interested in Wildlife Management are expected to have a background in the biological sciences if they plan to enter the cooperative program with the Department of Animal Sciences, or students with an undergraduate degree in forestry can take their master's degree in Wildlife in Forest Resources.

Each student will be expected to pass a final oral examination based on a general knowledge of the field, and on his thesis if he has written one. Whether a thesis is to be written will be determined by each student's advisory committee in consultation with the student.

The Institute participates in three doctoral degree programs on a cooperative basis with other departments in the University. The Department of Chemistry offers a Soil and Water Chemistry Option in their Ph.D. program, which is coordinated through joint efforts of the Soil and Water Program and the chemistry faculty (see Interdisciplinary Options and Programs). A Ph.D. program in Genetics is available to students in Forest Resources through the Genetics Program (see Genetics Program). Students can earn a Ph.D. in Economics in the cooperative program with Resource Economics and the Whittemore School of Business and Economics (see Economics).
Forest Resources (30)

702. **Natural Resources Policy**
Contemporary issues in the management and allocation of natural resources. The impact of human activity and demands on resources including: agricultural and forest lands, water, wildlife, fisheries, and minerals. Historical perspective as it contributes to an understanding of current public and private resource policies. Mr. Bruns, Mr. Weyrick, Mr. Bowring, Mr. Drew. Prerequisite: permission of instructor. 4 credits.

711. **Statistical Methods II**
An intermediate course in statistics. Topics include basic concepts of sampling, linear models, and analyses for one-way and multi-way classifications; factorial arrangement of treatments; multiple regression; and covariance. Computer programs used in analyzing data. Mr. Barrett. Prerequisite: Forest Resources 528, Applied Statistics, or equivalent. 4 credits.

712. **Sampling Techniques**
A study of the techniques of sampling a finite population. Topics include choice of sampling unit and frame, estimation of sample size, confidence limits, and comparisons of sample designs. Computer programs used in analyzing data. Mr. Barrett. Prerequisite: Forest Resources 528, Applied Statistics, or equivalent. 4 credits.

720. **Forest Tree Improvement**
The genetics of forest tree improvement with emphasis on variation in natural populations, the basis for selection of desired characters, and the fundamentals of controlled breeding. The application of principles will be directed toward silviculture, management, and utilization. Mr. Hocker. Prerequisite: permission of instructor. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1971-72.)

737. **Game Management I**
Biological characteristics, habitat usage, research, and management techniques of upland game birds and big game mammals. Students should be prepared for weekend field trips to wildlife areas in New England. Mr. Olson. Prerequisite: wildlife management major or consent of instructor. 2 lectures; 1 recitation; 1 laboratory; 4 credits.

738. **Game Management II**
Biological characteristics, habitat usage, research, and management techniques of small game mammals, furbearers, and waterfowl. Students should be prepared for weekend field trips to wildlife areas in New England. Mr. Olson. Prerequisite: wildlife management major or consent of instructor. 2 lectures; 1 recitation; 1 laboratory; 4 credits.

745. **Forest Management**
Production control in forests with many uses and management objectives. Analysis of silvicultural, economic, and business problems. Practice of forest administration. Professional responsibilities and opportunities. Mr. Weyrick and Mr. Bruns. Prerequisite: permission of instructor. 3 lectures; 1 laboratory; 4 credits.

753. **Operations Control and Analysis**
Applications of economic principles to the control and analysis of harvesting, manufacturing, and other timber-based operations. The use of quantitative methods in developing cost functions, mathematical programming, PERT, game
theory, simulation, and scheduling problems. Mr. Foster. Prerequisite: forest biometrics and forest economics. 4 credits.

754. Wood-Products Manufacture and Marketing
A study of the wood-products manufacturing industry from the harvesting and procurement of raw material to finished-product processes with emphasis on management decisions, marketing, and promotion problems. Visits to harvesting operations and manufacturing plants in the New England region are used as the basis for study. Mr. Hill. Prerequisite: Forest Resources 426, Wood Technology, and 753. 3 lectures; 1 laboratory; 4 credits.

758. Photogrammetry in Forestry
Elementary principles of photogrammetry. Emphasis is on the interpretation of information recorded through aerial cameras, with reference to other remote sensors. Application of photogrammetry in forestry, agriculture, engineering, urban planning, and geology. Mr. Bruns, Mr. Barrett. Prerequisite: permission of instructor. 3 lectures; laboratories arranged according to disciplinary interest of the student; 4 credits.

764. Forest Industry Economics
Application of business methods and economics in the establishment and operation of forest industries; planning for minimum-cost operation and the profitable use of capital in forest enterprises. Mr. Wallace. Prerequisite: senior standing and permission of instructor. 4 credits.

797. Forest Recreation Seminar
The recreational use of forest lands, including factors that affect demand and supply for recreation. Planning for state and local recreational use, emphasizing the economic and social aspects. Mr. Wallace. Prerequisite: junior standing and permission of instructor. Two 2-hour sessions; 4 credits.

798. Forest Resources Management Seminar
Population trends and human needs in relation to forest-land productivity for timber, wildlife, water, recreation, and grazing. Organized groups involved in forest-land use and management, and overall planning to help maximize forest-land use and productivity for our society. Mr. Wallace. Prerequisite: Forest Resources 745. 4 credits.

801, 802. Forest Management Seminar
Seminar discussions of current literature, plans, and principles, and new developments in the general field of forest management. Mr. Bruns and members of the department. Prerequisite: permission of instructor. 2 credits.

803. Approach to Research
The meaning of science and the scientific method. The application of logic in the scientific method. The general principles and techniques of scientific research. A general survey of statistical procedures as a tool for research. The organization of investigative work including problems analyses, working plans, and the preparation of reports. Mr. Foster and members of the department. Prerequisite: permission of instructor. 2 credits.

805. Utilization Seminar
Conferences, discussions, and reports on assigned topics. Consideration of current literature and developments in the general field of wood utilization. Mr. Hill. Prerequisite: permission of instructor. 2-hour seminar; 2 credits.
806. Operations Control Seminar
Conferences, discussions, and reports on assigned topics. Considerations of current developments in the field of quantitative control of forest operations. Mr. Foster. Prerequisite: permission of instructor. 2-hour seminar; 2 credits.

809, 810. Wildlife Management Seminar
Discussions and assigned reports on current investigations and developments in wildlife management. Mr. Olson. Prerequisite: undergraduate courses in wildlife management. 2-hour seminar; 2 credits.

815. Advanced Mensuration
Volume-table construction and application, advanced studies of growth and yield, and methods of prediction. Application of graphic and statistical solutions to these problems. Mr. Barrett. Prerequisite: permission of instructor. 2 lectures; 1 laboratory; 3 credits.

833. Forest Protection Seminar
Discussion and special problems based on principles and techniques of forest protection. Mr. Weyrick. Prerequisite: Forest Resources 660, Forest Protection, or courses in entomology or plant pathology. 3 credits.

Work to be arranged according to the needs of individual students. Staff. Hours to be arranged. Prerequisite: permission of instructor. 24 credits.

899. Thesis
Hours and credits to be arranged to meet the needs of the individual student. Prerequisite: graduate standing and permission of instructor in the selected field of study. 6-10 credits.

Resource Economics (21)

701. Applied Statistics I
Use of elementary statistical techniques in analysis of prepared data. Topics surveyed include elementary probability; discrete and continuous probability distributions; distributions of sample statistics; small-sample theory; elementary analysis of variance, regression, correlation; chi square; and non-parametric analogs of regression and analysis of variance. Mr. Durgin. 4 credits.

705. Structure, Economic Problems, and Planning of Communities in the Non-Urban Environment
The community is taken as an economic unit and analyzed using appropriate methodologies with emphasis on economic growth. Economic forces, as they relate to employment, income, transportation, housing, etc., are analyzed. Community income, expenditures, and public services are taken in the context of growth and planning. Mr. LeRay. Prerequisite: one course in Social Science. 4 credits. (Alternate years; not offered 1971-72.)

706. Economics of Resource Development
The classical and modern theories of economic development. Economic problems of land and resources in relation to market location, urban-rural conflicting demands, and conservation and water supply. Population mobility, capital needs, and the roles of public and private leadership will complete the framework for discussion of the major resource development problems of New England. Mr. Bowring. Prerequisite: Principles of Economics or equivalent. 4 credits.
707. Research Methods in Social Science
The scientific method of research, analysis of research problems in social sciences. The design of research and the application of research techniques to identifying and solving problems. Mr. Drew. Prerequisite. 3 hours of statistics. 4 credits.

715. Linear Programming Methods
Setting up and solving problems by the simplex and distribution methods; variation in linear programming methods with applications, non-linear programming, discrete programming, and solving input-output and game-theory problems. Applications to firm and aggregate economic analysis. Mr. Andrews. Prerequisite: Mathematics of Business and Economics or Fundamental Mathematics, or permission of instructor. 4 credits.

756. Regional Economic Analysis
Concepts and methods of delimiting regional economies, theories of regional growth, methods of measuring regional economic activity, empirical approaches to regional economic planning and development, and public policies for regional economies. Although theoretical aspects of regional economies will be considered, primary emphasis will be placed on empirical research studies and their policy implications for regional economic performance. Mr. Ching. Prerequisite: Intermediate Economic Theory, Elementary Statistics, Elementary Calculus, Elementary Linear Programming, or permission of instructor. 4 credits. (Alternate years: offered in 1971-72.)

758. Introduction to the Location of Economic Activity
Economic theories explaining the behavior of individual firms and consumers in selecting sites for carrying on economic activities. The relationship of these theories to patterns of industrial location, systems of cities, and land-use competition in general. Problems of locational change and adjustment and the effects of public policy on spatial economic activities. Mr. Ching. Prerequisite: Resource Economics 715 or its equivalent: Mathematics 415, Mathematics of Business Economics, or its equivalent; or permission of instructor. 4 credits. (Alternate years: offered in 1972-73.)

804. Economics of Production and Resource Use
Principles of choice, resource use, and production under perfect and imperfect knowledge. The economic theory of resource allocation and the use of this theory in problem-solving. Resource-product relationship, nature of cost, returns to scale, factor valuation and pricing, uncertainty, and interfirm relations. Mr. Andrews. 2 credits.

807. Statistical Analysis
Statistical measurement and research tools for use in the physical and social sciences. Regression, analysis of variance, factorial analysis, covariance, time series, sampling, and experimental design. Mr. Ching. 4 credits.

809. Agricultural Economics
Analysis of supply, demand, and price relationships. Appraisal of the economic theory relevant to decision-making in food production, marketing, and consumption, and on the competitive structure of the food industry. Mr. Henry. 3 credits.

895-896. Investigations in Resource Economics
Human-resource development, legal problems in resource development, economics of outdoor recreation, community development. Staff. 4 credits.
Soil and Water Science (23)

701. Physics of Soils
The treatment of soil as a physical system. Major topics include: textural and structural analysis of soils, water flow and retention, heat and gas transfer processes in soils. The influence of soil physical-properties on plant growth is also covered. Laboratory sessions deal with methods of soil physical analysis. Mr. Gee. Prerequisite: Soil and Water 501, Introductory Soils, or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

702. Chemistry of Soils
Chemical properties of soils in relation to their composition and use as a vital resource. Colloidal phenomena and their relation to exchange and fixation of elements in soil. Major topics include: cation exchange capacity and source of negative charge, the nature of soil acidity, the chemistry of nitrogen and phosphorus in the soil, and modern methods of soil chemical analysis. Laboratory sessions are designed to acquaint the student with analytical methods commonly used in soil chemistry. Mr. Harter. Prerequisite: Quantitative Analysis or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

703. Soil and Water Engineering
The treatment of engineering principles relating to the control of water. Major topics include precipitation and stream-flow measurement, hydrograph development, estimating run-off from a watershed and the design of structures to control this run-off. Laboratory sessions are designed to acquaint the student with instrumentation and problem analysis. Mr. Byers. 3 lectures; 1 laboratory; 4 credits.

704. Soil Classification
Soils are studied in relation to the genesis, morphology, and classification including the current U.S.D.A. soil classification system. The five major factors affecting soil development are reviewed in detail as are the soils found in the United States with special attention on those of New Hampshire. Emphasis is placed on the importance of chemical and physical characteristics. Mr. Peterson. Prerequisites: Soil and Water Science 501, Introductory Soils, and a basic geology course or permission of instructor. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1971-72.)

705. Principles of Hydrology
A study of the physical and chemical processes involved in the movement of water through the rainfall and run-off segment of the hydrologic cycle. Major topics include infiltration and percolation, overland and channel flow, channel processes, and the nature of the stream-discharge record or hydrograph. Laboratory sessions involve the use of a demonstration channel, electrical and fluid models, and selected problems to demonstrate important principles. Mr. Hall. Prerequisites: one year of geology and one year of calculus. 3 lectures; 1 laboratory; 4 credits.

709. Soils and Community Planning
A “Town Plan” and a soils map are studied by students to develop individual reports of land use. The course includes an introduction to the soils of New Hampshire, basic information on the U.S.D.A. soil classification system, and the Soil Conservation Service criteria for rating soils for multiple use;
Soil and Water Science

housing, recreation, sewage-effluent disposal, conservation, transportation, surface runoff, and other soil-use problems common to many rural and urban communities. A representative of a town planning firm and federal and state soil scientists are guest lecturers. Mr. Peterson. 2 lectures; 2 credits.

710. Ground-Water Hydrology
Introduction to the principles governing the occurrence, location, and development of ground water. Major topics include: well hydraulics, geophysical exploration, and chemical quality of water. Brief treatment given of water law and economics. Laboratory sessions are designed to illustrate principles by use of fluid and electrical models, geophysical instruments, and selected problems. Mr. Hall. Prerequisite: Soil and Water Science 703 or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

801. Advanced Soil Physics
The physics of unsaturated water flow. Theory of infiltration and drainage. Application of unsaturated water-flow theory to soil-plant-atmosphere systems. Mr. Gee. Prerequisite: permission of instructor. 3 lectures; 3 credits.

802. Advanced Soil Chemistry
Physical chemistry of soil colloids and soil colloidal phenomena. Major topics include: Electric double-layer theory, solid-solution interfacial reactions, surface acidity, theories of swelling, ionic diffusion in soil. Mr. Harter. Prerequisite: one year of physical chemistry or permission of instructor. 3 lectures; 5 credits.

803. Advanced Ground-Water Hydrology
Application of analytic techniques to ground-water systems. The emphasis is on development of mathematical, statistical, and graphical methods that can be applied to selected problems. Major topics include radial flow to wells; lateral flow to streams and drains; flow-set analysis; and simulation methods including fluid models, electric analog models, and digital computers. Brief treatment given of multiple-well problems and two-phase, fluid-flow systems. Mr. Hall. Prerequisite: Soil and Water Science 710 or permission of instructor. 2 lectures; 1 laboratory; 3 credits.

804. Hydrochemistry
The chemical principles for dilute aqueous solutions at relatively low temperatures and pressures are applied to the study of fresh waters at or near the earth's surface. Major topics include equilibrium concepts, buffering mechanisms, oxidation-reduction reactions, and ion exchange. Particular emphasis is given to selected systems involving water, carbon dioxide, calcium carbonate, and silicate minerals. Laboratory exercises utilize simple experiments to give experience with methods of measurement and interpretation of results. Mr. Hall. Prerequisite: two years of chemistry or equivalent, or permission of instructor. 2 lectures; 1 laboratory; 3 credits.

895-896. Investigations in Soil and Water Science
Offered in: 1) Soil-Plant Relationships, Mr. Peterson; 2) Physics of Soils, Mr. Gee; 3) Hydrology, Mr. Byers and Mr. Hall; 4) Chemistry of Water, Mr. Hall; 5) Chemistry of Soils, Mr. Harter; 6) Soil Classification, Mr. Peterson. Elective only after consultation with the instructor in charge. 1-4 credits.

899. (899). Master's Thesis
6-10 credits.
Interdisciplinary Options and Programs

Soil and Water Chemistry Option

The chemist can contribute much to the advancement of many scientific disciplines through the application of the principles of chemistry to research problems in these other disciplines. The Departments of Chemistry and Soil and Water Science offer an option in the Doctor of Philosophy program in Chemistry which enables the graduate student to apply his chemistry background to research problems of mutual interest to the two departments. A student entering this option must meet the entrance requirements for the Doctor of Philosophy program in Chemistry. So that the student may obtain a background in Soil and Water Science, he will be permitted to substitute graduate level courses in Soil and Water Science for certain courses in Chemistry. His dissertation will be on a basic problem of interest to faculty members in both departments. For further information, write to either the Department of Soil and Water Science or to the Department of Chemistry.

Chemical Physics Option

Doctor of Philosophy candidates in Chemistry may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Physics. In this option the doctoral student, with the advice of his guidance committee, elects courses in chemistry and physics (or, in some cases, mathematics), writes his dissertation on a research problem (experimental, theoretical, or both) appropriate to interdisciplinary treatment, and receives the doctorate in either Chemistry or Physics. In addition, each candidate must satisfy certain other requirements of the department in which the degree is granted. Ordinarily, students choosing the Chemical Physics option are expected to have undergraduate degrees in chemistry, physics, or mathematics, and reasonably strong backgrounds in the other two disciplines.

Zoology Option

Faculty from departments related to Zoology, such as Animal Sciences and Entomology, may direct master’s and doctoral dissertations.

Marine Science—Oceanography

The University of New Hampshire has long had an interest in marine science. The location of the University on the Great Bay and its tributaries provides a natural laboratory for marine sciences including oceanography and marine-oriented biochemistry, botany, geology, microbiology, and zoology. The recently constructed Jackson Estuarine Laboratory and the research vessel, R/V “Jere A. Chase,” give evidence of the heightened interest in marine studies. A prospective graduate student who wishes to emphasize marine science or oceanography in his graduate work may do so by selecting courses in the departments of Biochemistry, Botany, Geology, Microbiology, and Zoology. For further information, write to the Office of Marine Science and Technology, Kingsbury Hall.

Ocean Engineering—EDAL

The Engineering Design and Analysis Laboratory (EDAL) is an interdisciplinary faculty group mainly from the College of Technology. This group, early in its history, chose to make ocean-oriented engineering its principal, but not exclusive, interest. The stated purpose of EDAL is to involve both faculty and stu-
Mathematics

dents in realistic and challenging engineering projects. Projects thus far accomplished have made both EDAL-associated faculty and EDAL-associated graduate students participants in marine-oriented engineering. The degrees of Master of Science in Chemical, Civil, Electrical, and Mechanical Engineering all permit an ocean engineering orientation. An interdepartmental Ph.D. program in Engineering has as options: Engineering Systems Design, Signal Processing, Theoretical and Applied Mechanics, and Transport Phenomena. Any one of these options permits the student to pursue ocean engineering interests. Prospective graduate students who desire information regarding EDAL activities should write to the Office of Marine Science and Technology for further information.

Mathematics (84)
Chairman: M. Evans Munroe

ASSOCIATE PROFessORS: Homer F. Bechtell, William E. Bonnice, David M. Burton, Eric A. Nordgren, Samuel D. Shore
ASSISTANT PROFessORS: Albert B. Bennett, Loren Meeker, Berrien Moore III, Donovan Van Os dol

The Mathematics Department offers courses leading to three graduate degrees: Master of Science for Teachers, Master of Science, and Doctor of Philosophy.

Master of Science for Teachers

Admission requirements: Completion of all requirements for secondary school teacher certification in Mathematics. Degree requirements: (1) Ten semester courses approved by the department. These will normally be taken from the courses numbered 801-829 and will usually include the six courses numbered 803-808. (2) A comprehensive examination based primarily on material in courses 803-808. It is not possible to work full time during the academic year toward the Master of Science for Teachers degree. The courses is this program are offered primarily in summer institutes.

Master of Science

Admission requirements: Mathematics 640, 763, or 767-768 or the equivalent of one of these sequences elsewhere. Preference will be given to applicants who have completed both these sequences. Degree requirements: Ten semester courses approved by the department. These must be chosen from courses numbered 701-799 or 830-899. At least six of the ten must be from the 830-899 group.

Doctor of Philosophy

Admission requirements: same as for Master of Science. Degree requirements: (1) Course work as prescribed by the Department. This will normally include all the courses numbered 833-842 together with several courses numbered 860-898. (2) Proficiency in reading mathematical literature in two of the three languages: French, German, and Russian. (3) Experience in teaching, equivalent to at least one-half time for one year. (4) Qualifying examination. This is in two parts. The first part (written) must be taken after three semesters in residence. It will cover basic
Mathematics

topics in graduate level mathematics. The second part (oral) is normally taken in the third year and covers more advanced topics. (5) Thesis. This is the principal item in the doctoral program. New and original results will be required. At present, thesis work is available in the fields of algebra, analysis, and topology.

Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

635. Partial Differential Equations
Sturm-Liouville problems; exact and approximate determination of characteristic values and functions; Fourier series and Fourier integrals; solution of boundary value problems for partial differential equations by series and integrals; classification, canonical forms, and basic concepts of second order, linear, partial differential equations; elliptic, parabolic, and hyperbolic equations. Prerequisite: Mathematics 527, 528. (Differential Equations, Multidimensional Calculus). 4 credits.

640. Linear Algebra
Vector spaces, matrix algebra, bases and linear transformations, determinants, inner products, quadratic forms. Prerequisite: Mathematics 426. 4 credits.

656. Introduction to Number Theory
Unique factorization, linear and quadratic congruences, quadratic reciprocity law, arithmetic functions, quadratic forms, and introduction to algebraic numbers. Prerequisite: Mathematics 640. 4 credits.

657. Geometry I
Fundamental properties of Euclidean geometry from an advanced standpoint. Prerequisite: Mathematics 640. 4 credits.

658. Geometry II
Systems of postulates of various geometries, geometric invariants, synthetic and analytic projective geometry, introduction to non-Euclidean geometry. Prerequisite: Mathematics 640. 4 credits.

682. Non-Linear Differential Equations
Phase plane analysis of linear and non-linear autonomous systems; critical points; limit cycles; periodic solutions; approximate methods for second order, non-linear, ordinary differential equations; stability and asymptotic behavior of solutions of linear and non-linear equations. Prerequisite: Mathematics 527 (Differential Equations). 4 credits

A maximum of four of the following courses may be applied to the degree of Master of Science in Mathematics.

710. Advanced Programming Systems
An introduction to computer systems organization, machine language, and digital representation of data. Software studies are compilers, assemblers, loaders, system utility program, and macros. All programming will be done in Basic Assembly Language on the IBM 360. Prerequisite: Mathematics 410 (Digital Computer Systems) or equivalent. 4 credits.

735. Probability
Sample spaces (discrete and continuous); random variables; conditional probability; moments; binomial. Poisson and normal distributions; limit theorems for sums of random variables. Prerequisite: Mathematics 528 (Multidimensional Calculus). 4 credits.
736. Statistics
Sampling theory, estimation of parameters, testing of hypotheses, non-parametric methods. Prerequisite: Mathematics 735. 4 credits.

753-754. Numerical Methods and Computers
This course is oriented toward the use of numerical analysis on digital computers (with laboratory). Computer organization, algorithmic languages and compilers, solution of polynomial and transcendental equations, numerical solutions of differential equations, linear systems of equations, eigenvalues and eigenvectors, polynomial interpolation, quadrature, curve fitting, discussion of errors, systems simulations, and mathematical optimization techniques. Selected algorithms will be programmed for solution on high-speed computers in the Computation Center. Prerequisite: 753—Mathematics 410 (Digital Computer Systems) and 426 (Calculus II), 754—Mathematics 410 and 527 (Differential Equations). 4 credits.

763-764. Abstract Algebra
Groups, rings, integral domains, fields, and linear algebra. Prerequisite: Mathematics 640. 4 credits.

767-768. Real Analysis
Topology of the real line, metric spaces, topology of Euclidean spaces, limits, sequences and series, continuity, differentiation, integration, uniformity of limit operations, equicontinuity, function spaces, inverse and implicit function theorems. Prerequisite: Mathematics 258 (Multidimensional Calculus). 4 credits.

776. Logic
Development of formal mathematics. Discussion within that system of formal systems. Consistency, completeness, decidability. Prerequisite: consent of the instructor. 4 credits.

780. Theory of Ordinary Differential Equations
Fundamental existence and uniqueness theorems; linear systems and higher order linear equations; Wronskian theory; classical Sturm theorem and generalizations; boundary value problems for second order linear equations. Prerequisite: Mathematics 527 (Differential Equations), 640, and 767. 4 credits.

784. Topology
Basic topological notions, connectedness, compactness, metrizability, with special emphasis on the real line and plane. Prerequisite: Mathematics 767. 4 credits.

788. Complex Analysis
Complex functions, sequences, limits, differentiability and Cauchy-Reimann equations, elementary functions, Cauchy’s theorem and formula. Taylor’s and Laurent’s series, residues, and conformal mapping. Prerequisite: Mathematics 528 (Multidimensional Calculus). 4 credits.

793. Calculus on Manifolds
Differentiable manifolds; differential forms; exterior and Grassman algebras; integration of differential forms; Stokes theorem; closed and exact differential forms. Prerequisite: Mathematics 640 and 767. 4 credits.

The following courses may be applied to the degree of Master of Science for Teachers in Mathematics and to no other graduate degree in Mathematics.
801-802. Fundamental Concepts of Mathematics for Teachers
An introduction to the most fundamental concepts of analysis, geometry, and algebra. Basic elements of set theory; a survey of the real and complex number systems; the integers and the concept of an integral domain; introduction to groups; geometries, Euclidean and non-Euclidean; functions, sequences, and the limit concept; the derivative and the differentiation of algebraic functions. 3 credits.

803-804. Higher Algebra for Teachers
The integers, integral domains, and topics from number theory; equivalent relations and congruences; real numbers, complex numbers, and fields, polynomials; group theory; elements of matrix theory; vectors and vector spaces; rings; Boolean algebra. 3 credits.

805-806. Higher Geometry for Teachers
Systems of postulates of various geometries; geometric invariants; synthetic and analytic projective geometry; an introduction to non-Euclidean geometry; and topology. 3 credits.

807-808. Higher Analysis for Teachers
The real number system; variables, functions and limits; elements of set theory; numerical sequences and series; continuity; the derivative and the Riemann integral; maxima and minima. 3 credits.

809. Probability and Statistics for Teachers
Permutations and combinations; finite sample spaces; random variables; binomial distributions; statistical applications. 3 credits.

811. Computers and Their Uses
Computing machines and modern numerical methods. Each student will have an opportunity to make use of the University computer. 3 credits.

814. Topology for Teachers
Fundamental concepts of elementary topology; network and map problems; sets, spaces, and transformations. 3 credits.

816. Theory of Numbers for Teachers
Divisibility and primes; congruences; quadratic reciprocity; number theoretic functions; Diophantine equations; Farey fractions; algebraic numbers. 3 credits.

817. Theory of Sets and Elementary Logic
An introduction. 3 credits.

819. The Real Number System
A postulational approach. Brief discussion of algebraic structures. Introduction to the sequences, limits, and continuity. 3 credits.

820. History of Mathematics
A problem-study approach to mathematical problems and solutions from the period of Greek mathematics until the 1950's will be used to present the history of mathematics. 3 credits.

821. A Modern Approach to Geometry
The foundations and development of Euclidean geometry, with emphasis on the recent School Mathematics Study Group's recommendations in the field of high school geometry. 3 credits.
Mathematics

825. Internship
Experience under the direction of a master teacher in teaching university level mathematics to superior high school students. This work will be done in the Advanced Studies Program at St. Paul's School, Concord, New Hampshire. 6 credits.

826. Selected Topics in Algebra
Topics selected to supplement the teacher's previous training in algebra, chosen from the following: linear algebra, vector spaces, groups, rings and ideals, and fields. 3 credits.

827. Selected Topics in Geometry
Topics selected to supplement the teacher's previous training in algebra, chosen from among the following: analytic projective geometry, non-Euclidean geometry, transformation theory, elementary metric differential geometry, topology. 3 credits.

828. Selected Topics in Analysis
Topics selected to supplement the teacher's previous training in analysis, chosen from among the following: sequences and series of real functions, Riemann integration, partial differentiation, complex functions, differential equations. 3 credits.

829. Directed Reading
A directed reading project on a selected topic in mathematics chosen to supplement the teacher's previous institute courses. A written examination will be required. 3 credits.

The following are the basic courses for both the Master of Science and Doctor of Philosophy degrees in mathematics.

831. Set Theory
Foundations of the theory of sets; ordinal and cardinal numbers; Zorn's lemma; applications. 3 credits.

833-834. Algebra
Groups; rings; modules; fields; linear algebra. 3 credits.

835-836. Real Analysis
Outer measures and measures; Lebesgue integrals; convergence theorem; Banach spaces; representation of linear functionals; weak and weak* topologies. 3 credits.

837-838. Complex Analysis
Complex variables and functions; analytic functions; complex integration; series and products; conformal mapping; analytic continuation and Riemann surfaces. 3 credits.

839-840. General Topology
Topological spaces; nets and filters; product and quotient spaces; embedding and metrization; compact spaces; uniform spaces; homotopy and fundamental group; covering spaces and fibrations. 3 credits.

841-842. Algebraic Topology
Chain complexes; homology of simplicial complexes; singular homology and cohomology; axiomatic homology; cup and cap products; topological manifolds; sheaves. 3 credits.
851-852. Differential Equations
Ordinary differential equations; existence theory; linear equations; Sturm-Liouville theory; non-linear autonomous systems; Poincare-Bendixson theory; partial differential equations; second order linear equations; initial value problems; hyperbolic equations; the Dirichlet problem. 3 credits.

855-856. Applied Mathematics
Calculus of variations, integral equations; operator theory; distributions; Hilbert spaces. 3 credits.

The following are advanced courses primarily for Doctor of Philosophy candidates, though they may be elected by qualified Master of Science candidates. In each of these the content will vary from year to year. Thus, with permission of the instructor, each of these courses may be taken more than once for credits, even concurrently. Normally, the content will be chosen from among the topics listed.

861, 862. Topics in Algebra
Algebraic number theory; algebraic geometry; ring theory; theory of modules; group theory; non-associative algebras. 3 credits.

863, 864. Topics in Analysis
Measure theory; calculus of variations; integral equations; boundary-value problems; orthogonal series; theory of approximation; analytic number theory; Riemann surfaces. 3 credits.

865, 866. Topics in Topology
Algebraic topology; theory of sheaves; dimension theory; Riemann surfaces; homotopy theory. 3 credits.

867, 868. Topics in Geometry
Convexity; projective geometry; differential geometry; tensor analysis. 3 credits.

869, 870. Topics in Topological and Algebraic Analysis
Rings of functions; linear topological spaces; topological algebras; Hilbert spaces; rings of operators; topological groups; Lie groups; harmonic analysis. 3 credits.

871, 872. Topics in Differential Equations
Boundary value problems; asymptotic behavior and stability theory; non-linear equations; dynamic systems; classical theory of partial differential equations; functional analysis and partial differential equations. 3 credits.

873, 874. Topics in Applied Mathematics
Linear and dynamic programming; differential equations; special functions. 3 credits.

875, 876. Topics in Probability and Statistics
Stochastic processes. 3 credits.

898. Reading Courses
Offered in the following areas: (a) Algebra, (b) Analysis, (c) Topology, (d) Geometry, (e) Topological and Algebraic Analysis, (f) Differential Equations, (g) Applied Mathematics, (h) Probability and Statistics, (i) Mathematics Education. 3-6 credits.

899. Master's Thesis

999. Doctor of Philosophy Thesis
Mechanical Engineering

Mechanical Engineering  (85)
Chairman:  Robert W. Corell

PROFESSORS:  Robert W. Corell, Godfrey H. Savage, Charles K. Taft, Asim Yildiz
ADJUNCT ASSOCIATE PROFESSOR:  Wayne M. Beasley
ASSISTANT PROFESSORS:  Robert W. Alperi, Robert J. Becherer, David E. Limbert, John A. Wilson

The Mechanical Engineering Department offers programs of study, from the viewpoint both of the engineering sciences and of engineering design, in mechanics, materials science, automatic control, and the thermal sciences, leading to the degree of Master of Science in Mechanical Engineering. The programs provide the background required for careers in research, engineering design, or teaching, or for further graduate study.

To be admitted to graduate study in Mechanical Engineering, a student should have completed work equivalent to that required at the University of New Hampshire for a Bachelor of Science degree in his field.

A candidate for the degree of Master of Science shall satisfy the requirements of either a thesis plan or a project plan. The thesis plan requires 24 semester hours of course work in addition to Mechanical Engineering 899, Master’s Thesis; the project plan requires 30 semester hours of course work in addition to Mechanical Engineering 892, Master’s Project. Individuals with special qualifications may petition the Department to be excused from the project requirement. An oral examination covering the candidate’s graduate work will be given whether or not a thesis is presented.

Students interested in graduate study beyond the Master’s degree should refer to the interdepartmental Engineering Ph.D. Program which includes the following areas of specialization: Engineering System Design, Signal Processing, Theoretical and Applied Mechanics, and Transport Phenomena. For details refer to the section entitled Engineering Ph.D. Program on page 79.

Students completing degree requirements through the University Extension Service must be admitted to the Graduate School and have their programs approved by the Department.

No more than two graduate courses taken prior to admission to the Graduate School may be applied to the Master’s degree. Courses numbered between 600 and 699 may be taken for graduate credit by non-majors only.

Permission of the instructor and consent of the adviser are required for enrollment in all Mechanical Engineering graduate courses.

701. Macroeoscopic Thermodynamics
A continuation of the study of thermodynamic principles using an analytical approach consistent with that of Gibbs and Caratheodory. 4 credits.

702. Statistical Thermodynamics
An introduction to statistical thermodynamics. 4 credits.

703. Heat Transfer
Analysis of heat transfer phenomena; steady-state and transient conduction, radiation, and convection; engineering applications. 4 credits.
704. **Experimental Heat Transfer**
Experimental methods in the study and solution of heat transfer problems, including a critical comparison with analytical and other methods. Literature surveys and written and oral presentation of results will be emphasized. 4 credits.

707. **Analytical Fluid Dynamics**
An analytical study of the dynamic behavior of fluids. Topics include potential flow, development of the Navier-Stokes equations, turbulence, and boundary layer theory. 4 credits.

708. **Gas Dynamics**
Basic equations of motion of one-dimensional, subsonic and supersonic flows of compressible, ideal fluids. Wave phenomena. Rankine-Hugoniot relations. Linear approach to two-dimensional flow problems. 4 credits.

715. **Internal Combustion Engines**
Application of basic and engineering science to the engineering problems of spark and compression ignition engines; design, management, and reporting of experimental studies. 4 credits.

717. **Cryogenics**
The phenomena and processes associated with very low temperatures. Application of basic engineering sciences to the problems of low-temperature refrigeration, liquefaction, separation, storage and transport of cryogenic fluids; measurement systems; vacuum technology. 4 credits.

723. **Advanced Dynamics**
A traditional course in classical mechanics with an orientation to contemporary engineering applications. Review of particle dynamics. Hamilton's principle and the Lagrange equations. Kinematics and dynamics of rigid bodies, microscopic effects in machinery and space structures. 4 credits.

724. **Introduction to Vibrations**
The theory of discrete vibrating systems is treated in depth. Review of linear system concepts and detailed treatment of the single degree of freedom system with general excitation. Matrix and eigenvalue problems. Many degrees of freedom, normal mode theory for free and forced vibration. Numerical methods. Introduction to continuous systems. Applications are made to both structural and mechanical systems. 4 credits.

726. **Experimental Mechanics**
Experimental methods and their underlying theoretical bases are developed and applied to the measurement of stress, strain, and motion. Topics covered include transmitted and scattered light photoelasticity, strain gage applications, brittle coating and grid techniques, dynamic measurements, and associated instrumentation. 4 credits.

727. **Advanced Mechanics of Solids**
Advanced topics in the mechanics of solids are treated in depth; beams on elastic foundation, curved bars, inelastic behavior, instability, introduction to thin plates and shells. introduction to elasticity, energy methods, and numerical methods. 4 credits.

730. **Mechanical Behavior of Materials**
The elastic and inelastic behavior of materials, both organic and inorganic, is studied from the micromechanics and macromechanics points of view. Concepts of stress, strain, and constitutive relations are reviewed and related to recent developments in dislocation theory and other phenomena on the atomic scale.
Mechanical Engineering

and to continuum mechanics on the macroscopic scale. Mechanical behavior including elasticity, plasticity, viscoelasticity, creep, fracture, and damping will be treated. Anisotropic and heterogeneous materials such as composite materials will be studied in detail. 4 credits.

741. Control of Physical Systems
The mathematical modeling of hydraulic-, pneumatic-, and fluidic-control elements and control systems. Methods are developed for the analysis of systems using gases or liquids as the working fluid. Methods for the synthesis of the parameters of the control elements, used in automatic control systems, are developed and methods of design of these systems are discussed. 4 credits.

751. Naval Architecture in Ocean Engineering
Naval architectural principles related to surface and submerged vehicles are developed—including hydrostatic characteristics, fundamentals of powering, and rules and regulations of importance to this aspect of ocean engineering. Prerequisites: Mechanical Engineering 508 (Fluid Dynamics) or permission of instructor. 4 credits.

752. Submersible Vehicle Systems Design
A lecture and design course. Lectures review material pertinent to design, including a historical perspective, environmental factors, hydromechanic and structural principles, materials, intra-vehicle systems, extra-vehicle systems, operating considerations, pre-design and design procedures. Conceptual and basic preliminary designs of selected submersible vehicles are prepared by student teams. 4 credits.

761. Crystalline Solids
Theoretical and experimental studies of the structure of crystalline solids, using X-ray diffraction techniques. 4 credits.

763. Microstructure of Solids
Theoretical and experimental studies of the microstructure of solids, using optical and electron microscopy. 4 credits.

Mathematical methods in engineering sciences are discussed, including methods for solution of discrete and continuous systems. Course includes a review of calculus, linear algebra, complex numbers, Fourier series, and differential and partial differential equations, with examples from acoustics, vibration theory, hydrodynamics, elasticity, solid mechanics, transport theory, and particle mechanics. 4 credits.

793 a-d and 794 a-d. Special Topics in Engineering
Course numbers refer to topics in a) thermodynamics, b) mechanics, c) engineering design, and d) materials. Content of these courses may vary from year to year. 2-4 credits.

795 a-d and 796 a-d. Independent Study
Course numbers refer to topics in a) thermal science, b) solid mechanics, c) engineering design, and d) materials. 2-4 credits.

801. Irreversible Thermodynamics
Non-equilibrium thermodynamics from the viewpoint of fluctuation theory. The Onsager reciprocal relations. Prerequisite: Mechanical Engineering 701. 4 credits.
803. Conduction Heat Transfer
   Heat conduction equation; temperature fields and the heat flux vector; analytical solution of the conduction equation in several variables; initial and boundary value problems; numerical methods of solution. 4 credits.

804. Radiation Heat Transfer
   The fundamentals of radiant heat transfer. Development and solution of the wave equation for electromagnetic radiation. Analysis of Planck’s law of radiation and earlier theories. Methods of solution of radiant interchange in real systems with and without absorbing media. 4 credits.

806. Convection Heat Transfer
   An analytical study of heat transfer to laminar and turbulent boundary layers of compressible and incompressible fluids. Basic differential equations governing the heat transfer are derived and analytical solutions are obtained where possible and checked with experimental results. 4 credits.

807. Compressible Fluid Flow
   General equations of motion for real and ideal compressible fluid flow, including boundary layer equations; methods of solution. Prerequisite: Mechanical Engineering 707 or 708. 4 credits.

808. Theoretical Aero/Hydro-Mechanics
   The mathematical development of the equations of frictionless fluid flow, using both tensor notation and various coordinate systems. Conformal mapping; Blasius theorem; Joukowski hypothesis; flow around airfoils. Schwarz Christoffel theorem and vortex motion. 4 credits.

822. Continuum Mechanics
   Conservation laws for gases, liquids, and solids in a continuum are developed starting from Liouville and Boltzmann equations. Passage from a discrete system to a continuum is discussed. Constitutive equations for viscoelastic, thermoelastic and non-linear gas, liquid, and elastic fields. General discussion of rheological behavior. Causality conditions for continuum fields. Examples for solids, liquids, and gases, and biomechanics. Introduction to phenomenological Lagrangian theories. 4 credits.

824. Vibrations of Continuous Media
   Classical and numerical methods are employed to study the vibration of continuous elements and structures. Topics considered are axial and torsional vibration of rods, transverse vibration of beams and thin plates, wave propagation, and vibration of simple structures. 4 credits.

826. Theory of Elasticity
   The analysis of stress and deformation in elastic solids; conservation laws for elastic media; stress and strain relations by continuous functions; Airy stress functions; elastodynamic fields; inhomogenous, anisotropic, wave equations; wave propagation and stress concentration problems; generalizations to thermoelasticity and viscoelastic fields. Complex variable techniques will be used. 4 credits.

827. Theory of Plasticity
   Analysis of stress and deformation in inelastic solids; general development of stress invariants, variational principles, constitutive relations, and yield and loading functions. Special emphasis on ideal plasticity, strain-hardening, creep, limit analysis, and limit design. 4 credits.
Mechanical Engineering

829. Theory of Plates and Shells
Theory of elasticity developed for plates and shells; conservation laws for elastic media; stress and strain relations by continuous functions; Airy stress functions; stress and strain relations in curvilinear coordinates; thin and thick plate and shell theories; vibration of spherical, cylindrical, and conical shells and plates. 4 credits.

842. Discontinuous Control
The analysis and synthesis of feedback control systems operating on quantized information; compensation and performance improvement methods which use the quantized nature of the information are also developed. 4 credits.

860. Physical Metallurgy
Introduction to the electron theory of materials; entropy and free-energy concepts of the solid state; diffusion in metals; nature and kinetics of selected solid state reactions. 4 credits.

866. Physical Ceramics
Characteristics of crystalline and noncrystalline ceramic solids; defect structures; diffusion in ceramic materials; nucleation, crystal growth, and solid-state reactions; kinetics of grain growth, sintering, and vitrification. 4 credits.

882. Mathematical Methods in Engineering Science II
This course is a continuation of ME 781 which is a prerequisite. Topics treated include complex variable techniques, integral transform techniques for the solution of differential and partial differential equations, Green’s functions, Wiener-Hopf techniques, variational techniques. Stochastic problems with application to random vibration, statistical control theory, turbulence, heat conduction and fluctuation phenomena in solids, transport theory, gases, and liquids. Topics may vary from year to year. 4 credits.

883. Tensor Analysis and Differential Geometry

890 a-d and 891 a-d. Special Topics in Engineering
Course numbers refer to topics in a) thermodynamics, b) mechanics, c) engineering design, and d) materials. Content of these courses may vary from year to year. 2-4 credits.

892. Mechanical Engineering Master’s Project
The student works with a faculty member during one or two semesters on a well defined research and/or original design problem. A written report and seminar are presented. 1-4 credits.

895 a-d and 896 a-d. Graduate Independent Study
Investigation of graduate level problems or areas germane to mechanical engineering. 1-4 credits.

899. Master’s Thesis
6-10 credits.

For additional courses, see listing under Technology, page 158.
Microbiology (47)

Acting Chairman: Theodore G. Metcalf

PROFESSORS: William R. Cheshbro, Galen E. Jones, Theodore G. Metcalf, Lawrence W. Slanetz

ASSISTANT PROFESSORS: Fred T. Hicken, Robert M. Zsigray

Students admitted to graduate study in Microbiology are expected to have had adequate preparation in the biological and physical sciences and in the basic courses in Microbiology. The candidate for the Master of Science degree will be required to complete a thesis and pass an examination covering his graduate courses and thesis.

Candidates for the Doctor of Philosophy degree must demonstrate proficiency in reading microbiological literature in one foreign language, usually French or German; must demonstrate to the doctoral committee a broad, basic knowledge of the field of Microbiology; and must complete a dissertation on some original research in Microbiology.

701. Advanced Microbiology
The growth, nutrition, and metabolism of microorganisms; consideration of cell structure and localization of function; aspects of genetic and nongenetic regulation of metabolism; study of the influences of chemical and physical factors of the environment upon microorganisms. Mr. Cheshbro. Prerequisite: Microbiology 503 (General Microbiology). 2 lectures; 1 laboratory; 4 credits.

702. Pathogenic Microbiology
The morphological, cultural, biochemical, serological, and pathogenic characteristics of microorganisms causing human and animal diseases. Mr. Zsigray. Prerequisite: Microbiology 503 (General Microbiology). 2 lectures; 2 laboratories; 4 credits.

705. Immunology and Serology
The defensive elements possessed by man and animals which serve to protect them from infectious microorganisms. A consideration of serum proteins, including immunoglobulins and complement, autoimmune phenomena, hypersensitivity and immunohematology. The principles of serological techniques used in the recognition and identification of biological materials, including microorganisms. The preparation of vaccines and the production of antisera in animals. Mr. Metcalf. Prerequisite: Microbiology 702. 2 lectures; 2 laboratories; 4 credits.

706. Virology
The animal and plant viruses, including bacteriophages and the rickettsiae; a consideration of techniques for the propagation and recognition of animal viruses; the interactions between virus and host cell; and the application to problems of human, plant, or animal infections caused by viruses. Mr. Metcalf. Prerequisite: Microbiology 702. 1 lecture; 3 laboratories; 4 credits.

707. Marine Microbiology
Characterization of microbes in the sea as to taxonomy, physiology, ecology, and transformations of carbon, nitrogen, sulfur, and phosphorus; methods of sampling and enumeration; biogeochemistry; properties of sea water and the marine environment. Parallels to soil microbiology will be drawn. Mr. Jones. Prerequisite: Microbiology 503 (General Microbiology) and Biochemistry 751. 2 lectures; 1 laboratory; 4 credits. (Not offered in 1971-72.)
795, 796. Problems in Microbiology
Special problems, depending upon the training and desire of the student. Elective only upon consultation. Staff. Credits to be arranged.

800. Systematic Bacteriology
Procedures and methods for the classification of bacteria; review of modern systems of classification. Staff. Prerequisite: one year of microbiology. 2 lectures; 1 laboratory; 3 credits.

802. Microbial Physiology
Microbial physiology is the study of the means by which microorganisms survive. It deals with the effects of nutritional, chemical, and physical factors on microbial growth, the generation of activated metabolites during catabolism; and the use of these metabolites for the synthesis of macromolecules, the non-genetic mechanisms directing and regulating cellular metabolism; the biochemical cytology of the microbial cell; and with evolutionary and ecological relationships among microbial species. Mr. Chesbro. Prerequisite: a course in general biochemistry (may not be taken concurrently) and Microbiology 503 (General Microbiology). 2 lectures; 2 laboratories; 4 credits.

803. Microbial Cytology
The fine structure of bacteria and related organisms. (Procaryotic Protists). Application of current techniques for the demonstration and isolation of external appendages, cell walls, cytoplasmic membrane, protoplasts, inclusions, and chromatin bodies. Prerequisite: Microbiology 701. 2 lectures; 2 laboratories; 4 credits.

804. Microbial Genetics
An introduction to genetic principles and methodology applicable to microorganisms; fine structure of genetic material, mutation, selection, adaptation, recombination, transformation, and transduction. Mr. Hickson. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

851. Cell Culture
A consideration of the theory and principles fundamental to the culture of cells in vitro. An introduction to the techniques of preparing and maintaining animal, plant, insect, and fish cell cultures. The application of cell culture to contemporary research in the biological sciences. Mr. Strout and staff; Mr. Metcalf and Mrs. Biggs. Prerequisite: Microbiology 503 (General Microbiology); permission of instructor. 2 lectures; laboratory hours arranged; 4 credits. (Also offered as Animal Science 851.)

897-898. Microbiology Seminar
Reports and discussions on microbiological literature and recent developments in microbiology. Staff. Prerequisite: permission of instructor. 1 credit.

899. Master's Thesis
6-10 credits.

999. Doctoral Research
Music (63) (64)
Chairman: Keith Polk

Professor: Donald Steele
Associate Professors: Alan Grishman, Keith Polk, Mary Rasmussen, John Whitlock, John Wicks
Assistant Professors: Mark DeVoto, Stanley Hettinger, Cleveland Howard, John Rogers, Henry Wing Jr.

The Department of Music offers programs leading to the degrees of Master of Arts in Music and Master of Science in Music Education.

Master of Arts in Music

At the University of New Hampshire the degree of Master of Arts in Music is designed for students interested in broadening their knowledge of the history of music, but at the same time it offers ample opportunity to pursue more specialized studies in music theory, performance, performance-practice, or music literature. The following courses are required: Music 855, 856, 857, 858, 891, 893 or 894, or their approved equivalents. The student may elect courses from the 700 series in music or the 600, 700, and 800 series in other departments with the permission of his adviser. The Department recommends that a student allow more than two semesters for completion of the program.

The Department requires a Bachelor of Arts degree in Music or its equivalent from an accredited institution for admission to this program. Placement examinations in theory, music history, and aural identification will be required of all applicants. The student will normally take these examinations in the semester or summer preceding his entrance into the graduate program. Students not meeting standards in the placement examinations will be required to make up their deficiencies.

A reading knowledge of both German and French is strongly recommended in undergraduate preparation and is essential to the completion of this program. Oral examinations in music are required of all Master of Arts degree candidates.

Master of Science in Music Education

The goal of the Master of Science in Music Education degree is to develop a broad knowledge at the graduate level in the fields of music education, performance, history, theory, and independent study. Each candidate will be required to complete one of the following: a professional paper; a field study in music education; a satisfactory recital appearance; a major composition, orchestration, or band arrangement; or the preparation and conducting of a major work in public performance for band, orchestra, or chorus. The following courses are required: Music 855; 893 or 894; Music Education 796; 883 or 884. Also required are 6 credits in the Department of Education from courses such as the following: Education 820, 855, 858, 865, 883, 886, 892, and the 700 courses. Vocal or instrumental study at the 800 level is required to a minimum of 4 credits. A maximum of 9 credits is allowed if the graduate recital option is elected. Sufficient electives must be taken to total 30 credits.

Admission to this program depends upon a bachelor’s degree in Music Education or its equivalent from an accredited institution. Placement examinations in theory, music history, and aural identification will be required of all applicants. The student will normally take these examinations in the semester or summer preceding his entrance into the graduate program. Students not meeting standards in the placement examinations will be required to make up their deficiencies.
Music

Music (63)

701. Music of the Medieval Period
   The nature of the beginnings of polyphony. The preeminent influence of the church in the thirteenth century and the rising secular movement in the fourteenth. Music as a dominant force in the political and social life of the Middle Ages. Mr. Polk. 4 credits.

703. Music of the Renaissance
   A study of the works of the composers of the fifteenth and sixteenth centuries from Dunstable to Palestrina. Mr. Polk, Mr. Wicks. 4 credits.

705. Music of the Baroque
   A study of the music from de Rore to Bach. Mr. Wicks. 4 credits.

707. Music of the Classical Period
   The growth of musical styles and forms from early classical, Baroque-influenced composers, through the high classicism of Haydn and Mozart, to the budding Romanticism of the young Beethoven. The class will hear representative works in the areas of symphony, concerto, and opera. Mr. Grishman. 4 credits.

709. Music of the Romantic Period
   The symphonies, concerti, chamber music, and keyboard works of Beethoven, Berlioz, Schubert, Mendelssohn, Schumann, Brahms, Franck, Chopin, and Liszt. Romantic elements contained in the development of harmony orchestration, sonority, expressive content. The rise of the short piano piece, the German art-song, the symphonic poem, nationalism in music. Mr. Steele. 4 credits.

711. Music of the Twentieth Century
   A study of contemporary music, including its literature, its trends, and an analysis of techniques, styles, forms, and expression. Mr. DeVoto. 4 credits.

721. The Life and Works of Beethoven
   The piano sonatas, the concerti, symphonies, and string quartets. Lectures, analysis, reports, required readings, and listening. Mr. Steele. 4 credits.

731. The Lied
   Study of the history and literature of the German art-song, with special emphasis on the nineteenth and early twentieth centuries. Mr. Wing. 4 credits.

732. The Art Song
   This course will emphasize the non-German song of the late nineteenth and twentieth centuries. Mr. Wing. 4 credits.

733. Survey of Opera
   An investigation of representative masterpieces of this art form through listening, reading, and discussion. Mr. Wing. 4 credits.

734. Survey of Oratorio
   Oratorio from its beginnings to the masterpieces of Handel. Some emphasis will be placed on the cantata. Mr. Wicks. 4 credits.

735-736. Survey of Pianoforte Literature
   The history and development of keyboard literature from Bach to the present. Discussion and performance of the works of Bach, the sonatas and concerti of Haydn, Mozart, Beethoven, Schubert, the Romantic composers, and contemporary writers. Mr. Steele. 4 credits.
An investigation of music for vocal, vocal-instrumental, and instrumental ensemble, circa 1100 to 1450, and its realization in performance, especially with regard to rhythm, musica ficta, notation, melodic ornamentation, improvised polyphony, and the clear projection of a polyphonic texture. Course work includes an evaluation of the writings of selected Medieval theorists and modern scholars; practical exercises in transcription; and performance on reconstructions of Medieval instruments, especially the organ, harp, psaltery, rebe, vielle, and recorder. Mr. Polk. 2 or 4 credits.

756, (756). Performance Studies in Renaissance Music
An approach to the problems of musical performance, circa 1450 to 1600, via the small vocal, vocal-instrumental, and instrumental ensemble, with special reference to rhythm and tempo, musica ficta, text underlay, articulation, diminution, tablature notation, and effective distribution of voices and instruments. Course work includes a survey of performance manuals, iconographical sources, and current research; development of editing technique through the preparation of transcriptions; and an opportunity to perform on representative musical instruments of the period, notably the organ, harpsichord, lute, viols, recorders, cornetto, and trombones. Mr. Polk, Miss Rasmussen. 2 to 4 credits.

A study of performance practices in solo keyboard works, sonatas, a2 and a3 and solo cantatas, circa 1640 to 1750, concentrating on ornamentation, realization of figured basses, improvisation, articulation, rhythm, keyboard registration, and the influence of the construction of Baroque musical instruments (including the organ) on sonority and technique. Course work includes an examination of manuscripts (on microfilm), prints, treatises, and iconographical sources, and the editing and realization of selected works for recital performance. Miss Rasmussen, Mr. Wicks. 2 to 4 credits.

An intensive examination of musical styles, circa 1760 to 1815, through the performance of keyboard music and instrumental chamber music, emphasizing the relationship between structure and interpretation, late eighteenth-century conventions of ornamentation and articulation, a survey of tutors and relevant theoretical writings, and a critique of currently published editions and editing techniques. Mr. Grishman, Miss Rasmussen. 2 or 4 credits.

The art of performing and coaching Lieder, piano music, and instrumental chamber music from Schubert through Debussy, with special consideration given to effective ensemble, traditions of interpretation, and the influence of structure on performance. Mr. Steele, Mr. Grishman. 2 to 4 credits.

760, (760). Performance Studies in Twentieth-Century Music
Performance of representative twentieth-century compositions for small instrumental or vocal-instrumental ensemble, with intensive work in structural analysis, rhythmic ensemble coordination, dynamic and articulation control, new instrumental techniques, notation, improvisation, and the interaction between jazz and European styles. Mr. Polk, Mr. Rogers, Mr. Verrette. 2 or 4 credits.

771-772. Counterpoint
First semester: polyphony in two to four voices, based on the linear, harmonic, and rhythmic techniques of sixteenth-century vocal music. Work in
species and imitative forms as exemplified by Palestrina. Second semester:
tonal counterpoint, based on eighteenth-century style. Various exercises in two
to four voices, referring to keyboard and instrumental examples of Bach and
Handel. Mr. Rogers. Prerequisite: Music 571-572 (Counterpoint) or permis-
sion of instructor. 2 credits.

773. Canon and Fugue
Continuation of studies in tonal counterpoint. Construction of canons and 2-, 3-
and 4-voice fugues, based on the keyboard and instrumental style of Bach.
Mr. Williams. Prerequisite: Music 771-772 or permission of instructor. 2 credits.

775-776. Composition
Consideration of simple phrase structures, binary and ternary forms as ex-
emplified in classic sonata movements, theme and variations, and textsettings
as basic models for the uniting of specific composition projects. Mr. Williams.
Prerequisite: permission of instructor. 2 credits.

777-778. Advanced Composition
Composition projects of the student, unlimited in scope and nature and reflect-
ing the student's compositional interests. Guidance and advice of the instructor
as appropriate to each individual project. Mr. Williams. Prerequisite: permis-
sion of instructor. 4 credits.

779. Orchestration
The characteristics of band and orchestral instruments, both individually and
in small (homogeneous) and large (mixed) groupings. Students will be ex-
pected to study appropriate scores, to write arrangements utilizing these vari-
ous groupings, and to have these arrangements performed if at all possible.
Some aspects of vocal writing will also be covered. Mr. DeVoto, Mr. Rogers.
Prerequisite: permission of instructor. 4 credits.

781. Form and Analysis
A consideration of various formal and textural elements as concepts and within
the context of musical examples. Thorough analysis of smaller and larger master-
works from the standpoint of harmony, counterpoint, structural line, and formal
articulation. Mr. DeVoto. Prerequisite: permission of instructor. 4 credits.

785. Electronic Sound Synthesis
A practical course in the creation of sounds by electronic and computer syn-
thesis. The course will be divided into three sections. Part I will deal with
"traditional" or "analog" electronic sound synthesis, with students having the
opportunity to work with the Buchla Synthesizer in the UNH Electronic Music
Studio. Part II will deal with the following areas of computer sound synthesis:
(1) elementary programming in FORTRAN, (2) the logic of computer sound
synthesis, and (3) programming in MUSIC4BF. Students will have the oppor-
tunity to run programs on the IBM 360/50 Computer and its associated 12-bit
digital/analog converter. Part III will be devoted to supervised independent
study in one or both of the above areas. Mr. Rogers. Prerequisite: permission
of instructor. 4 credits.

795. Special Studies in Music Literature
Presuming a sound musical background, this course allows the student to in-
vestigate independently and in depth any of a vast range of subjects. Barring
duplication of material, this course may be repeated for credit. Prerequisite:
permission of instructor. 4 credits.
Music

817 (817). *Applied Music for Graduate Credit*
(1) Piano; (2) Organ; (3) Violin, Viola; (4) Violoncello; (5) Voice; (6) Woodwind; (7) Brass; (8) Percussion. Further development of technique, music interpretation, and repertory. Emphasis may also be directed toward the functional use of the instrument in the schoolroom. Prerequisite: must exhibit sufficient proficiency to warrant graduate study and permission of Department Chairman and the student's graduate supervisor. Audition required. A student may register for credit in the same courses in successive years with the approval of his major professor. Music staff. 1-2 credits.

855. *Introduction to Bibliography*
An intensive survey of basic reference works, music periodicals, collected editions, series, treatises, books on musical instruments and performance practice, and the important monographs on major composers from Machaut to Schoenberg. A reading knowledge of German and French is very useful. Miss Rasmussen. 3 credits.

856. *Readings in Music History: Antiquity to 1600*
An opportunity to read and study in detail a restricted number of monographs and editions. Mr. Polk. 3 credits.

857. *Readings in Music History: 1600-1820*
An opportunity to read and study in detail a restricted number of monographs and editions. Mr. Polk, Mr. Wicks. 3 credits.

858. *Readings in Music History: 1820 to the Present*
An opportunity to read and study in detail a restricted number of monographs and editions. Mr. DeVoto, Mr. Grishman. 3 credits.

891-892. *Research Seminar*
Guidance in individual research projects. Prerequisite: permission of instructor. Variable credit.

893. *Theory Seminar*
Through reading, analysis, and composition, the student is acquainted with music theory from the Middle Ages to Monteverdi. Mr. Polk. Prerequisite: permission of instructor. 3 credits.

894. *Theory Seminar*
Theory and practice from the Baroque to contemporary music. Performance practice in the Baroque and later periods. Score analysis. Mr. Rogers. Prerequisite: permission of instructor. 3 credits.

Music Education (64)

741-742. *Techniques and Methods in Choral Music*
A lecture-workshop course concerning problems in the organization and performance of high school, college, and community choruses. Emphasis is placed on techniques of choral conducting and rehearsal, repertory, and materials. Mr. Howard. 2 credits.

743. *Materials and Methods in Piano Music*
A course designed to give potential piano teachers a coherent but flexible approach to the instruction of students of different ages and levels of talent, through evaluation of methods and materials and discussion of the role of the private teacher. Mrs. Edwards. 2 credits.

129
745-746. Techniques and Methods in String Instruments
Class and individual instruction on stringed instruments, students are expected to practice four hours per week as a basic course requirement. A high level of instrumental proficiency results from intensive training on the violin, viola, cello, and double bass, enabling participants to perform in string ensembles. The course will explore classroom procedures, the establishment of string programs, and the evaluation of available methods materials. Mr. Grishman. 2 credits.

747-748. Techniques and Methods in Woodwind Instruments
Basic fundamentals of performance in woodwind instruments, techniques of class instruction, associated acoustical problems, and study of woodwind literature. Emphasis in the first semester will be on clarinet, flute, and saxophone. The double reed instruments will be emphasized in the second semester. Mr. Hettiger. 2 credits.

749-750. Techniques and Methods in Brass Instruments
A basic course in embouchure formation, tone, tonguing, fingering, flexibility, accuracy, and range development as applied to the trumpet or baritone horn, French horn, and trombone, in conjunction with a survey of the methods, studies, solos, and ensembles most likely to be useful with grade school, junior high school, and high school players of brass instruments. Qualified, advanced students may elect honors work in composition, arranging, and ensemble coaching. Miss Rasmussen. 2 credits.

751. Techniques and Methods in Percussion Instruments
The basic skills necessary for performance on snare drum, tympani, mallet instruments, and the other percussion instruments used in bands and orchestras. Materials and methods of instruction are included. Mr. Whitlock. 2 credits.

785. Music for the Elementary Classroom Teacher
For the non-specialist interested in utilizing music in the classroom. The correlation and integration of music in the school curriculum, and the basic skills and techniques necessary. Mr. Whitlock. 4 credits.

787. Problems in the Teaching of Elementary School Music
Aims, scope, and organization of materials and activities in the elementary schools. Modern trends in educational philosophy, development of the child’s voice, and demonstration of materials and methods for the various grades. Observation and teaching in schools. Mr. Howard, Mr. Whitlock. Seminar and laboratory. 2 credits.

791. Problems in the Teaching of Secondary School Music
The application of educational principles to the teaching and learning of music and the organization of the music curriculum on the junior and senior high school levels. The adolescent voice, the classification of voices, the selection of vocal and instrumental materials, and the building of unified concert programs. Problems of administration, management, and the relationship of the teacher to school and community. Observation of music programs in secondary schools. Mr. Howard, Mr. Whitlock. 4 credits.

796. Organization and Administration of School Music Groups
Problems of school orchestra, band, glee club, chorus, and small-ensemble organization and administration, such as objectives, motivation, schedule, discipline, equipment, programs, finances, rehearsal techniques, contests and festivals, materials, personnel selection, and grades. Mr. Howard, Mr. Whitlock. 4 credits.
883. Instrumental Literature and Its Performance
Exploration of representative solo and ensemble music for string, wind, and percussion instruments. Typical literature from each period of music is studied. As much as is possible, live performance is included; recordings are used as required. Detailed attention given to interpretation. Project required. Mr. Grishman, Mr. Hettinger. 3 credits.

884. Choral Literature and Its Performance
Analysis, discussion, and conducting of excerpts from choral masterpieces from all major periods and styles. Students will have the opportunity to act as assistant conductors for some of the choral organizations on campus. Evaluation of current high school and college repertoires. Mr. Howard. 3 credits.

895. Special Projects in Music Education
Independent study, investigation, or research in Music Education. Creative projects may be included. Mr. Howard, Mr. Whitlock. Prerequisite: permission of instructor. 1-4 credits.

Occupational Education (22)
Chairman: William H. Annis

ASSOCIATE PROFESSORS: William H. Annis, Paul A. Gilman, Jesse James

The degree of Master of Occupational Education is designed for teachers of occupational education, county Cooperative Extension Service personnel, and others in adult education. A comprehensive examination will be required of all candidates for this degree.

783. Preparation for Conducting and Supervising Adult Education Programs
The techniques of adult education in terms of: identifying needs, program planning, methods of teaching, supervision, and evaluation. Prerequisite: Occupational Education 650, Principles of Occupational Education, or permission of instructor. 4 credits.

785. Advanced Methods and Materials of Instruction
The organization of instruction to meet individual and student needs; development and use of resource files and instructional materials. Evaluation in teaching vocational-technical education. Open to teachers of vocational-technical education, and others by permission of instructor. 4 credits.

786. Concepts of Vocational-Technical Education
The development of vocational-technical education in the United States, with emphasis on the socio-economic influences responsible for its establishment. The federal and state requirements for programs in the secondary and post-secondary schools will be discussed. Coordination of programs with general education and other vocational fields. 4 credits.

791. Planning for Teaching
The organization of materials of instruction to meet group and individual needs. Techniques of instruction, planning for teaching, the function of consulting committees, working with youth groups, and program evaluation. Prerequisite: permission of instructor. 4 credits.
Occupational Education

An opportunity is provided for a student to study a special problem in one of the areas listed. Elective after consultation with the instructor. Hours to be arranged. 2 to 4 credits. May be repeated.

801. Advanced Methods in Agricultural Mechanics Instruction
Agricultural mechanics problems and how to approach them in the high school as a part of the course of study in vocational agriculture. The physical setup, as well as the processing of supplies and equipment; methods of supervision and direction of agricultural-mechanics projects; and the preparation and presentation of demonstrations. Mr. Gilman. 2 credits.

802. Methods of Teaching Power and Machinery in Occupational Education
Teaching the servicing and maintenance of the agricultural power and machine complex as it relates to the production and non-production phases of vocational agriculture. The development of teaching plans, techniques of instruction, and the development of multi-media teaching units will be stressed. 3 credits.

804. Program Planning in Occupational Education
The basic problems, principles, and procedures in the process of program planning in occupational education. 2 credits.

805. Planned Agricultural Experience Programs in Occupational Education
Development of cooperative relations, selection and development of individual programs with the students, and the supervision and evaluation of such programs. 2 credits.

806. Preparation and Use of Visual Aids for Occupational Education
The purpose of visual aids and the kinds best adapted to use in the program, together with their preparation and use. 2 credits.

807. Organization and Supervision of Youth Organizations
The purposes and organization of youth organizations, establishing the local organization, planning and developing a program of work, ways and means of improving the local organization, and methods of evaluation. 2 credits.

809. Community Organization and Public Relations
The composition, purposes, and objectives of the various social and economic organizations operating in local communities. The importance of their membership to the general welfare of the area and the development of a public relations program. 2 credits.

(895). Independent Study in Occupational Education
Individual study problems in various phases of occupational education. Prerequisite: permission of staff. 2-6 credits. May be repeated.

899. Master of Occupational Education Thesis
6-10 credits.
Physics (86)

Chairman: Lyman Mower


ASSOCIATE PROFESSORS: Roger L. Arnoldy, L. Christian Balling, David G. Clark, Richard L. Kaufmann, Robert E. Simpson

ASSISTANT PROFESSORS: John F. Dawson, Harvey Shepard, Richard N. St. Onge, John J. Wright

GRADUATE ADVISER: John A. Lockwood

The Physics Department offers courses leading to three graduate degrees: Master of Science for Teachers, Master of Science, and Doctor of Philosophy. Graduate students entering in the Master of Science and Doctor of Philosophy programs are expected to demonstrate a proficiency in undergraduate work equivalent to that of the senior year in physics at the University of New Hampshire. To assist in starting a student’s work at the proper level, a placement examination is required of all entering graduate students. This examination will be offered prior to the fall registration period.

Master of Science for Teachers

The degree of Master of Science for Teachers is offered for candidates who satisfy the general admission requirements (see page 25) or who hold a secondary school teacher certification in physics or in general physical science. The course leading to this degree will normally be chosen so as to improve the candidate’s ability to teach physics or general physical science at the secondary school level. These courses should total at least 30 semester hours and should be chosen in consultation with the graduate adviser in physics. Persons interested in this degree should confer with the Department Chairman or the graduate adviser.

Master of Science Degree

For admission to graduate study in physics leading to a Master of Science Degree, the student should have completed 24 to 30 semester hours of undergraduate courses in physics. Suitable undergraduate preparation in mathematics is essential to graduate study in physics and should include differential equations, linear algebra, and advanced calculus. Candidates for admission are also required to take the Graduate Record Examination (both the aptitude test and the advanced test in physics). The results of this examination will be used in conjunction with transcripts to evaluate the applicant’s undergraduate training. The courses required for a Master of Science degree include Physics 833, 839, 841, and 843. Candidates may select one of the following two options:

a) Complete 30 semester hours of courses chosen in consultation with the graduate adviser.

b) Complete 24 semester hours of courses chosen in consultation with the graduate adviser, complete a thesis representing the equivalent of 6 semester hours work, and pass an oral examination on the thesis.

Doctor of Philosophy Degree

For admission to graduate study in physics leading to a Doctor of Philosophy degree, the student should satisfy the same general admission requirements as for a Master of Science Degree. In addition, he is expected to demonstrate an outstanding proficiency in undergraduate physics. Candidates for the degree must pass
Physics

the placement examination with distinction within one year of enrollment. Admission to candidacy for the degree is based on demonstrated ability in formal course work, satisfaction of the language requirement, and passing of a written and oral qualifying examination based on courses in the graduate physics curriculum. For students entering with a Master's degree, the qualifying examination must be taken within one year of enrollment; for students entering with a Bachelor's degree, the qualifying examination must be taken within two years of enrollment. Students are allowed two attempts to pass the qualifying examination. Finally, upon completion of a thesis, the doctoral candidates will take an oral examination based on his area of research.

The courses required for a Doctor of Philosophy degree consist of 831, 833, 839, 841-842, 843-844, and five courses selected as follows:

I. Two courses from any one of the following areas:
Area 1 835-836 Statistical Physics
Area 2 861-862 Quantum Mechanics
Area 3 863-864 Nuclear Physics
Area 4 865-866 Solid State Physics
Area 5 850, 852 Plasma Physics
Area 6 887-888 Cosmic Physics

II. Three additional courses chosen from the above list of areas. If a student elects area 5 or 6 to satisfy I, he must select three courses from Areas 1 through 4.

The language requirement consists of demonstrating a reading ability in one of the following foreign languages: German, French, or Russian. This requirement may be satisfied by any one of the following methods:


b) Satisfactory performance on the reading examination administered by the department.

c) After two attempts at either a) or b), the requirement may be satisfied only by the completion of a one-year course in the language.

Chemical Physics Option

Doctor of Philosophy candidates in physics may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Chemistry. In this option the doctoral student, with the advice of his guidance committee, elects courses in physics and chemistry (or, in some cases, mathematics), writes his dissertation on a research problem (experimental, theoretical, or both) appropriate to interdisciplinary treatment, and receives the doctorate in either physics or chemistry. In addition, each candidate must satisfy certain other requirements of the department in which the degree is granted. Ordinarily, students choosing the chemical physics option are expected to have undergraduate degrees in physics, chemistry, or mathematics, and reasonably strong backgrounds in the other two disciplines.

607. Physical Optics

The electromagnetic theory of light, interference, diffraction, polarization, related phenomena, and non-linear optics. Prerequisite: Mathematics 527 (Differential Equations). 4 credits.

701. Introductory Quantum Mechanics

Quantum mechanics with application to atomic and molecular spectra. Prerequisite: Mathematics 635 passed or taken concurrently. 4 credits.
702. Atomic and Nuclear Physics
Natural radioactivity, nuclear reactions, nuclear scattering, models of the nucleus, high energy nuclear physics, cosmic rays. Prerequisite: Physics 701. 4 credits.

703-704. Electricity and Magnetism I and II
Foundation of electromagnetic theory, including electrostatic, dielectric theory, electromagnetism, magnetic properties of matter, alternating currents. Maxwell's field theory, and an introduction to electrodynamics. Prerequisites: Physics 407-408 (General Physics I and II); and Mathematics 635 or equivalent passed or taken concurrently. 4 credits.

831-832. Mathematical Physics
Complex variables, differential equations, asymptotic methods, integral transforms, special functions, linear vector spaces and matrices, Green's functions, integral equations, variational methods, numerical methods, and tensor analysis. 3 credits.

833-834. Experimental Physics
Modern research techniques, including discussion and laboratory exercises in fundamental measurements in optics; electromagnetism; nuclear, atomic, and molecular phenomenon. 1-3 credits.

835. Statistical Physics I
A review of thermodynamics and kinetic theory, followed by an introduction to statistical thermodynamics. Prerequisite: Physics 831 or permission of instructor. 3 credits.

836. Statistical Physics II
Basic formulation and application of statistical mechanics to physical problems. (Offered on request.) Prerequisite: Physics 844. 3 credits.

837. Mathematical Physics
Formulation and solution of physical problems grouped according to their mathematical properties. (Offered on request.) Prerequisite: Physics 831-832. 3 credits.

839. Theoretical Mechanics
Newtonian, Lagrangian, and Hamiltonian formulation of the classical mechanics of particles and rigid bodies, with particular attention to those topics that serve as background for the study of modern physical theories. 3 credits.

841-842. Electromagnetic Theory
The formulation and detailed application of electromagnetic theory to physical problems. Prerequisite: permission of instructor. 3 credits.

843-844. Quantum Mechanics
Wave mechanical and Dirac formulations of non-relativistic quantum mechanics. Prerequisite: Physics 701, 839. 3 credits.

850. Plasma Physics I (Hydromagnetic Phenomena)
Steady state conditions, hydromagnetic waves, turbulence, shock waves, and individual particle motion will be discussed. 3 credits.

852. Plasma Physics II
A description of plasma physics from the kinetic theory point of view. (Offered on request.) Prerequisite: Physics 835. 3 credits.
861-862. Advanced Quantum Mechanics
Generalized formulation of quantum mechanics, formal scattering theory, and introduction to relativistic theory. Field theory and related topics. Prerequisite: Physics 839 and 844. 3 credits. (Offered alternate years, not offered 1971-72.)

863-864. Nuclear Physics
Formulation of theory underlying current experiments. Prerequisite: Physics 843. 3 credits. (Offered alternate years, not offered 1971-72.)

865-866. Solid State Physics
Development of quantum mechanical theory of solids, transport phenomena, etc. Prerequisite: Physics 843 and 835. 3 credits. (Offered alternate years; offered in 1971-72.)

887. Cosmic Physics I
Introduction to particle motion in the geomagnetic and interplanetary field, study of the energy-loss processes of energetic particles and their interaction with the earth's atmosphere; the earth's ionosphere and exosphere; and interplanetary physics. 3 credits.

888. Cosmic Physics II
General transport equations for energetic particle motion in the galaxy; structure and measurement of the interstellar medium; the origin of electrons, x-rays and gamma rays; and the introduction to cosmological problems. 3 credits.

889-890. Space Physics Seminar
Lectures and discussions of current research in the physics of fields and particles in space. 1-3 credits.

891, 892. Problems in Theoretical Physics
May be taken more than once. (Offered on request.) 3 credits.

893, 894. Problems in Experimental Physics
May be taken more than once. (Offered on request.) 3 credits.

895, 896. Special Topics
Any special fields of study not covered by the above courses may be included. Choice of topic to be determined by class. May be taken more than once. 1-3 credits.

897-898. Colloquium
Required of all graduate students. Topics to be selected. No credit.

899. Master's Thesis
6 credits.

999. Doctoral Research
Plant Science
(32)
Chairman: Lincoln C. Peirce

PROFESSORS: Gerald M. Dunn, C. A. Langer, Lincoln C. Peirce, Douglas G. Routley
ASSOCIATE PROFESSOR: Owen M. Rogers
ASSISTANT PROFESSORS: George O. Estes, Yun-Tze Kiang, J. Brent Loy, James E. Pollard, Otho S. Wells

The graduate research program in Plant Science is concerned with solving basic and applied problems associated with growth and response of crop plants to environment. Facilities include laboratories, field and greenhouse research areas, and plant growth chambers.

Program emphasis is directed toward breeding and genetics and toward crop physiology or biochemistry. Research and teaching in plant genetics, cytogenetics, and plant breeding is a major strength and is complemented by expanding University programs in statistics and genetics. (See description of Genetics Program.) Increased emphasis also is being given to research in plant physiology and plant biochemistry. In certain instances these research areas are integrated with the genetics projects to provide unique approaches toward solving fundamental problems.

It is recommended that all graduate students first complete work for the Master of Science degree. Candidates for this degree will be required to pass an oral examination and will be required to prepare a thesis. Candidates for the Doctor of Philosophy degree, in addition to the general requirements, must also demonstrate proficiency in a language approved by the major department. This requirement may be satisfied during graduate study or upon entering graduate school either by presenting 8 college semester credits with each course grade no less than B, or by passing a language examination approved by the Department. In general, German, French, Spanish, and Russian are considered acceptable for American students. Foreign students whose native language is not English will satisfy the language requirement by passing a qualifying English examination administered by the Department. A thesis on original research in the student’s area of specialization is required for the doctoral degree.

Advanced Plant Physiology
708. Plant Nutrition
Nutrient requirements of plants; ion uptake, translocation and accumulation mechanisms; role of elements in metabolic processes. Genetic and environmental factors governing nutrient absorption composition of plants. Mineral element and soil-plant relationships governing nutrient availability; growth, yield, and crop quality as influenced by nutrient status; characteristics and formulation of commercial fertilizers. Laboratory emphasis on analytical procedures and instrumentation for soil and plant tissue analysis. Mr. Estes. Prerequisite: Plant Physiology, Organic Chemistry, Soils. 3 lectures; 1 laboratory; 4 credits.

762. Plant Metabolism
The function, occurrence, synthesis, and degradation of plant constituents. Emphasis is placed on respiration and photosynthesis and the metabolism of nitrogenous and aromatic compounds. Biochemical mechanisms such as those involved in seed dormancy, fruit ripening, and disease resistance are discussed in relation to their roles in plant survival. Mr. Routley. Prerequisite: General Biochemistry. 2 or 4 credits.
769. **Plant Growth Regulators**  
Study of hormones and plant growth substances; relationships to differentiation and development of plant tissues. Mr. Routley. Prerequisite: Plant Physiology, Biochemistry. Laboratory optional. 2 or 4 credits. (Alternate years; offered fall 1971.)

863. **Plant Growth and Development**  
Designed for students with a sophisticated appreciation of plant physiology and biochemistry. Topics in growth and development will be studied through current research papers illustrating the sequential development of concepts and how they are presently conceived. Topics to be discussed include juvenility; senescence; assimilation; stress physiology; dormancy; flowering; fruit growth and ripening; tuber and bulb formation; environmental physiology as related to photosynthesis, photoperiodism, circadian rhythms, radiation, temperature and water relations; differential growth; growth regulators; organic translocation and mobilization. An optional laboratory involves a research project of the student's choosing. Prerequisite: plant physiology and biochemistry (or permission of instructor). Mr. Pollard. 3 lectures; 1 laboratory (optional); 3 or 4 credits.

**Advanced Offerings and Independent Studies**

706. **Plant Physiology**  
Structure and properties of cells, tissues, and organs; absorption and movement of water; metabolism; growth and irritability. Mr. Pollard and Mrs. Biggs
(Botany). Prerequisite: Botany 411 (General Botany), or Botany 503 (The Plant World), or Plant Science 421 (Concepts of Plant Growth), and one year of chemistry. 2 lectures; 2 laboratories; 4 credits.

776. Radioisotopic Techniques for Life Sciences
Fundamental concepts and laboratory practice on the application of radio-isotopes to biological systems. Techniques include detection and measurement principles, liquid scintillation spectrometry and autoradiography, gamma-ray spectrometry, radiochromatogram scanning, and tissue distribution of radio-isotopes in whole animals. Prerequisite: general inorganic chemistry and general physics. Mr. Estes. 2 lectures; 2 laboratories; 4 credits.

795, 796. Advanced Topics in Plant Science
A flexible course structure permitting independent study or group discussion of advanced technical or scientific topics. Students should consult with appropriate course coordinator before registering. 2-4 credits.
R-1 Physiology — Mssrs. Estes, Pollard, Routley
R-2 Genetics — Mssrs. Dunn, Loy, Peirce, Rogers
R-3 Plant Utilization — Staff

895-896. Research in Plant Science
Advanced investigations in a research subject, exclusive of thesis. Staff. 1-4 credits.

897-898. Graduate Seminar
Library research and discussion of current topics of Plant Science. Required of all graduate students majoring in Plant Science. Staff. 1 credit.

899. Master’s Thesis
A thesis requiring study in depth of a phase of Plant Science. Required of all master’s candidates in Plant Science. 6-10 credits.

999. Doctor of Philosophy Thesis
Dissertation reflecting independent research in a phase of Plant Science is required. Credit received upon completion.

Political Science (52)
Chairman: George K. Romoser

Professors: Robert B. Dishman, John T. Holden, George K. Romoser
Associate Professors: Erwin A. Jaffe, David L. Larson, Peter Savage, John Woodruff, Frederic Wurzburg
Assistant Professors: John R. Kayser, Lawrence W. O’Connell, Ann T. Schulz, Susan O. White

A candidate for admission to graduate study in the Department of Political Science is normally expected to have majored in Political Science or a closely related field as an undergraduate, and to have achieved an academic record of some distinction. In exceptional cases, however, the Department will waive this requirement, provided that the candidate will follow without credit a program of study agreed upon by the student and the departmental advisor and chairman. This waiver is usually reserved for the unusual student. The Graduate Record Exam is required.

The Department offers the Master of Arts in Political Science and the Master of Public Administration. The candidate in each of these programs is expected to
complete eight full courses of four credits each, for a total of thirty-two credits. Of these eight courses, it is recommended that two courses be taken in a related discipline, and more may be taken outside the Department with the approval of the adviser and the chairman. It is also expected that the candidate will develop an area of concentration among the fields offered by the Department: American Politics, Comparative Politics, International Relations, Political Thought, and Public Administration. The student is required to take Political Science 899, Directed Research and Study, in which he will write a research paper in his major field of interest. Where it is necessary to his program of study and research, the student must demonstrate capability in the relevant foreign language, or capacity in the tools of quantitative analysis.

To receive a master of Public Administration degree a candidate must complete eight full courses of four credits each, for a total of thirty-two credits. Of these eight courses, four will deal with the administrative process, two will be in statistics and research in government problems, and the remainder will be selected to suit the particular interests of the candidate. The degree is designed for individuals intending to pursue an administrative career. Candidates are expected to serve an internship for which they receive academic credit.

Candidates for advanced degrees are expected to take courses at 700 and 800 levels in Political Science and related disciplines, and to maintain a passing grade (B) in all courses.

Consult the Department for schedule of courses offered in a particular semester.

American Politics

715, 815. Urban and Metropolitan Politics
Planning, management, and problems of the urban community. Mr. O'Connell. 4 credits.

716, 816. Political Parties and Voting Behavior
Functions, organization, operation, and bases of electoral support of American political parties. 4 credits.

717, 817. Pressure Groups and Public Policy
Functions, organization, operation, and bases of support of American pressure groups. 4 credits.

718, 818. Psychology of Political Behavior
Cultural, social, economic, and emotional forces molding the citizen's political activity. 4 credits.

719, 819. Legislative Behavior
Role, organization, operation, and conduct of American legislatures. Mr. Dishman. 4 credits.

720, 820. The President as Political Executive
The American President's ways and means of pursuing political objectives. Mr. Dishman. 4 credits.

721, 821. Administrative Process
The administrative and bureaucratic process in public life. Mr. O'Connell, Mr. Savage. 4 credits.
722, 822. Administration of Justice
Criminal and civil justice under various legal institutions; contemporary role of police, prosecutors, judges, juries, counsel, and interest groups in the legal process. Mr. Dishman, Mrs. White. 4 credits.

723, 823. Supreme Court and the Judicial Process
The Supreme Court as interpreter of law and arbiter among forces in American politics. Mr. Dishman, Mrs. White. 4 credits.

724. 824. Political Socialization
Pressures integrating the individual into the context of American political life. 4 credits.

725. 825. United States Foreign Policy
The formulation and execution of American foreign policy. Mr. Larson. 4 credits.

727. 827. Selected Topics in American Politics
Courses in American politics of a special nature not regularly offered. Staff. 4 credits.

Comparative Politics

736, 836. Communist Systems
A comparative study of Communist politics. 4 credits.

737, 837, 738, 838. Comparative and International Area Studies
The politics of individual nations, groups of nations, or regions. The following listing of individual courses may be expanded or contracted from time to time, and courses will be offered as staff is available and student needs dictate: 1) Government and Politics of the U.S.S.R.; 2) Soviet Foreign Policy; 3) Government and Politics of China, Mr. Woodruff; 4) Government and Politics of Japan, Mr. Woodruff; 5) Contemporary South Asia, Mr. Holden; 6) Contemporary Southeast Asia, Mr. Holden; 7) Governments of Latin America, Mr. Larson; 8) Contemporary Politics in Europe, Mr. Romoser, Mr. Wurzburg; 9) Government and Politics of France, Mr. Wurzburg; 10) Government and Politics of Germany, Mr. Romoser; 11) Government and Politics of Canada, Mr. Woodruff; and 12) Government and Politics in the Middle East, Mrs. Schulz. 4 credits.

744, 844. Comparative Judicial Process
Comparative court systems and their relationships to political life; political, social, and structural influences on judicial behavior; law and human behavior. Mrs. White. 4 credits.

745. 845. Politics of Development
Concepts of political change viewed in relation to existing political situations. Mr. Savage. 4 credits.

746. 846. Comparative Administration
The history, organization, and potential of public bureaucracies as a political instrument. Mr. Savage. 4 credits.

747. 847. Selected Topics in Comparative Politics
Courses in comparative politics of a special nature not regularly offered. Staff. 4 credits.

International Relations

737, 837, 738, 838. Comparative and International Area Studies
See listing under Comparative Politics. 4 credits.
Political Science

755, 855. International Politics
Problems and choices confronting nation-states in dealing with conflicts of regional and international scope. Mr. Holden. 4 credits.

756, 856. Foreign Policies of the Great Powers
Application of foreign policies in the international political process. Mr. Holden. 4 credits.

758, 858. International Law
Theory, practice, and function of law in international disputes as analyzed from decisions of national and international tribunals. 4 credits.

759, 859. International Organization
Collective security and cooperation through international organizations such as the League of Nations, United Nations, and regional bodies. Mr. Romoser, Mr. Larson. 4 credits.

767, 867. Selected Topics in International Relations
Courses in international relations of a special nature not regularly offered. Staff. 4 credits.

Political Thought

775, 875. Classical and Medieval Political Thought
Origins of political philosophy in the West, and political thinkers from the Greeks to Machiavelli. Mr. Kayser. 4 credits.

776, 876. Modern Political Thought
Modern political theorists from Hobbes to Marx. Mr. Jaffe. 4 credits.

777, 877. Contemporary Ideologies and Political Thought
Liberalism, conservatism, and radicalism; contemporary ideologies of commitment and scientism and their implications. Mr. Romoser. 4 credits.

787, 887. Selected Topics in Political Thought
Courses in political thought of a special nature not regularly offered. Mr. Romoser, Mr. Jaffe, Mr. Kayser. 4 credits.

Scope and Methods

793, 893. Political Sociology
The social bases of political activity. 4 credits.

794, 894. Methods of Research in Political Behavior
Methodology and techniques in evaluating political behavior, surveys, experimental designs, and basic data processing. Aspects of computer technology and political research. 4 credits.

Independent Study and Seminars

795, 895. 796, 896. Independent Study
Research in various fields on subjects of special interest to the student, carried out under the instructor's supervision. Staff. 4 credits.
(1) American Politics
(2) Comparative Politics
(3) International Relations
(4) Political Thought
(5) Scope and Methods
Psychology

797, 897, 798, 898. Seminars
Small group discussion and examination of themes chosen by the instructor. 897 and 898 are offered independently from time to time as seminars limited to graduate student enrollment. Staff, 4 credits.
(1) American Politics  (4) Political Thought
(2) Comparative Politics  (5) Scope and Methods
(3) International Relations

899. Directed Research and Study
4 credits.

Psychology (67)
Chairman: Raymond L. Erickson

Professors: Raymond L. Erickson, George M. Haslerud, Frederick M. Jervis, Robert I. Watson
Associate Professors: Robert G. Congdon, Peter S. Fernald, Gordon A. Haaland, Earl C. Hagstrom, Ronald E. Shor
Assistant Professors: Gregory J. Bertsch, James R. Davis, Kirk E. Farnsworth, G. Alfred Forsyth, Leslie A. Fox, Burton I. Klinger, Daniel C. Williams

Doctor of Philosophy
The Department of Psychology offers a four-year program of study leading to the Doctor of Philosophy degree. The basic goal of the program is the development of behavioral scientists who can carry out sound research in an area of specialization and make meaningful contributions to the field of psychology. The rationale of the program requires that the development of specialized research competence take place within a larger context provided by theoretical and systematic psychology. In addition, a concern with other specific needs of the research psychologist who intends to become a college or university teacher is woven into the program. In his third year, the student has the opportunity to teach a small section of introductory psychology under close staff supervision while concurrently enrolled in a teaching seminar that has among its goals a deepening of the student’s appreciation of the objectives and problems of teaching in the liberal arts.
Areas in which the student may specialize are: History and theory, learning, physiological psychology, perception-cognition, personality, and social psychology. The student’s guidance committee will counsel with him to help plan an effective graduate program, which will typically require four years. Core courses taken by all students include methodology and statistics; history, theory, and systems in psychology; and the seminar and practicum in the teaching of psychology. Work outside the department also is included in each student’s program. Depth in a particular area is obtained through participation in the graduate offerings listed in Group II below, and by independent study and research conducted under the supervision of a staff member. Psychology 895, 896, Reading and Research in Psychology, is specifically designed to serve this purpose.
Prior to his doctoral dissertation, the student will carry out original research that culminates either in a master’s thesis or a paper of publishable quality. A Master’s degree may be awarded as part of the student’s program. Detailed information concerning language requirements and the qualifying examination for advancement to candidacy for the Ph.D. degree can be obtained from the department.
A student admitted to graduate study must meet the requirements for admission to the Graduate School. In applying for admission to the department’s program,
he must submit Graduate Record Examination scores on the verbal and quantitative sections of the aptitude test and his score on the advanced test in psychology.

To be accepted into the program, the applicant must desire to pursue the doctoral degree and be deemed qualified to do so on the basis of initial selection procedures. He need not necessarily have been an undergraduate major in psychology. However, before beginning his graduate career proper, he must have completed a minimum of 15 undergraduate credits in psychology, including courses in elementary statistics, experimental psychology, learning theory, and systematic psychology.

Preference in admission will be given to those who have recently received their bachelor's degree. Only under unusual circumstances will admission be granted to applicants who already hold a master's degree.

Graduate Curriculum in Psychology

The courses and seminars listed below provide the general framework within which the student will develop, with the counsel of his guidance committee, his program of research and study leading to the doctoral degree. The range and sequence of seminars will vary to some extent with each student, though there will be common features to all programs.

The 700-series courses are not normally taken for graduate credit, though a student may be advised to enroll in one of these courses as a way of improving his background in the field. Graduate credit for a 700-series course is permitted only with the previous approval of the student's adviser.

701 (701). Contemporary Topics in Psychology
A non-credit seminar focusing on topics of particular interest to students in psychology. Jointly organized by students and faculty to respond to requests of students. No credit.

751-752. The Development and Behavior of Man in the Social System
A systematic examination of normal and abnormal behavior in the context of the social system. Problems of development, personality, and abnormal behavior are considered in the context of social psychological variables. Significant topics are socialization, personality, theory, normal and abnormal behavior patterns, and social-influence processes. Prerequisite: Statistics. 4 credits.

758. Psychology of Learning and Motivation
The roles of learning and motivation are studied in relation to contemporary theories of behavior and integrated with other areas of psychology. Emphases are on theory, research methods, and applications. The major concepts and most recent research findings in the areas of learning and motivation are discussed. Prerequisite: Statistics. 4 credits.

778. Brain and Behavior
The study of relationships between the nervous system and behavior. The course examines the physiological, neural, and biochemical mechanisms underlying instinct, memory, learning, emotion, and consciousness in man, as well as the evolution of these functions in lower animals. Prerequisite: Statistics. 4 credits.

789 (789). Special Topics
Taught by a different staff member each year. The instructor presents advanced material in an area in which he has developed specialized knowledge through research and study. Students may repeat the course, but may not duplicate areas of specialization. Prerequisite: 16 major credits in Psychology or permission of instructor. 4 credits.
Psychology

794. The History of Psychology: An Integration
This course provides an opportunity for the major to reassess, extend, and integrate his knowledge of psychology within a historical perspective. Attention is given to antecedents in philosophy and the physical sciences and their relationship to the subsequent development of schools and systems of psychology. In addition, the course examines contemporary thought and research in the field. Normally taken during the senior year. Prerequisite: 20 major credits in Psychology or permission of instructor. 4 credits.

795 (795). Independent Study
This course provides the opportunity for a psychology major to pursue independent study with a member of the faculty. Arrangements are to be made with a specific faculty member, and enrollment is by permission only. 1-4 credits.

Graduate Courses in Psychology

Group I (to be taken by all first-year students)

801-802. Graduate Proseminar
Students and graduate faculty in psychology meet every two weeks for a mutual exchange on current issues in psychology. No credit.

803-804. History, Theory, and Systems in Psychology
The nature of the science; directed toward increasing the student's awareness of both the strengths and limitations of the approach that characterizes psychology as a behavioral science. Attention is given to the philosophical bases upon which psychological research rests, the nature of psychological inquiry, the history of the study of behavior, and the evolution of theory-building in psychology. Mr. Watson. 3 credits.

809-810. Research Methodology and Statistics I, II
A consideration of research techniques and problems of methodology in psychology. The first semester stresses the principles of statistical inference, correlational approaches, and their interrelatedness in design. Topics considered include probability theory, linear regression, function-free prediction, the theory underlying statistical inference, parametric and non-parametric tests of significance, and principles of analysis of variance. The second semester extends the correlational approach to the techniques and methodology of multiple regression and considers the appropriate use and theoretical bases of complex designs. Mr. Forsyth. Prerequisite: undergraduate Statistics and Experimental Psychology. 3 credits.

811. Research Methodology and Statistics III
A continuation of Psychology 809-810, covering computer techniques in statistical analysis, factor analysis, and other commonly used multivariate analytical techniques. Mr. Fox. 3 credits.

Group II

820. Measurement and Assessment
A seminar devoted to the nature of measurement in psychology. Emphasis is given both to the techniques for evaluating various assessment procedures and to the theory of data. Current issues in the problems of measurement will be discussed and the course will culminate in a project relating the area of measurement to specific content areas of interest to the student. Mr. Fox. Prerequisite: Psychology 811. 3 credits.
Psychology

338. Theories of Behavioral Change
An examination of man's behavior in the process of problem-defining and problem-solving. Recognizing that solutions to problems are based on the definitions of problems, the course examines the process by which problems are defined. The essential nature of functional fixedness or set in problem-solving is examined in relation to insight and creativity. The defining and solving of problems is related to changes in the individual, the organization, and the nation. The course recognizes that man's experiences and his actions are the result of how he defines and attempts to solve problems. Mr. Jervis. 3 credits.

341. Psychology of Personality I
The evolutionary development of the major personality theories, with particular reference to the theoretical, clinical, and experimental contributions to current theories. Mr. Fernald. 3 credits.

342. Psychology of Personality II
A seminar devoted to an examination of current approaches to the study of personality. Emphasis will be placed on evaluation of research findings in selected content areas. Students will be expected to develop their own areas of interest and to design research relevant to these areas. Mr. Klinger. Prerequisite: Psychology 841 or its equivalent. 3 credits.

343. Psycholinguistics
Issues relevant to the development, structure, and functions of language. Topics include the problem of meaning, acquisition of grammar by the child, personality and voice, and the interrelationship of language and culture. 3 credits.

351. Seminar in Social Psychology
A seminar devoted to theoretical and experimental support for major topics of current concern. These may include attitude change, power, interpersonal perception and attraction, roles, interaction, and analysis of structure and function in complex social systems. Staff. Prerequisite: Psychology 752 or its equivalent. 4 credits. (Also offered as Sociology 851.)

352. Theories of Attitude Change
An in-depth study of some of the current approaches to attitude development and change, with particular emphasis on recent theoretical issues. To be examined are theories emerging from the Gestalt tradition as well as those developing out of the classical- and operant-conditioning approaches. Mr. Williams. Prerequisite: Psychology 851 (Sociology 851) or permission of instructor. 3 credits.

353. Group Process and Social Influence
An examination of the problems of the individual in the group and the group as a system, with special emphasis on aspects of social influence. This course focuses on social influence as a decision-analysis problem with attention to topics such as conformity, leadership, bargaining and negotiation, group problem-solving, and other variables of group process. Mr. Haaland. Prerequisite: Psychology 851 (Sociology 851) or permission of instructor. 3 credits.

359. Physiological Psychology I
The examination of the concepts and research methods involved in the relationship between the nervous system and behavior. Topics examined include neuroanatomy and the physiological mechanisms of motivation and learning. Mr. Hagstrom, Mr. Davis. 3 credits.

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860. **Physiological Psychology II**  
Continuation of a two-semester sequence examining the concepts and research methods involved in the relationship between the nervous system and behavior. Topics examined include electrophysiological techniques and the analysis of coding in the sensory systems. Mr. Hagstrom, Mr. Davis. 3 credits.

861. **An Integration of Perceptual-Cognitive Processes**  
The ambiguous border between perception and cognition requires an inference of similar processes in the active organisms which operate on the overt world of stimuli and on the covert symbolic world of consciousness and memory. This course attempts to identify and integrate these processes so that from a unifying theory, perception and cognition can be seen as specialized differentiations in a perceptual-cognitive complex. Mr. Haslerud. 3 credits.

862. **Psychology of Perception**  
An information-processing approach to perception is taken. A study is made of the development of perceptual theory and its relationship to current perceptual research. Research and theory are examined as they pertain to issues such as: the definition of the stimulus, selective attention in perception, active vs. passive perception, the interactions between sense modalities in information-processing, the development of perception in the individual, methodologies and problems of measurement in perception, the role of adaptation in perception, parallel vs. serial processing of information, the role of peripheral and central mechanisms in perception, and the relationship of perception to other content areas in psychology. Opportunities are given for designing and running perception experiments. Mr. Forsyth. 3 credits.

863. **Cognitive Processes**  
A study of the complex mental processes which characterize man. Concept formation, reasoning, problem-solving, symbol use, creative thinking, imagination, fantasy behavior, pathology of thought, consciousness and its alternatives, and the relationship between cognition and effective behavior are among the topics examined in depth. Mr. Shor. 3 credits.

865. **Advanced Physiological Psychology**  
A seminar devoted to an intensive examination of specific topics relating behavior to its physiological correlates. Among the topics considered are receptor functions, cortical mechanisms, memory, neural correlates of drive states, emotional behavior, and intracranial stimulation. Mr. Hagstrom, Mr. Davis. Prerequisite: Psychology 859-860 or equivalent. 3 credits.

870. **Advanced Psychology of Learning**  
Problems in conditioning and other forms of learning. Emphasis is given to the evaluation of current experimental and theoretical literature. Mr. Erickson, Mr. Bertsch. Prerequisite: Psychology 758 or its equivalent. 3 credits.

**Group III**

891-892. **Seminar and Practicum in the Teaching of Psychology**  
Typical problems encountered in teaching psychology on the college level, including an examination of the implications of the liberal arts philosophy for teaching. Under close supervision of the staff, the student will be given an opportunity to teach an undergraduate section of introductory psychology. The seminar and practicum operate in close coordination throughout the year. Required of all doctoral students, typically during the third year. Mr. Fernald. 5 credits.
Psychology

895, 896. Reading and Research in Psychology
As part of his development as an independent scholar, the student is encouraged to plan: (1) broad reading in an area, (2) intensive investigation of a special problem, or (3) experimental testing of a particular question. The project may involve library research, empirical research, or both. Registration must be acceptable to the student’s guidance committee and to the staff member who has agreed to serve as his adviser on the project. May be repeated. (1) Physiological, (2) Perception, (3) History and theory, (4) Learning, (5) Social, (6) Cognition, (7) Statistics and Methodology. Staff. 3-6 credits per semester.

897, 898. Problems and Issues in Psychology
A seminar to be offered by one or more members of the staff, concerning problems and issues of special importance in the current development of the field. On occasion, the seminar will feature a problem which has been the subject of specialized research and study by a member of the staff. The personnel and topical focus will vary from year to year, and the course may be repeated by the student. Staff. 3 credits.

899. Master’s Thesis
Each student will carry out original research that culminates either in a master’s thesis or a paper of publishable quality. 6 credits.

999. Doctoral Research

Group IV (graduate courses offered primarily for students enrolled in other graduate programs)

822. Case Studies in Counseling
Case studies are used to illuminate the differences among a variety of personality theories and counseling techniques. The seminar is designed to help develop an appreciation of the complexities of human behavior, to gain increased respect for the integrity of individuals and their difficulties in revealing themselves to a counselor, and to understand better the difficulties encountered in applying theoretical knowledge to the counseling situation. Mr. Farnsworth. 3 credits. (Offered only in the summer.)

823. Individual Testing
Training in administration, scoring, and behavioral observation necessary for interpretation of individual tests of intelligence with discussion and demonstration of certain other instruments for cognitive measurement. The focus will be on children rather than adults, and on technique rather than interpretation. Each student will be required to purchase one set of test materials. Miss Riggs. Prerequisite: permission of instructor. (Student’s background in Statistics, Measurement, Exceptional Child, and Personality Theory will be evaluated by the instructor.) One lecture; one laboratory; 4 credits, to be granted only after the student has passed the companion course, Psychology 824 (Use of Individual Intelligence Tests).

824. Practicum in Individual Intelligence Testing
Supervised experience in use of individual intelligence tests in elementary and junior high school settings. Prerequisites: Psychology 823 or equivalent, and permission of instructor. 2 credits, to be granted only after the student has passed Psychology 825 (Use of Individual Intelligence Tests). Psychology 825 may be taken concurrently or subsequently.
825. Use of Individual Intelligence Tests
Interpretation and use of individual intelligence test results in relation to the
cognitive functioning of the child within the school setting. Emphasis will be
on taking into account background factors such as culture, emotional status,
meaning of the test to the child, and on ethical and administrative problems
connected with interpreting test results to parents and school personnel. Stu-
dents will have an opportunity to discuss case material from their actual daily
work. Miss Riggs. Prerequisite: Psychology 823, Psychology 824, which may
be taken concurrently; permission of the instructor. 3 credits.

Resource Economics
See Institute of Natural and Environmental Resources

Sociology (68)
Chairman: Murray A. Straus

A. Straus

Associate Professors: Melvin T. Bobick, Peter Dodge, Richard E. Downs, Bud B.
Khleif, Arnold S. Linsky, Fred Samuels

Assistant Professors: Thomas R. Burns, Robert M. Cabral, Matthew Cooper,
Richard L. Ingersoll, Amnon Orent, Howard M. Shapiro

Director of Graduate Studies: Peter Dodge

The Department of Sociology and Anthropology offers a program of graduate
study in Sociology leading to the degrees of Master of Arts and Doctor of Phil-
osophy. The Master of Arts curriculum is largely designed to give the student
the opportunity to acquire professional competence in the core areas of theory
and methodology; the Doctor of Philosophy program presents the candidate with
three substantive areas for possible specialization: social disorganization, social psy-
chology (in conjunction with the Department of Psychology), and comparative insti-
tutional analysis.

The student's proficiency in theory, statistics, and methods, and in the major
and minor areas of study is determined by examination. Within the context of a
curriculum organized largely in the form of seminars and research under the
supervision of assigned faculty members, the student is expected to select from
the Departmental specializations one major area for intensive study, and also with
the approval of his adviser and the Graduate Committee to design a minor area
tailed to his particular interests from the balance of the curriculum offered by
the Department—including anthropology courses. In addition, a student is expected
to give evidence of satisfactory performance in an extra-Departmental field that
has also been approved as appropriate to his professional development. The
design of a program most suitable to the individual will take into consideration
both his past experience and his intellectual goals, and, given the guidelines
sketched above, flexibility will be emphasized. The selection of thesis and disser-
tation topics is thus limited only by the areas of expertise available among Depart-
mental faculty members.

Upon establishing residence the student shall inform himself about any modi-
fications in the requirements of the degree program in which he is enrolled.
To be awarded the Master of Arts degree the candidate must fulfill the following requirements: (1) Complete satisfactorily at least one full year (24 credit-hours) of graduate-level course work including Sociological Methods I and II (801 and 802) and Sociological Theory I or II (811 or 812). (2) Register for one credit of thesis work during the second semester of residence and submit a draft of a proposal to the thesis committee by the middle of the semester. (3) Submit for approval a report of an original research endeavor to the thesis committee. This report may be in the form of either (a) a thesis, or (b) a paper in the form outlined in the publication format of any major sociological journal.

To be awarded the Doctor of Philosophy degree the candidate must fulfill the residence requirement of three years' work after the bachelor's degree, including: (1) A minimum of 12 courses in sociology, including Sociological Theory I and II (811 and 812); Sociological Methods I and II (801 and 802) and one other course in methods or statistics (which would normally be 803); three courses in a major area, and two in a minor area, of sociology. (2) A minor in a field other than sociology, consisting of three related courses. (3) Pass an oral and written examination in his major and minor areas of sociological specialization and in advanced theory and methodology. (4) Demonstrate advanced reading knowledge of a foreign language, defined as achieving a score of at least 550 on the Educational Testing Service language examinations. With the permission of his adviser and the Graduate Committee, a student may substitute for proficiency in a single language either: (a) intermediate reading knowledge of two languages (defined as a score of at least 450 on the ETS examinations), or (b) intermediate reading knowledge of one language and knowledge of a research tool not normally required of graduate students in sociology, such as symbolic logic, historiography, computer programming, econometric techniques, or mathematical statistics. (5) Fulfill the research and/or teaching requirement described below. (6) Write and defend an acceptable doctoral dissertation.

In planning his program of study the student will be advised at first by an assigned faculty member and, subsequently, in the case of doctoral students, by a guidance committee. Specially appointed committees will be organized for the direction and assessment of the thesis and dissertation. Under such supervision the student is expected to go considerably beyond the minimal common requirements of the graduate program to establish a knowledgeability and competency peculiarly his own, but he will be permitted to take courses outside the Department or below the 700-level within the Department only with the express permission of his adviser.

Students are encouraged to register for Reading and Research in Sociology and Anthropology (895, 896) to pursue their individual interests. Any and all course work, including required course work, may be satisfied through the directed study. Upon completion, work done under this rubric will be reported, in writing, to the Graduate Committee and the student's adviser by the faculty member who assumes the responsibility for supervising such activities, specifying (a) the area within which the work was done, and (b) the general content of the course experience achieved by the student.

In all cases, a student having knowledge equivalent to any of the required courses may substitute an examination to be given by the faculty member responsible for the course.

An important part of the graduate program is the opportunity to learn from participation in the teaching and research activities of the Department faculty. All candidates for doctoral degrees are therefore expected to assist a member of the Department in teaching and/or research. Assignments to work with a specific member will be made by the Graduate Committee on the basis of the student's experience, his needed areas of training, and the interests and preferences expressed by the students and faculty members.
To be accepted as a graduate student in sociology, the applicant must present, in addition to meeting the general Graduate School requirements, Graduate Record Examination scores on the verbal and quantitative sections of the aptitude test and his score on the advanced test in sociology. Undergraduate majors in other fields may be admitted. However, if the student's undergraduate work has not included an introductory course in sociological theory, research methods, statistics, and two other sociology courses, these five courses must be taken—or equivalent knowledge demonstrated through examination—in addition to the requirements outlined above.

Ordinarily, students will be admitted in the expectation of their completing the entire graduate program. Well-qualified applicants for a terminal Master of Arts degree, and applicants who have initiated their graduate work in sociology at another institution, will, however, be given full consideration.

703. Criminology

The scientific study and control of crime. The following are considered: indexes, rates and theories of crime and delinquency, police, courts, probation, prison, and parole. 4 credits.

720. Current Developments in Family Sociology

Study of the theoretical and empirical research on specific aspects of the family. A different topic will be selected each semester to reflect issues of current importance, for example: stratification and the family, intra-family communication, power structure of the family, kinship in modern societies. In addition to critical review of the literature, a class or individual research project will usually be carried out. Prerequisite: 8 credits of sociology; Sociology 520 (The Family) recommended. 4 credits.

721. The Social Psychology of the Family

Relationships of family members to one another and the influence of family interaction on human behavior. The interactionist and role approach is used. Research which relates to scientific knowledge of family interaction is analyzed. Prerequisites: 8 credits in sociology and/or psychology; Sociology 500 (Social Psychology) recommended. 4 credits.

727. Public Policy in Social and Labor Legislation

American social and labor legislation of the recent decades. An opportunity is provided to study the way in which American economic and human values have been implemented and modified by law. Attention will be given to legislation and private-industry programs in social security, reemployment, unemployment insurance, health services, training and retraining, and fair employment practice. Lectures, discussion, assigned reading, and individual student projects. Prerequisite: one year's work in economics or sociology. 4 credits. (Also offered as Economics 727.)

735. Complex Organizations

Analysis of the structure and dynamics of complex, formal organizations (business, military, political and governmental, and educational). Emphasis on the construction of theory to account for the findings of empirical studies, both historical and comparative. Special problems treated in the course: power and social control in formal systems; organizational processes, performances, and effectiveness; impact of complex, formal organizations on persons and societies. Prerequisite: permission of instructor. 4 credits.

740. Culture Change

Various types of society are studied with a view to the development of a theory of culture change. Descriptive studies of institutional as well as theoretical
Sociology

materials, selected from the writing of Comte, Marx, Spencer, Durkheim, Spengler, Sorokin, Redfield, and others. Prerequisite: Sociology 400 (Introductory Sociology) or permission of instructor. 4 credits.

741. Social Change and Societal Development
Comparative, interdisciplinary approach to the study of social change. The course focuses on the interrelationships among economic, political, and social factors in determining the structure, dynamics, character, and level of development of societies. Prerequisite: permission of instructor. 4 credits.

745. Social Stratification
The pattern of distribution of economic, honorific, and political variables within the populations of complex societies; the allocation of personnel to the roles in question, notably through occupational mobility; and the impact of such processes upon behavior, both individual and social. Prerequisite: junior standing and Sociology 400 (Introductory Sociology). 4 credits.

751. Sub-Saharan African Social Systems
The stress will be on the analysis of segmentary and non-segmentary systems in terms of their variation throughout the continent. The focus will be on "how" these societies solve the problems of daily living in terms of the tribe, clan, and lineage. Prerequisite: Sociology 400 or 411 (Introductory Sociology or Cultural Anthropology). 4 credits.

752. Social Problems in Modern Africa
The focus will be on urban and rural adjustments (acculturation) of tribal systems in Africa (below the Sahara) to the 20th century. This course is a follow-up of Sociology 751, although the latter is not a prerequisite. Prerequisite: Sociology 400 or 411 (Introductory Sociology or Cultural Anthropology). A background in sociological theory and methods is desirable. 4 credits.

755. Ethnography of Southeast Asia
The geographical, racial, cultural and historical factors in the development of the area, together with detailed examinations of selected peoples and aspects of their culture. Prerequisite: Sociology 411 (Cultural Anthropology) or permission of instructor. 4 credits.

757. Social Institutions of Latin America and the Caribbean
Selective analysis of distinctive institutions and social systems, with particular attention to social aspects of the process of modernization. Prerequisite: permission of instructor. 4 credits.

761. Population Dynamics
Examination of major population trends, including changes in birth and death rates, population characteristics, mobility, migration, world population growth, population problems, and policies of countries at different stages of economic development. Emphasis is on the interrelationship of population and society. 4 credits.

770. Culture, Personality, and Society
Emergence of personality from the matrix of genetic, situational, and sociocultural determinants viewed in cross-cultural perspective; dynamic interplay of the sociocultural and psychological behavior systems. Prerequisite: any two courses from Sociology 400, 411, or Psychology 401 (Introductory Sociology, Cultural Anthropology, or Introduction to Psychology). 4 credits.
780. Social Conflict
The nature of social conflict, especially war, will be investigated. The setting and initiation of conflict, its dynamics, and the factors affecting its course and outcome will be analyzed. Prerequisite: permission of instructor. 4 credits.

785. The Study of Work
This course is centered on the assumption that to understand society, one needs to understand the structure of work. Case studies of high-status and low-status occupations are used as clues to a larger perspective—an awareness of social processes and interrelationships in the social structure. The student is encouraged to study occupations in an ethnographic manner. Graduate students may enroll only with permission of instructor. 4 credits.

801. Sociological Methods I. Intermediate Social Statistics
Application of descriptive and inductive statistical methods to the analysis of sociological data, including sampling distributions, statistical decision-making, analysis of variance, correlation and regression, and nonparametric measures. Prerequisite: Sociology 601 (Methods of Social Research) or permission of instructor. 4 credits.

802. Sociological Methods II. Research Design
Systematic investigation of each step in the design and implementation of sociological research. Selected techniques of data collection and analyses will be pursued. Prerequisite: Sociology 601 (Methods of Social Research) and 602 (Social Statistics) or their equivalent, or permission of instructor. 4 credits.

803. Sociological Methods III. Special Problems in Methods and Statistics
Attention is focused on one or more special problems in sociological research, such as the following: measurement and scaling, field and laboratory experiments in sociology, multivariate analysis, historical methods, community studies, mathematical models in sociological research, and survey design and analysis. Prerequisite: Sociology 801, and Sociology 802 or Psychology 809. 4 credits.

805. Sociology as a Profession
Sociological analysis of teaching and research in sociology, including the social organization of the discipline and social-psychological aspects of careers in sociology. Although primarily a seminar on the sociology of science and the sociology of education, the materials covered also provide professional orientation for a career in sociology. Prerequisite: a year of graduate study in sociology. 4 credits.

811. Sociological Theory I
The content, presuppositions, and implications of the body of sociological theory, exemplifying the full range of sociological inquiry. Prerequisites: Sociology 611 (History of Social Theory) and 612 (Contemporary Sociological Theory) or their equivalents. 4 credits.

812. Sociological Theory II
The content, presuppositions, and implications of contemporary sociological theory. The student will engage in theory construction and analysis, and in this endeavor will be encouraged to develop his particular interests in substantive areas. Prerequisite: Sociology 811. 4 credits.

813. Sociological Theory III
A seminar of intensive study of specific figures and movements in sociological theory. Sample topics include: Max Weber; evolution, pragmatism, and reform and classical social theory. Prerequisites: Sociology 611 (History of Social Theory).
Sociology

Theory) and 612 (Contemporary Sociological Theory) or their equivalents. 4 credits.

821. Deviant Behavior
A seminar in which attention is directed to the relationships among cultural, subcultural, and personality variables and deviant behavior. Special emphasis is placed on the following forms of deviant behavior: invention, crime, alcoholism, and emotional illness. Prerequisite: permission of instructor. 4 credits.

830. The Small Group
The small group as a unit for sociological study, for the testing and the developing of hypotheses. Both the behavioral and the attitudinal levels shall be considered with respect to group interaction and group-to-group interaction. The effects of different independent variables upon group structure shall be of particular interest. Prerequisite: a course in social psychology, or permission of instructor. 4 credits.

838. Sociology of Education: Social Organization of Schools and Community
This course emphasizes viewing schools in their socio-cultural context; it is centered on a number of field studies of urban and suburban communities. Among the topics discussed are the following: (a) Comparative institutional analysis—what is church-like, hospital-like, factory-like, and prison-like about the school; (b) relations and perspectives of functionaries and clients in culturally deprived and culturally endowed settings; and (c) teaching as an emergent profession. 4 credits. (Also offered as Education 838.)

851. Seminar in Social Psychology
A seminar devoted to theoretical and experimental support for major topics of current concern. These may include attitude change, power, interpersonal perception and attraction, roles, interaction, and analysis of structure and function in complex social systems. Prerequisite: permission of instructor. 4 credits. (Also offered as Psychology 851.)

852. Socialization and Abnormal Behavior
A seminar concerned with socialization and the effects of socialization on abnormal behavior. A survey of those orientations that relate socialization to abnormal behavior with the aim of synthesizing the major concepts into current sociological and social-psychological frames of reference. In addition, emphasis will be placed on the methodological problems of research concerned with socialization. Prerequisite: at least one course in social psychology or permission of instructor. 4 credits.

854. Sociology of Religion
Critical analysis of the reciprocal relationship of religion and culture; the function of religion in society; the contributions of sociological research; the relationship between religion and other social institutions; religion and social change; and the problem of church and state. 4 credits.

861. Demography
Survey and analysis of current problem areas in demography, including: fertility, mortality, migration, population growth, population theory, formal demography, and the use of demographic sources and techniques in sociological investigation. Prerequisite: Sociology 761 or permission of instructor. 4 credits.

870. Comparative Institutional Analysis
Theoretical and methodological aspects of cross-national, comparative research in sociology, including: history of comparative research, examination of differences in objectives and methods employed, problems of translation and con-
ceptual equivalence of behaviors and indexes, and field techniques. Prerequisites: Sociology 601 (Methods of Social Research) and 602 (Social Statistics). 4 credits.

885. Occupations and Professions
Professionalization is discussed as adult socialization, an acquisition of a new identity; professions are explored as ideologies and as extended families. Low-status and high-status occupations are compared with regard to the way their members are recruited and trained, their career stages, work problems, and role-sets. A symbolic interactionist approach is adopted; issues of work are considered in their socio-cultural and institutional contexts; a number of the Chicago studies of occupations are examined. 4 credits.

888. Sociology of Education: The Cultures of Poverty and Affluence
The two cultures are treated as a unit; culture change is discussed. Issues of current interest are explored, e.g., poverty, school desegregation, the schooling of geographically-mobile children, problems of social mobility and abundance, the rise of the counseling and healing trades, and teachers’ quest for professionalism. The education of culturally deprived and culturally endowed children receives special attention. A comparative approach is adopted; issues are examined cross-cultural and in relation to the schooling process. 4 credits. (Also offered as Education 888.)

889. Sociology of Education: Race and Ethnic Relations in Schools and Society
This course deals with ethnic stratification and inter-group processes both inside and outside the school. The public schooling of disadvantaged groups such as black, Indian, white Appalachian, and Mexican Americans receives special attention. Caste and class relations between schoolmen, parents, and pupils are examined within such contexts as slums, reservations, Levittowns, and “golden ghettos.” A socio-anthropological perspective is emphasized. 4 credits. (Also offered as Education 889.)

895, 896. Reading and Research in Sociology and Anthropology
A student prepared by training and experience to do independent work under the guidance of an instructor may register for one or more of the following sections: (1) communications, (2) criminology, (3) cultural/social anthropology, (4) culture change, (5) culture and personality, (6) deviant behavior, (7) pre-historic archeology, (8) family, (9) population, (10) rural-urban, (11) social control, (12) social differentiation, (13) social movements, (14) social psychology, (15) social research, (16) social theory, (17) anthropological linguistics. Prerequisites: 16 graduate hours of sociology and permission of instructor. Hours and credit to be arranged.

897, 898. Special Topics Seminar
Under the direction of members of the department on the basis of rotation and interest, seminars are offered in those fields listed under Sociology 895, 896. Prerequisite: permission of instructor. 4 credits.

899. Master’s Thesis
Usually 6 credits, but up to 10 credits when the problem warrants.

999. Doctoral Research
Spanish and Classics

Soil and Water Science
See Institute of Natural and Environmental Resources

Spanish and Classics
Chairman: Michael S. Pincus

PROFESSOR: R. Alberto Casas
ASSOCIATE PROFESSORS: Richard J. Callan, Charles H. Leighton, Michael S. Pincus

The Department of Spanish and Classics offers courses leading to two degrees in Spanish, the Master of Arts and the Master of Science for Teachers. To be admitted to graduate study for the Master of Arts degree in Spanish, a student must have met requirements substantially equal to those set up for an undergraduate major in that language at the University. In addition, all candidates for admission to the graduate program in Spanish must take the general Graduate Record Examination and the advanced test in Spanish. To obtain the degree, the student must fulfill the course requirement and submit an acceptable thesis.

To satisfy the course requirements, he must complete at least eight courses of three or four credits, six of which must be from the courses listed below (six credits are granted for the thesis, thus completing the minimum of thirty credits required by the Graduate School).

To take a course numbered 850-898, a student must register for the corresponding undergraduate course numbered 750-798, pass it with a grade of B or better, do supplementary work assigned by the instructor, and prepare a paper of graduate quality on a topic assigned by the instructor. No student may register for a graduate course if he has already taken the corresponding undergraduate course here or its equivalent elsewhere.

Before undertaking work on the thesis, the student must pass a comprehensive written examination. The examination will be given four times a year: in January, May, August, and September. The candidate will be permitted to take the examination only twice. If he fails in his first attempt, he must wait at least three months before taking it again. The thesis must embody the results of independent investigation and be written in a form acceptable to the department. It must be submitted to the thesis director six weeks before expected time of degree conferral.

To be admitted to graduate study for the Master of Science for Teachers degree in Spanish, a candidate must have satisfactorily completed the requirements for secondary school teacher certification in the language. To obtain the degree, he must complete 30 semester hours of work at the graduate level. Since it is intended for teachers already in service, courses leading to this degree will normally be chosen from Summer Session offerings. Secondary school teachers interested in this degree should consult the Department Chairman.

Spanish (62)

701, 702. Catalan
An introduction to Catalan grammar and literature. Semester I: study of the linguistic elements of Catalan, especially in its contrasts with other Romance languages, and basic readings in Catalan. Semester II: a survey of Catalan literature from the Middle Ages to the present. Prerequisite: completion of an intermediate-level course in Latin or one of the Romance languages, or permission of instructor. 4 credits.
752. Drama and Poetry of the Siglo de Oro
The social background of the Baroque period. Readings of representative plays of Lope de Vega, Tirso de Molina, Calderon, and the poetry of Lope, Gongora, and Quevedo. Development of the prose of the period. Conducted in Spanish. 4 credits.

754. Cervantes
The development of Cervantes' literary art. Reading and discussion of selections from all the major works of Cervantes. Comprehensive study of the Quijote, its originality and significance; its antecedents; its religious, philosophical and sociological aspects; and its artistic structure. Conducted in Spanish. 4 credits.

757. Theater and Poetry of the Twentieth Century
Critical analysis, reports, and discussion of the major developments in poetry and the drama of the twentieth century, beginning with the Generation of '98. Major writers to be studied will include Benavente, Machado, J. R. Jiménez, García Lorca, Casona, Sastre, Buero Vallejo, Dámaso Alonso, and Miguel Hernández. Conducted in Spanish. 4 credits. (Offered alternate years.)

758. Spanish Prose of the Twentieth Century
Readings and discussion of the novels, short stories, and essays of such major writers of the twentieth century as Unamuno, Baroja, Menéndez Pidal, Ortega y Gasset, Julián Marias, Aranguren, Pérez de Ayala, Gironella, and Cela, as well as a survey of contemporary prose. Conducted in Spanish. 4 credits. (Offered alternate years.)

760. Unamuno and Ortega y Gasset
Critical examination of the philosophical ideology and literary content of the major contributions of Miguel de Unamuno and José Ortega y Gasset. 4 credits. (Offered alternate years.)

771. Spanish-American Drama
From pre-Hispanic origins to the present, with emphasis on the modern playwrights of Mexico and Puerto Rico. Conducted in Spanish. 4 credits. (Offered alternate years.)

772. Spanish-American Novel
Development of the genre from Romanticism to present-day writers, with special emphasis on contemporary trends and techniques. Conducted in Spanish. 4 credits. (Offered alternate years.)

773. Spanish-American Short Story
Development of the genre through study of representative authors, with stress on the twentieth century. Principles of interpretation. Conducted in Spanish. 4 credits. (Offered alternate years.)

774. Spanish-American Poetry
Discussion of major poets from modernismo to the post-Vanguard movements: Dario, Huidobro, Mistral, Vallejo, Octavio Paz. Conducted in Spanish. 4 credits. (Offered alternate years.)

801. Bibliography and Methods of Research
Required of all graduate students in their first year of study. An introduction to standard bibliographical techniques, to form and style in the preparation and writing of research findings, and to the use of computers in research in the Spanish language and literatures. Preparation of a research paper. 1 credit.
803. Applied Linguistics
   Required of all graduate assistants teaching in the departmental program, but
   open to all graduate students in Spanish. Discussion of current methodology
   and linguistic approaches to the teaching of Spanish. Instruction in the use of
   audio-visual aids, including language laboratories. Readings, discussion, class
   observation. 1 credit.

811. Medieval Spanish Literature
   Study of a topic or topics in Spanish literature of the period 1100-1500. Works
   normally to be studied include Berceo, the Libro de buen amor, the poetic
   schools of the 15th century, and La Celestina. Social and historical backgrounds
   of the period. Conducted in Spanish. 3 credits. (Offered alternate years.)

831. River Plate Literature
   Sarmiento, José Hernández, Rodo, Florencio Sanchez, Mallea. Focus on the
   question of argentinidad. Conducted in Spanish. 3 credits. (Offered alternate
   years.)

891. Spanish-Education: Problems in the Teaching of Spanish in the
   High School
   The special objectives, methods, and devices of modern-language teaching in
   high school. For prospective or actual teachers of Spanish. Prerequisite: inter-
   mediate Spanish; and grade of C or better in Education 658 or one year's
   teaching experience. 3 credits.

895, 896. Special Studies in Spanish Language and Literature
   Individual guided study in special topics, with training in bibliography, note
   taking, and organization of material. Staff. Conducted in Spanish. Prerequi-
   site: permission of Department Chairman. Variable credit.

899. Master's Thesis
   6 credits.

Technology (79)
Dean: Richard S. Davis

601. Statistical Methods in Engineering and Physical Science
   Methods of organizing data and statistical techniques for data analysis, as applied
   to problems in engineering and physical science. Elementary probability theory,
   probability distributions, tests of significance, correlation, and regression analysis.
   Design of experiments; completely randomized blocks; factorials, fractional
   factorials; process optimization. Introduction to quality control; construction
   and analysis of control charts for variables and attributes; statistical aspects
   of tolerance. 4 credits.

610. Introduction to Ocean Technology
   This course will be conducted on a seminar basis. It will deal with engi-
   neering problems arising in various fields of current oceanographic interest.
   Typical areas will be marine biology, saturation diving systems, and physical
   oceanography. In addition to the engineering faculty directing this course, other
   experts in the fields of ocean science and engineering will be invited to partici-
   pate. Prerequisite: permission of instructor. 4 credits.
683. Technology: Role and Function in Society
Examination of the impact of technology on the physical, social, economic, and political environment and the constraints imposed by these on engineering systems design. Course work will include readings in the history of technological growth and in current effects of the interaction between environment and technology, seminar and workshop discussions, and position papers on selected topics. Each student will, in lieu of a final examination, evaluate an engineering system design with respect to environmental impact. Prerequisite: senior or graduate status within the College of Technology. 4 credits.

Zoology (70)
Chairman: Langley Wood

ASSOCIATE PROFESSORS: Arthur C. Borror, Frank K. Hoornbeek, Marcel E. Lavoie, John J. Sasner, Paul E. Schaefer

The graduate program in Zoology is intended for the student who aspires to a professional career of scholarly research and teaching at the college level. The graduate program in Biology is designed for teachers in secondary schools.

To be admitted to graduate study in Zoology, a student must have completed an undergraduate major in biology or zoology. In addition to a basic array of courses in the major field, applicants should have a satisfactory background in botany, chemistry, mathematics, and physics. Two foreign languages (usually French, German, or Russian) or the equivalent are also necessary, and satisfaction of the language requirement is prerequisite to candidacy for the degree of Doctor of Philosophy. Students who are deficient in any of these requirements may sometimes be admitted to graduate status but may be required to remedy their deficiencies by taking courses which do not give graduate credit.

All beginning graduate students in Zoology will be required to pass an examination, both written and oral, in General Biology plus four of the following eight fields: Behavior, Biochemistry and Physiology, Development, Ecology, Evolution and Systematics, Genetics, Morphology, and Parasitology. Normally, this examination will be passed by the end of the second year of graduate work, but must be taken during the first year of residence. This examination may function in partial satisfaction of the master's degree requirements, or to identify academic deficiencies in students who wish to proceed to doctoral candidacy. If the deficiencies revealed are regarded by the Zoology faculty as sufficiently serious, the student's tenure may be terminated, or he may be allowed a second examination after additional preparation.

A candidate for the Master of Science degree in Zoology, in addition to the requirements mentioned above, will ordinarily complete a special problem (Zoology 895 or 896) or a thesis that is acceptable to his guidance committee.

In addition to the language requirements, and after the successful completion of all required courses, the student who wishes to be admitted to doctoral candidacy must demonstrate a broad basic knowledge of his major and minor fields in an oral qualifying examination, administered by his doctoral committee. In addition, he must convince his proposed major professor and doctoral committee, in whatever way the committee finds acceptable, of his superior capacity to carry
out basic research in biology. Normally, the student may accomplish this by presenting to his committee a research proposal in which the soundness, originality, and feasibility of his investigative ideas are clearly revealed, and which—when approved—serve as the basis of his doctoral dissertation.

(700). Research Methods
A workshop introduction to the process of biological investigation. Includes presentations of current research by members of the Zoology faculty; critical discussions of the philosophy and history of biological investigation; methods and practice of literature search and the handling of bibliographic data; and lectures and laboratories in scientific writing. Each student will prepare written and oral presentations of a review of a selected biological topic. Required of all beginning Zoology graduate students; permission of instructor required. Mr. Wood and staff. 4 credits.

703. Genetics
Comparative analysis of genetic systems, with emphasis given to diploids and the role of gene and chromosome mutations in their evolution. Evolution of dominance and sex determination. Laboratory emphasizes general analysis of diploid inheritance, with experimental and statistical approaches. Mr. Hoornbeek. Prerequisite: Zoology 604 (Principles of Genetics) or equivalent. 4 credits.

704. Comparative Endocrinology
The various endocrine organs are considered in their relationship to control of the internal environment, growth, development, and adaptation to the external environment. Mr. Tillinghast. Prerequisites: vertebrate anatomy and physiology, and organic chemistry. 4 credits.

711. Natural History of Cold-Blooded Vertebrates
The various classes of poikilothermic vertebrates, their habits, habitats, and life histories, with special reference to those occurring in eastern North America. Mr. Sawyer. Prerequisites: general zoology and Zoology 518, (Vertebrate Morphology). 4 credits.

(712). Mammalogy
The origin and diversification of mammals, their ecology and economic importance. Laboratories will emphasize techniques of the mammalogist and identification of local forms. Mr. Francq. Prerequisites: general zoology and Zoology 508 (Human Anatomy and Physiology). 4 credits.

(713). Animal Behavior
Individual and group behavior of animals, including the role of anatomy, physiology, and prior experience, and the ecological significance of these patterns. Techniques and the practical application of the study of animal behavior. Mr. Francq. Prerequisite: one year of zoology. 4 credits. (Not offered 1971-72.)

715. Natural History of Marine Invertebrates
A field and laboratory course designed to acquaint the student with the inshore marine invertebrate metazoan animals of northern New England. Emphasis will be on identification, classification, habitat preferences, and behavior of these animals. Field work (collection and observation) will constitute a major part of the course, and the student must be prepared to assume some travel expense. Staff. Prerequisite: general zoology. 4 credits. (Offered in Summer 1971.)
(721). Parasitology
An introductory course in some of the more important parasites causing disease of man and animals. Living materials will be used as far as possible. Mr. Bullock. Prerequisite: one year of zoology. 4 credits.

723. Cell Physiology
Application of the principles of chemistry and physics to the understanding of cell structure and function. Metabolic reactions and their control are considered in relation to cell organization. Treatment is also given to the genesis and function of specialized cells. Mr. Tillinghast. Prerequisite: organic chemistry. 4 credits.

726. General Physiology
A study of some of the physical and chemical phenomena common to all biological systems. Special emphasis is placed on membranes, permeability, excitability, conductivity, contractility and bioenergetics. Mr. Sasner. Prerequisites: organic chemistry, physics, and one year of zoology. 4 credits.

729. Vertebrate Morphogenesis
The fundamental principles of vertebrate growth and development, including embryogeny, metamorphosis, senescence, and regeneration. Mr. Foret. Prerequisites: Zoology 527 (Vertebrate Physiology) and 604 (Principles of Genetics) or equivalent. 4 credits.

772. Fisheries Biology
Designed to introduce the student to some of the information and techniques used by the freshwater fisheries biologist. Emphasis on freshwater fisheries, but many of the techniques and some of the reading pertain as well to salt water fisheries. Mr. Sawyer. Prerequisites: Zoology 711 or equivalent, and permission of instructor. 4 credits.

795, 796. Special Problems in Zoology

801. Freshwater Ecology
An introduction to some of the chemical, physical, and biological facets of the special relationships between freshwater organisms and their environment. Laboratories will include limnological techniques and others necessary for analyzing the variations in freshwater habitat. Mr. Sawyer. Prerequisite: Biology 641 (General Ecology) or equivalent; courses in physics, chemistry, invertebrate and vertebrate zoology, geology, algology, and aquatic entomology are desirable. 4 credits.

(803). Marine Ecology
The marine environment and its biota, with emphasis on intertidal and estuarine habitats. Laboratory and field work will stress inquiry and the application of ecological, physiological, behavioral, biometrical, systematic, and chemical techniques to local problems. Field trips may be scheduled for early morning,
late afternoon, or weekends. Travel will be at student's expense, and should not exceed $30 for the course. Mr. Croker. Prerequisites: Biology 641 (General Ecology) and permission of instructor; courses in marine invertebrate zoology, oceanography, and statistics are desirable. 4 credits.

806. Biological Oceanography
The ocean as an environment for life, emphasizing oceanic populations, their interrelationships, and their adaptations to an oceanic existence. Field work will include short cruise in the Gulf of Maine aboard R/V "Jere A. Chase," in addition to a longer cruise aboard R/V "Eastward" in the Gulf Stream and Sargasso Sea. Mr. Wheeler. Prerequisites: Earth Science 501 (Introduction to Oceanography) or the equivalent and instructor’s permission. 4 credits.

815. Population Ecology
Lectures and seminars dealing with the evolution, genetic theory, differentiation, and functioning of animal populations. Current literature and research methods will be reviewed. Mr. Wheeler. Prerequisites: one semester of ecology and genetics; courses in calculus and statistics are desirable. 1 lecture; 1 seminar; 4 credits.

(820), (821). Advanced Invertebrate Zoology
A detailed and comprehensive study of the morphology, phylogeny, and natural history of the major invertebrate phyla in lecture and laboratory. Staff. Prerequisite: Zoology 618 (Introduction to Invertebrate Zoology) or equivalent. 4 credits. (Not offered 1971-72.)

(822). Protozoology
The general biology of Protozoa, with particular emphasis on morphology, natural history, and economic importance. Mr. Borror. Prerequisite: Zoology 721 or 820 or permission of instructor. 4 credits.

823. The Host-Parasite Relationship
Examination of the interactions of host and parasite, using examples from fish, wildlife, and human parasitology. Particular attention will be given to ways in which host ecology influences parasite populations, and the interplay of host and parasite in parasite pathology and immunology. Mr. Bullock. Previous training in parasitology, histology, and ecology desirable. 4 credits.

(824). Advanced Parasitology
The morphology, life cycles, and systematics of the protozoan and helminth parasites of local fishes, with particular reference to the estuarine environment. Mr. Bullock. Prerequisite: Zoology 721. 4 credits. (Not offered in 1971-72.)

826. Comparative Physiology
The means whereby animals, chiefly invertebrate, have met the problems of irritability, nutrition, maintenance of a constant internal environment, and reproduction. Mr. Sasner. Prerequisite: Zoology 725. 4 credits.

828. Experimental Embryology
An examination of cellular differentiation during developmental processes. Laboratories will illustrate important techniques in experimental morphogenesis. Mr. Foret. Prerequisite: Zoology 729 or equivalent. 4 credits. (Not offered in 1971-72.)

830. Invertebrate Embryology
The developmental patterns as exhibited by the major invertebrate groups. This will be essentially a descriptive study based upon lectures, library, and
laboratory work with living material. Staff. Prerequisites: Zoology 820, 821. 4 credits. (Offered in Summer, 1971.)

895, 896. Advanced Studies in Zoology
The sections of this course provide opportunity for advanced work either on an individual or group seminar basis. They may involve reading, laboratory work, organized seminars, and conferences. Prerequisite: permission of Department Chairman and staff concerned. (Sections of this course are the same as those listed under Zoology 795, 796.) 2 or 4 credits.

897, 898. Zoology Seminar
Preparation, presentation, and discussion of reports of recent zoological literature. Subject matter fields are the same as those listed under Zoology 795, 796. Not all areas will be available every semester. Required of graduate students in zoology. Staff. No credit.

899. Master's Thesis
Open to students who wish to do independent, original research. Prerequisite: permission of Department Chairman and prospective supervisor. 6 credits.

999. Doctoral Research
Open to students who have declared their intention of proceeding to candidacy for the Doctor of Philosophy degree.
Faculty of the Graduate School

Allen, Fred E.
Professor of Animal Science and Veterinarian
B.S., University of New Hampshire, 1932; B.V.M., Ohio State University, 1936. Appointed 1940.

Allmendinger, E. Eugene
Associate Professor of Mechanical Engineering

Alperi, Robert W.
Assistant Professor of Mechanical Engineering

Amell, Alexander R.
Professor of Chemistry
B.S., University of Massachusetts, 1947; Ph.D., University of Wisconsin, 1950. Appointed 1955.

Andersen, Kenneth K.
Professor of Chemistry

Anderson, Kenneth K.
Assistant Professor of Geology

Andrew, Michael D.
Assistant Professor of Education

Andrews, Richard A.
Associate Professor of Resource Economics
B.S., University of Maine, 1949; M.S., Pennsylvania State University, 1951; Ph.D., University of Minnesota, 1959. Appointed 1959.

Annis, William H.
Associate Professor of Agricultural Education

Arnoldy, Roger L.
Associate Professor of Physics
B.S., St. Mary's College, 1956; M.S., University of Minnesota, 1959; Ph.D., ibid., 1962. Appointed 1967.

Ashley, Charles H.
Assistant Professor of Education

Austin, Gilbert R.
Assistant Professor of Education

Azzi, Victor D.
Associate Professor of Mechanics
Balling, L. C.
Associate Professor of Physics

Balomenos, Richard H.
Professor of Mathematics Education

Barlow, Robert F.
Professor of Economics and Administration

Barrett, James P.
Associate Professor of Forest Biometrics

Batchelder, Gerald M.
Adjunct Associate Professor of Civil Engineering
B.S., University of New Hampshire, 1950; M.S.C.E., Purdue University, 1952. Appointed 1953.

Batho, Edward H.
Professor of Mathematics

Beasley, Wayne M.
Research Associate Professor, Engineering Experiment Station, and Adjunct Associate Professor of Materials Science

Becherer, Robert J.
Assistant Professor of Mechanical Engineering

Bechtell, Homer F., Jr.
Associate Professor of Mathematics

Becket, John A.
Forbes Professor of Management
B.S., University of Oregon, 1939; M.B.A., Harvard University, 1946. C.P.A.
Appointed 1962.

Bennett, Albert B.
Assistant Professor of Mathematics

Berney, Charles V.
Assistant Professor of Chemistry
B.S., Whitman College, 1953; PH.D., University of Washington, 1962.
Appointed 1965.

Bertsch, Gregory
Assistant Professor in Psychology

Betz, George W.
Associate Professor of Economic Development
A.B., University of Kansas, 1952; PH.D., University of Wisconsin, 1966.
Appointed 1970.

Biggs, May K.
Instructor in Botany
B.S., Southern University, 1959; M.S., Yale University, 1960. Appointed 1969.

Blanchard, Fletcher A., Jr.
Professor of Electrical Engineering

Blickele, Robert L.
Professor of Entomology
B.S., Ohio State University, 1937; M.S., University of New Hampshire, 1939; PH.D., Ohio State University, 1942.
Appointed 1938-1941, 1946.
Bolick, Melvin T.
Associate Professor of Sociology
Appointed 1958.

Boehne, Linda
Assistant Professor of Home Economics

Bogle, Alfred Linn
Assistant Professor of Botany

Bolland, Thomas W.
Assistant Professor of Business Administration

Bonnice, William E.
Associate Professor of Mathematics

Borror, Arthur C.
Associate Professor of Zoology

Bothner, Wallace A.
Assistant Professor of Geology

Bowring, James R.
Professor of Resource Economics
B.S., University of Manitoba, 1936; M.A., University of Alberta, 1941; Ph.D., Iowa State University, 1944. Appointed 1948.

Boy, Angelo V.
Professor of Education

Boynton, C. Hilton
Professor of Dairy Science
B.S., Iowa State College, 1934; M.S., ibid., 1940; Ph.D., Rutgers University, 1962. Appointed 1945.

Boynton, Jason E.
Assistant Professor of Education

Braff, Allan J.
Associate Professor of Economics and Business

Briden, Earl F.
Assistant Professor of English

Bruns, Paul E.
Professor of Forest Resources
A.B., New York University, 1937; M.F., Yale University, 1940; Ph.D., University of Washington, 1956. Appointed 1958.

Bullock, Wilbur L.
Professor of Zoology
B.S., Queens College, 1942; M.S., University of Illinois, 1947; Ph.D., ibid., 1948. Appointed 1948.

Burns, Thomas R.
Assistant Professor of Sociology

Burton, David M.
Associate Professor of Mathematics

Byers, R. Lee
Associate Professor of Chemical Engineering

Byers, Gordon L.
Professor of Soil and Water Science
California, Robert M.
Instructor in Sociology

Caldwell, S. Anthony
Assistant Professor of English

Callan, Richard J.
Associate Professor of Spanish

Carnicelli, Thomas A.
Associate Professor of English

Casas, R. Alberto
Professor of Spanish

Cavanaugh, John R.
Assistant Professor of Education

Chaltas, John G.
Associate Professor of Education

Chapman, Donald H.
Professor of Geology
B.A., University of Michigan, 1927; M.A., ibid., 1928; Ph.D., ibid., 1931. Appointed 1931.

Chesbro, William R.
Professor of Microbiology

Ching Channeey T. K.
Assistant Professor of Resource Economics

Chupp, Edward L.
Professor of Physics

Clark, Charles E.
Associate Professor of History

Clark, David G.
Associate Professor of Electrical Engineering

Clark, Ronald R.
Associate Professor of Organizational Development

Clee, Jan E.
Dean of the Whitemore School of Business and Economics and Professor of Organizational Development

Cohen, Allan R.
Associate Professor of Business Administration

Colbourn, H. Trevor
Dean of the Graduate School and Professor of History
Cole, Lawrence P.
Assistant Professor of Economics and
Assistant Dean of the Whittemore
School of Business and Economics

Collins, Walter M.
Professor of Poultry Science
B.S., University of Connecticut, 1940; M.S., ibid., 1949; Ph.D., Iowa State University, 1950. Appointed 1951.

Colovos, Nicholas F.
Professor of Animal Science
B.S., University of New Hampshire, 1927; M.S., ibid., 1931. Appointed 1928.

Congdon, Robert G.
Director of Counseling and Testing
Center and Associate Professor of
Psychology

Conklin, James G.
Professor of Entomology
B.S., Connecticut Agricultural College, 1926; M.S., University of New Hampshire, 1929; Ph.D., Ohio State University, 1941. Appointed 1931.

Cooper, Matthew
Assistant Professor of Anthropology

Copeland, Arthur H., Jr.
Professor of Mathematics

Corbett, Alan C.
Associate Professor of Poultry Science
B.S., University of Maine, 1936; M.S., ibid., 1937; B.V.M., Michigan State College, 1940. Appointed 1941.

Corell, Robert W.
Professor of Mechanical Engineering
B.S.M.E., Case Institute of Technology, 1956; M.S.M.E., Massachusetts Institute of Technology, 1959; Ph.D., Case Institute of Technology, 1964. Appointed 1964.

Crocker, Robert A.
Assistant Professor of Zoology

Curcio, Ronald P.
Assistant Professor of Education

Daggett, Albert F.
Professor of Chemistry
B.S., University of New Hampshire, 1928; M.S., ibid., 1930; Ph.D., Columbia University, 1934. Appointed 1928-31, 1935.

Davis, James R.
Assistant Professor of Psychology

Davis, Richard S.
Dean of the College of Technology and
Professor of Materials Science

Dawson, Carl
Associate Professor of English

Dawson, John F.
Assistant Professor of Physics

Degler, Carroll M.
Professor of Business and Economics

DeVoto, Mark B.
Assistant Professor of Music
Dewey, Richard S.
Professor of Sociology
A.A., Pasadena Junior College, 1934; B.A., College of Wooster, 1936; M.A., Oberlin College, 1939; Ph.D., University of Wisconsin, 1941. Appointed 1958.

Dishman, Robert B.
Professor of Political Science

Dodge, Peter
Associate Professor of Sociology

Downs, Richard E.
Associate Professor of Anthropology

Draves, David D.
Associate Professor of Education

Drew, William H.
Associate Dean of the Graduate School and Professor of Resource Economics

Duffy, John J.
Assistant Professor of English
B.S.S., Georgetown University, 1957; M.A., University of Vermont, 1958; Ph.D., University of Syracuse, 1965. Appointed 1969.

Dunlop, William R.
Professor of Poultry Science

Dunn, Gerald M.
Professor of Agronomy
B.S., West Virginia University, 1948; M.S., Purdue University, 1950; Ph.D., ibid., 1951. Appointed 1951.

Durgin, Owen B.
Associate Professor of Resource Economics

Durnall, Edward J.
Director of the Division of Continuing Education, and Associate Professor of Education

Durost, Walter N.
Adjunct Professor of Education

Ellis, David W.
Associate Academic Vice President and Associate Professor of Chemistry

Elwell, Albert R.
Assistant Professor of Education

Erickson, Raymond L.
Professor of Psychology

Estes, George O.
Assistant Professor of Plant Science

Faiman, Robert N.
Vice President for Research and Special Projects Administrator, Professor of Electrical Engineering
B.S.E.E., North Dakota State College, 1947; M.S.E.E., University of Washington, 1948; Ph.D., Purdue University, 1956. Appointed 1959.
Fairold. Thomas P.
Assistant Professor of Dairy Science

Fan, Stephen S. T.
Associate Professor of Chemical Engineering

Farnsworth, Kirk E.
Psychologist, Counseling and Testing Center, and Assistant Professor of Psychology

Federer, C. Anthony
Adjunct Associate Professor of Micrometeorology

Fernald, Peter S.
Associate Professor of Psychology

Fink, Stephen L.
Visiting Associate Professor of Organizational Development, and Psychologist, Counseling and Testing Center

Fisher, G. Thomas
Assistant Professor of Entomology
B.S., Iowa State University, 1950; M.S., Rutgers University, 1952; Ph.D., ibid., 1954. Appointed 1969.

Foret, John E.
Assistant Professor of Zoology

Forsyth, G. Alfred
Assistant Professor of Psychology

Fort, Marron C.
Associate Professor of German

Foster, Bennett B.
Associate Professor of Forest Resources

Fox, Leslie A.
Assistant Professor of Psychology

France, Edward N.
Assistant Professor of Zoology

Frick, George E.
Adjunct Professor of Resource Economics

Frost, Albert D.
Professor of Electrical Engineering

Fuller, Gene B.
Assistant Professor of Animal Science
B.S., Sam Houston State College, 1962; M.S., Oklahoma State University, 1964; Ph.D., Purdue University, 1968. Appointed 1969.

Gadon, Herman
Professor of Business Administration
A.B., Dartmouth College, 1947; Ph.D., Massachusetts Institute of Technology 1953. Appointed 1964.
Garrett, Peter W.
Adjunct Assistant Professor of Forest Genetics

Gaudette, Henri E.
Associate Professor of Geology

Gee, Glendon W.
Assistant Professor of Soil and Water Science

Gerhard, Glen C.
Assistant Professor of Electrical Engineering
B.S.E.E., Syracuse University, 1956; M.S.C., Ohio State University, 1958; Ph.D., ibid., 1963. Appointed 1967.

Gilman, Paul A.
Associate Professor of Agricultural Education
B.S., University of Vermont, 1938; M.S., Pennsylvania State University, 1951. Appointed 1945.

Gilmore, Robert C.
Associate Professor of History
A.B., University of Vermont, 1944; M.A., McGill University, 1947; M.A., Yale University, 1951; Ph.D., ibid., 1954. Appointed 1952.

Glanz, Filson H.
Assistant Professor of Electrical Engineering

Goffe, Lewis C.
Associate Professor of English

Goodman, Earl O., Jr.
Associate Professor of Home Economics

Goodrich, Robert W.
Assistant Professor of Electrical Engineering
B.S.E.E., University of New Hampshire, 1957; M.S.E.E., Purdue University, 1958; Ph.D., Case Western Reserve University, 1970. Appointed 1959.

Grant, Clarence L.
Research Professor, Engineering Experiment Station and Adjunct Professor of Chemistry

Green, D. MacDonald
Professor of Biochemistry

Green, Mary Elizabeth
Assistant Professor of Education

Greenleaf, William
Professor of History

Grishman, Alan
Associate Professor of Music

Haaland, Gordon A.
Associate Professor of Psychology
Haendler, Helmut M.
Professor of Chemistry
B.S., Northeastern University, 1935; Ph.D.,
University of Washington, 1940.
Appointed 1945.

Hagstrom, Earl C.
Associate Professor of Psychology
B.S., Tufts University, 1952; M.A., Brown
University, 1954; Ph.D., ibid., 1957.
Appointed 1965.

Hall, Francis R.
Associate Professor of Hydrology
B.S., Stanford University, 1949; M.A., Univer-
sity of California at Los Angeles,
1953; Ph.D., Stanford University, 1961.
Appointed 1964.

Hall, Otis F.
Director of the Institute of Natural and Environ-
mental Resources,
Professor of Forest Resources
A.B., Oberlin College, 1943; M.P., Yale
University, 1948; Ph.D., University of

Hapgood, Robert D.
Professor of English
B.A., University of California, 1950; M.A.,
ibid., 1951; Ph.D., ibid., 1955.
Appointed 1965.

Hardy, Hubert A.
Psychologist, Counseling and Testing
Service, and Assistant Professor of Educa-
tion
A.A., San Diego Junior College, 1954;
A.B., George Washington University, 1958;
M.A., ibid., 1963; Ph.D., University of

Harris, Larry G.
Assistant Professor of Zoology
A.B., University of California, 1965; Ph.D.,

Harter, Robert D.
Assistant Professor of Soil Chemistry
B.S., Ohio State University, 1961; M.S.,
ibid., 1962; Ph.D., Purdue University,

Haslerud, George M.
Professor of Psychology
B.A., University of Minnesota, 1930;
Ph.D., ibid., 1934. Appointed 1945.

Hebert, David J.
Assistant Professor of Education
B.S., University of Maine, 1962; M.Ed.,
Duquesne University, 1964; Ph.D., Kent

Heilbronner, Hans
Professor of History
A.B., University of Michigan, 1949; M.A.,
ibid., 1950; Ph.D., ibid., 1954.
Appointed 1954.

Held, Warren H., Jr.
Associate Dean of the College of Liberal
Arts and Professor of Classics
B.A., Princeton University, 1950; M.A.,
Yale University, 1952; Ph.D., ibid., 1955.
Appointed 1967.

Henry, William F.
Professor of Resource Economics
B.S., Louisiana State University, 1940;
M.S., University of Connecticut, 1942.
Appointed 1952.

Herbst, Edward J.
Professor of Biochemistry
B.S., University of Wisconsin, 1942; M.S.,
ibid., 1944; Ph.D., ibid., 1949.
Appointed 1962.

Herr, Guenter K. W.
Assistant Professor of German
M.A., University of Freiburg, Germany,
1956; Ph.D., University of Texas, 1966.
Appointed 1968.

Hickson, Fred T.
Assistant Professor of Microbiology
A.B., Indiana University, 1954; M.A., ibid.,
1961; Ph.D., Michigan State University,

Hill, John L.
Associate Professor of Wood Science
and Technology
B.S., Colorado State University, 1942;
M.S., Yale University, 1947; D.F., ibid.,

Hochgraf, Frederick G.
Associate Professor of Materials Science
B.Met.E., Rensselaer Polytechnic Institute,
1954; M.S., Cornell University, 1958.
Appointed 1958.
Hocker, Harold W., Jr.  
*Associate Professor of Forest Resources*  
B.S.F., Pennsylvania State College, 1949; M.F., North Carolina State College, 1952;  

Hodgdon, Albion R.  
*Professor of Botany*  
B.S., University of New Hampshire, 1930; M.S., ibid., 1932; Ph.D., Harvard University, 1936. Appointed 1930-32, 1936.

Hogan, John A.  
*Carter Professor of Economics*  

Holden, John T.  
*Professor of Political Science*  
A.B., Wesleyan University, 1936; M.P.A., Harvard University, 1941; M.A., ibid., 1942; Ph.D., ibid., 1943. Appointed 1947.

Holder, Mary E.  
*Associate Professor of Home Economics*  

Holter, James B.  
*Associate Professor of Dairy Science*  

Hoornbeek, Frank K.  
*Associate Professor of Zoology*  

Horrigan, James O.  
*Associate Professor of Business Administration*  

Hosek, William R.  
*Assistant Professor of Economics*  

Houston, Robert E., Jr.  
*Professor of Physics*  
B.S., Michigan State University, 1949; M.S., ibid., 1951; Ph.D., Pennsylvania State University, 1957. Appointed 1957.

Hraba, John B.  
*Dean, Office of Institutional Research and Planning, and Professor of Electrical Engineering*  

Hubbard, Colin D.  
*Assistant Professor of Chemistry*  

Hudon, Edna S.  
*Visiting Associate Professor of French*  

Hudon, Louis J.  
*Professor of French*  
A.B., Bowdoin College, 1938; M.A., Yale University, 1942; Ph.D., ibid., 1943. Appointed 1961.

Hunter, William B., Jr.  
*Professor of English*  
A.B., Princeton University, 1937; M.A., Vanderbilt University, 1939; Ph.D., ibid., 1946. Appointed 1968.

Ikawa, Miyoshi  
*Professor of Biochemistry*  
B.S., California Institute of Technology, 1941; M.S., University of Wisconsin, 1944; Ph.D., ibid., 1948. Appointed 1963.

Ingersoll, Richard L.  
*Assistant Professor of Sociology*  

Irwin, Manley R.  
*Professor of Economics*  
Jacob, Robb
Professor of Mathematics
B.S., University of Chicago, 1941; M.S., ibid., 1942; Ph.D., ibid., 1946. Appointed 1961.

Jaffe, Erwin A.
Associate Professor of Political Science

James, Jesse
State Leader, 4-H Youth Development, Cooperative Extension Service, and Associate Professor of Agricultural Education
B.S., University of Georgia, 1937; M.S., ibid., 1951. Appointed 1957.

James, Marion E.
Associate Professor of History

Jansen, Edmund F., Jr.
Associate Professor of Resource Economics

Jellison, Charles A., Jr.
Professor of History

Jenks, Robert
Assistant Professor of Business Administration

Jervis, Frederick M.
Professor of Psychology

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Professor of Mathematics
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