

University of New Hampshire

Graduate Catalog

1972-73

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The Graduate School 1972-73

**Cover Scene: New Hampshire seacoast.
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University Calendar 1972-73

Semester I

September 9, Saturday	8 A.M. Residence halls open
September 10, Sunday	Registration
September 10, Sunday	4 P.M. First faculty meeting
September 11, Monday	8 A.M. Classes begin
September 12, Tuesday	1 P.M. Opening Convocation
September 22, Friday	4:30 P.M. Last day to drop courses
September 29, Friday	4:30 P.M. Last day to add courses
October 4, Wednesday	4 P.M. First graduate faculty meeting
October 11, Wednesday	4:30 P.M. Last day for partial tuition refund on withdrawal
November 3, Friday	4:30 P.M. Mid-semester, last day to drop courses without academic liability
November 27, Monday	8 A.M. Classes resume
January 3, Wednesday	8 A.M. Classes resume
January 5, Friday	Last day for presenting dissertations or theses at graduate school office for January graduation
January 15, Monday	8 A.M. Semester I final examinations begin
January 19, Friday	Last day for Ph.D. oral examination if degree candidate in January
January 25, Thursday	6 P.M. Final examinations end

Semester II

February 4, Sunday	Registration
February 5, Monday	8 A.M. Classes begin
February 16, Friday	4:30 P.M. Last day to drop courses
February 23, Friday	4:30 P.M. Last day to add courses or opt for Pass/Fail
March 7, Wednesday	4:30 P.M. Last day for partial tuition refund on withdrawal
April 2, Monday	8 A.M. Classes resume
April 6, Friday	4:30 P.M. Mid-semester, last day to drop courses without academic liability
May 4, Friday	Last day for presenting dissertations or theses at graduate school office for June graduation
May 5, Saturday	8 A.M. Classes hold Thursday schedule
May 12, Saturday	8 A.M. Classes hold Friday schedule
May 18, Friday	Last day for final Ph.D. oral examination if degree candidate in June
May 17-18, Thursday-Friday	Holidays
May 21, Monday	8 A.M. Semester II final examinations begin
May 28, Monday	Memorial Day Holiday
June 1, Friday	6 P.M. Final examinations end
June 3, Sunday	8 P.M. Babcock Hall closes
June 3, Sunday	Commencement

The University reserves the right to modify the Calendar subsequent to printing.

Contents

University Calendar	2
Campus Map	4

Trustees and Officers of the University

Trustees	7	Committees	9
Administrative Officers	8	Graduate Degree Programs	11

Graduate Education at the University of New Hampshire

Background	13	University Services	18
Location and Facilities	14	Financial Information	22
Student Activities	15	Assistantships, Scholarships, and Fellowships	23
Teaching, Service, and Research	15	Loan and Work-Study Programs	25
Cultural Activities	17		

Regulations of the Graduate School

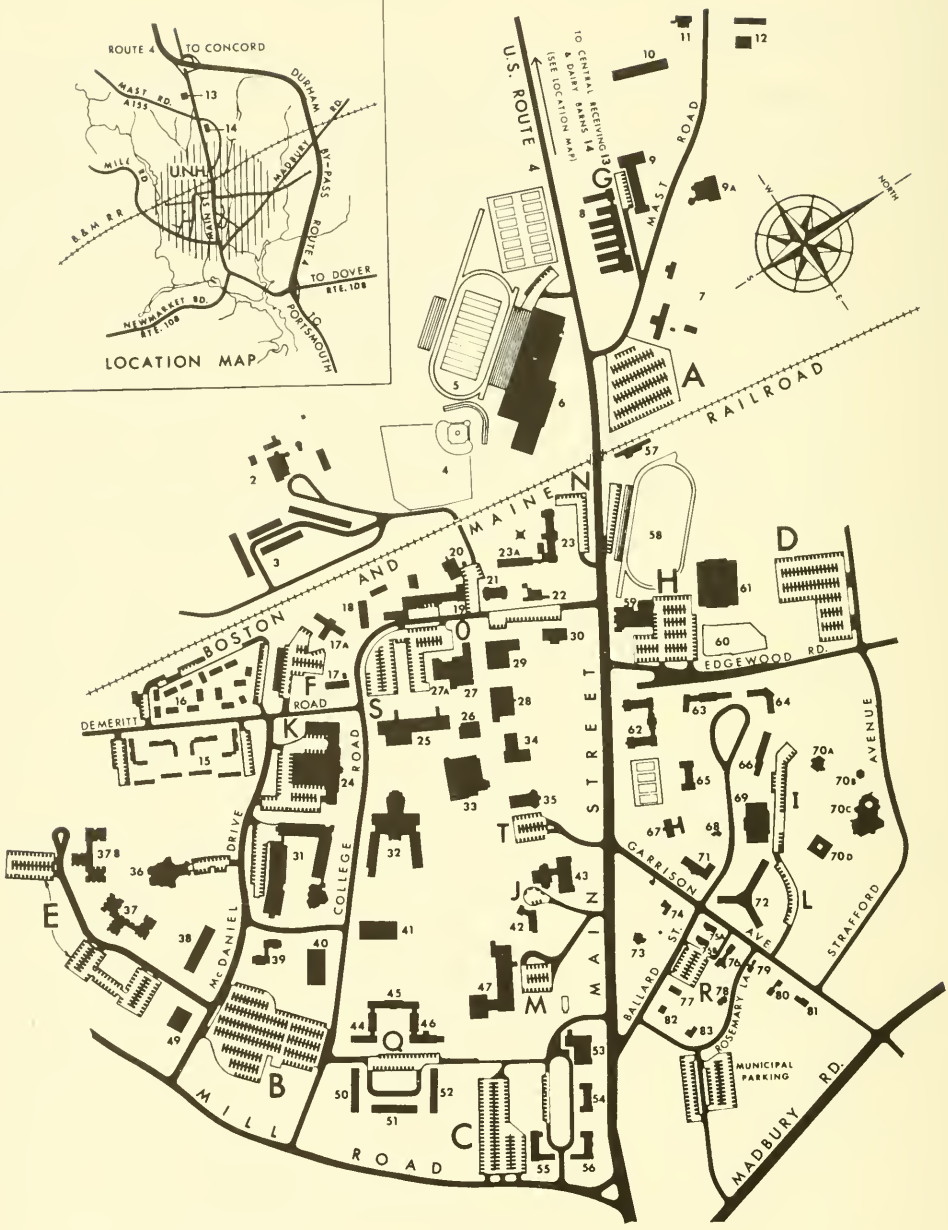
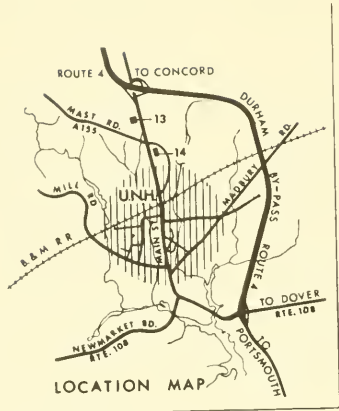
Admission	27	Requirements for Master's Degree	33
Degree Candidacy and Program Requirements	30	Requirements for Doctor's Degree	34
Graduate Credits & Grades	31	Course Numbering System	36
Registration	32	IBM Key Codes	37

Departmental Requirements and Course Descriptions

Animal Sciences	39	Institute of Natural and Environmental Resources	109
Biochemistry	42	Forest Resources	111
Biology	43	Resource Economics	113
Botany	44	Soil and Water Science	115
Business Administration	48	Interdisciplinary Options and Programs	117
Chemical Engineering	53	Mathematics	119
Chemistry	56	Mechanical Engineering	126
Civil Engineering	61	Microbiology	131
Earth Sciences	65	Music	133
Economics	68	Occupational Education	139
Education	72	Physics	141
Electrical Engineering	79	Plant Science	145
Engineering Ph.D. Program	85	Political Science	148
English	87	Psychology	152
Entomology	93	Sociology	159
French and Italian	94	Spanish and Classics	166
Genetics Program	95	Technology	168
German and Russian	99	Zoology	169
History	101		
Home Economics	107		

Faculty of the Graduate School

Campus Map



Campus Map

Adams Residential Tower (NECCE)*	70a	Kellogg Learning Center (NECCE)*	70c
Administration Building (NECCE)*	70d	Kendall Hall	23a
Admissions Office	35	Kingsbury Hall	24
Agronomy Field Station	11	Lewis Fields	5
Alexander Hall	55	Livestock Barn	7
Alumni House	74	Lord Hall	64
Arrival Shelter (NECCE)*	70b	McConnell Hall (WSBE)†	40
Babcock House	39	McLaughlin Hall	63
Barton Hall	9a	Memorial Field	58
Batcheller House	78	Memorial Union Building	47
Bookstore	27a	Morrill Hall	30
Brackett Field	4	Murkland Hall	34
Brook House	79	Nesmith Hall	23
Central Receiving (location map)	13	New England Center for Continuing Education	70
Christensen Hall	37	New England Telephone Building	49
College Woods	1	New Hampshire Hall	59
Conant Hall	26	Nursery School	68
Congreve Hall	62	Parsons Hall	31
Dairy Bar	57	Paul Creative Arts Center	32
Dairy Barns (location map)	14	Pettee Hall	21
DeMeritt Hall	28	Philbrook Dining Hall	36
Devine Hall	46	Poultry Plant	3
Dimond Library	33	President's House	73
Elizabeth DeMeritt House	81	Putnam Hall	9
Engelhardt Hall	52	Randall Hall	45
Fairchild Hall	54	Richards House	77
Farm Service Building	12	Ritzman Nutrition Laboratory	2
Field House	6	Sawyer Hall	71
Fire Station and Service Building	19	Schofield House	76
Forest Park Apartments-East	15	SCORE Building	17b
Forest Park Apartments-West	16	Scott Hall	65
Garage	18	Sculpture Laboratory	17a
Gibbs Hall	50	Smith Hall	67
Greenhouses	8	Snively Arena	61
Hamilton Smith Hall	43	Social Science Center	41
Heating Plant	20	Spaulding Life Sciences Building	25
Hersey House	75b	Stillings Dining Hall	69
Hetzel Hall	56	Stoke Hall	72
Hewitt Hall	27	Swimming Pool	60
Hitchcock Hall	44	Taylor Hall	22
Hood House Infirmary	42	Thompson Hall	35
Horse Barn	10	Verrette House	75
Hubbard Hall	38	Williamson Hall	37b
Huddleston Hall	53	Wolf House	82
Hunter Hall	51		
International House	80		
James Hall	29		
Janetos House	83		
Jessie Doe Hall	12		

* New England Center for Continuing Education

† Whittimore School of Business and Economics



Trustees and Officers of the University

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ex officio

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Nashua (1971-1976)

Edna B. Weeks, B.S.
Greenland (1971-1973)

David Gagne
Student Member
Keene (1971-1972)

Babcock House—The Graduate Residence Hall

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Vice-President for University Relations

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David Landrigan
Graduate Student, Psychology

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Robert Seidenstadt
Graduate Student, Psychology

Bruce Smith
Graduate Student, Zoology

Diek Vogelsong
*Graduate Student,
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Engineering*

John J. Korbelt, 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

Education

Master of Science for Teachers

Biology
Chemistry
English
French
German
Mathematics
Physics
Spanish

Master of Occupational Education

Occupational Education

Master of Business Administration

Whittemore School of Business
and Economics

Master of Education

Education

Master of Public Administration

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. Academic and cultural resources of each campus are amplified through System-shared programs and facilities. Cooperative ventures among the 10-member public institutions of the New Hampshire College and University Council blend public and private higher education resources.

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.

Location and Facilities

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.

Location and Facilities

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 24 residence halls for men and women. Book value of the physical plant exceeds \$68 million. Total University lands—including athletic fields, farms, and woodlands—comprise about 3,500 acres.

Major construction projects of the past ten years include:

University Library, housing 600,000 volumes, 5,000 periodicals, and substantial microfilm and tape collections.

Paul Arts Center, a \$2,250,000 structure with separate wings for music, drama, the arts, and speech therapy.

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, having recently been completed at a cost of \$3,600,000.

McConnell Hall, houses the Whittemore School of Business and Economics 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.

Student Activities

Graduate student participation in University activities is substantial. The Graduate Student Organization is an independent body representing all departments with graduate programs. Graduate students are often consulted by departments about academic decisions. Graduate students are elected as voting members to the Graduate Council and similar 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.

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

The Black Student Union participates actively in University affairs.

Information and counseling are available concerning the military obligation of students.

The Ecumenical Ministry to the University of New Hampshire is a cooperative endeavor involving a full time "on campus" minister, concerned administrators, faculty and students, the designated denominational chaplains, and Durham residents. The Ecumenical Ministry focuses on issue-oriented programs, teaching, involvement in the needs and concerns of various members in the University, and counseling. In addition, there are specific organizations such as Hillel for Jewish students, the Inter-Varsity Christian Fellowship, the Fellowship of Christian Athletes, the Christian Science and Latter Day Saint's group, and the Durham Unitarian Universalist Fellowship, which provides religious activities. In Dover are the Greek Orthodox Church and a Friends Meeting; and Protestant, Catholic, and Episcopal churches are located in Durham.

Teaching, Service, and Research

The University of New Hampshire has a teaching faculty of 594. Although their main function is teaching, the faculty is also deeply involved in research and service activities.

Among the University's specialized research facilities are the *Space Science Center* in DeMerritt Hall, *The Ritzman Animal Nutrition Laboratory*, the *Computation Center* in Kingsbury Hall, and the *Jackson Estuarine Laboratory* on nearby Great Bay.

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*.

Several interdisciplinary research and service units, such as the *Water Resources Research Center* and the *Resources Development Center* add significantly to the University's contribution to the students' opportunities and to the state's welfare.

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 their resources at the service of the state are the *Public Administration Service*, which specifically aids town and city officials, 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 interdepartmental 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 Great Bay at Adams Point. The tide-water 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 approxi-

mately thirteen miles steaming distance from the Laboratory. Marine research facilities for the departments of biochemistry, botany, microbiology, zoology, and earth sciences 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.

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 bring professional musicians to the campus. In recent years, this series has included the French National Orchestra, the Swingle Singers, and the Juilliard String Quartet.

Dramatic productions are offered during the year by the University Theater. There are professional productions in the "Allied Arts" series, which has included "You're a Good Man, Charlie Brown," performances 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 the arts, letters, science, and the humanities to the campus for formal lectures and informal meetings with students. Recent visitors in this series have included Daniel Moynahan, James Van Allen, Stewart Udall, and Ralph Nader. Another series concentrates on issues, and brings one or more noteworthy public figures to speak on an important topic as Black arts, population, and pollution. Symposia on Alternative Life Styles and on Innovations in Higher Education have been offered.

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 AM-FM radio station. Political clubs often bring speakers of national prominence to the campus.

University Services

The Counseling and Testing Center

The Counseling and Testing Center, in collaboration with the Student Health Service at Hood House, is the primary mental health facility on campus. The full- and part-time staff of seven psychologists, one consulting psychiatrist, and seven interns provides services for both undergraduate and graduate students. Services include individual and/or group therapy and consultations on a wide range of situations related to the University environment.

The University Health Service

The University Health Service, located in Hood House, is devoted to the total health care of the student. A well equipped outpatient clinic functions for diagnosis and treatment of ambulatory patients and an infirmary is available for students requiring inpatient care. For serious medical problems a student is generally referred to the Emergency Room at the Wentworth Douglass Hospital, by ambulance if necessary.

During the regular academic year, Hood House is staffed by full-time physicians, nurses, and part-time consultants. Individual health guidance is given through personal conferences with the University physicians. Routine office hours of the physicians are from 8:30-12:00 noon and 1:30-4:00 p.m. daily except Saturday and Sunday. Nurses are available twenty-four hours a day and a duty doctor is likewise available at all times. Appointments may be made up to four weeks in advance upon request and "walk-ins" are also acceptable.

The Health Service is closed when the University is officially closed for holidays and semester breaks, closing one hour after residence halls and opening at 3:00 p.m. on the day before classes resume. During Summer Session Hood House operates on a limited basis.

X-Rays, laboratory tests, inpatient room and board, certain routine medications, and ambulance services are charged either to student insurance or directly to the individual. Injury and illness which require hospital confinement, service of specialists, operations, consultations, etc., are at the expense of the student as well.

To supplement its Health Service program, an optional group accident and sickness insurance is offered by the University to all full-time students. Complete details are available upon 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

Babeock House, the graduate residence, is designed: 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.

Graduate Education

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 consists of 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, easy chair, desk chair, waste basket, and 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 (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 Resident and family live in a two-bedroom apartment on the ground floor. The Faculty Resident works in an advisory capacity within the hall on educational and social problems, and with individual students on a personal level. The Faculty Resident, with the aid of two Graduate Resident Assistants, carries out the administrative responsibilities required by the students and the University and is knowledgeable 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 the Head Linen Clerk, 7 Stoke Hall (Residence Office), University of New Hampshire, Durham, N. H. 03824.

Notification of acceptance by the University does not mean that the student is being considered for graduate housing. Interested students must contact the Residence Office, (603-862-2120) in 7 Stoke Hall, University of New Hampshire, Durham, N. H., either in person or by mail in order to apply. Assignments are made in the order in which they are received. There are usually more applicants than there is space available, so it is important that the student return the application promptly. Application and a \$50 room pre-payment should be sent to the Residence Office by August 15th in order to be considered.

The residents of Babcock House may elect to take their meals on contractual basis at any of the three University Dining Halls. Available 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 \$460. If capacity permits, individual meals may be purchased on a per-meal basis. The University Dining Services also operates a cafeteria in the Memorial Union where meals may be obtained on a à la carte plan. 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.

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. At times, the waiting list approaches one year from date of receipt of application until assignment; it would be wise to apply as early as possible.

To be eligible for University Housing a graduate student must have been admitted to the University and be a full-time student as defined on page 32 of this catalog.

Off-Campus Housing

During the academic year, a list of off-campus rooms and apartments is kept by the Residence Hall Advisory Council in the Memorial Union Building, University of New Hampshire. During the summer months, this same list is maintained by the Residence Office. The day-to-day changes in the list make it difficult to maintain a current list for mailing. Therefore, students are encouraged to make every effort to come to 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.

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 32,000, 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

Financial Information

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 \$1000 per academic year for New Hampshire residents and \$2000 for non-residents. Students enrolled in five or more credits including thesis registration will be charged full tuition. (If a student takes courses in the Division of Continuing Education or at the Merrimaek Valley Branch, in addition to regular University courses, the combined total of credits for which the student is registered will be used in determining liability for 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 Division of Continuing Education are listed in their respective catalogues.

Doctoral students who are in residence and engaged in dissertation research 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 "Master's Thesis 899" even if they are not registered for other courses.

When a student completes degree requirements *in absentia*, a charge of \$100 for the privilege of taking the final examination must be paid four 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 all admitted students.

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

Students, though they may be 21, will not be recognized as New Hampshire residents by the University unless they can clearly establish that their residence in New Hampshire is for a purpose other than the temporary one of obtaining an education at the University.

Full-time employees filling budgeted positions, their spouses, and/or dependent children may enroll in any of the University's credit courses at one-half tuition at UNH (Durham), Keene State College, or Plymouth State College. This benefit will be extended to all employees who are on the payroll on the Monday preceding the first day of classes. Applications for the staff tuition rate at Durham may be obtained from the Financial Aid Office, Thompson Hall.

Assistantships, Scholarships, and Fellowships

University supported graduate assistants receiving the full stipend are exempted from the payment of tuition and *academic* fees during the academic year of their appointment and the following summer session. University supported graduate assistants receiving half the normal stipend are exempted from the payment of half of their tuition and academic fees during the academic year of their appointment and the following summer session.

The University reserves the right to adjust rates for tuition, charges, and fees.

Assistantships, Scholarships, and Fellowships

Assistantships

Approximately 300 graduate assistantships are awarded annually to superior students: appointments are normally for one academic year but may be renewable. These appointments normally involve half-time employment. The normal load for students holding appointments is three full courses per semester or master's thesis or doctoral research. Graduate assistants must register for a minimum of one course or thesis or dissertation research each semester.

Appointments are made in the following categories:

Graduate Assistants: Most assistants are involved in assisting faculty members in instructional activities. A limited number of appointments involve assisting in research activities in the Agricultural Experiment Station. Stipends for graduate assistants are \$2800 per academic year plus tuition waiver for the academic year and the following summer.

Project Assistants: An assistant who assists faculty members in an externally funded research project. Stipends for project assistants are \$3850 per academic year. Project assistants do not receive a tuition waiver, but are charged tuition at the resident rate.

Full time summer employment may be available for project assistants or graduate assistants. Assistants employed during the summer are paid \$560 per month for a maximum of two months full time employment.

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

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 \$5000 per academic year, according to qualifications and

Assistantships, Scholarships, and Fellowships

duties. Inquiries should be addressed to the chairman of the appropriate department.

Summer Fellowships for Graduate Assistants

A limited number of Summer Fellowships are available for students who have held graduate assistantships involving teaching during a previous academic year. The stipend for summer study is \$750

Tuition Scholarships

Up to 50 superior students may be granted academic-year tuition scholarships. These awards provide only for waiver of tuition charges and are subject to the maintenance of a high scholastic record in the Graduate School.

Up to 30 superior students may be granted tuition scholarships for the Summer Session. Applications may be obtained from the Dean of the Graduate School.

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 research assistant. The stipends for this program are \$2800 for the first academic year, \$3000 for the second academic year, and \$3200 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.

Martin Luther King Awards

Martin Luther King Awards provide support for qualified members of minority groups. Applications should be made to the Dean of the Graduate School.

Dissertation Fellowships

Dissertation Fellowships with stipends of up to \$3000 for a maximum tenure of one year are available. These awards include a waiver of the doctoral research registration fee for the period of the award. Applications should be made to the Dean of the Graduate School.

Federally Funded Traineeships and Fellowships

Subject to the availability of federal funds, a variety of federal fellowships and traineeships are available for outstanding graduate students. These awards are open to U.S. citizens only. The stipends for

Loan and Work-Study Program

these awards vary somewhat but average \$3000 for 12 months of study plus tuition waiver.

The following awards are made by the Graduate School Student Fellowship Selection Committee from nominations from the various departments:

National Science Foundation Graduate Traineeships: Awarded to either master's or doctoral students in various science and engineering fields. Awards may be held for two years by master's candidates, and four years by doctoral candidates.

National Defense Education Act Fellowships (Title IV): Awarded to students pursuing the Ph.D. degree who are interested in college teaching careers. Doctoral students in biochemistry, chemistry, genetics, history, mathematics, microbiology, physics, psychology, sociology, and zoology may be considered for these awards.

National Science Foundation Summer Traineeships: Awarded to students who have held assistantships involving teaching during the previous academic year. These awards provide for full time study during the summer.

Application for the following awards should be made to the offices noted:

Public Health Service Traineeships and Fellowships: Awards are made for study in health related fields by National Institutes of Health and other federal agencies. Applications should be made directly to Career Development Review Branch, Division of Research Grants, National Institutes of Health, Public Health Service, Bethesda, Maryland 20014.

United States Office of Education Fellowships: Awarded for study in the early childhood development program. Applications should be addressed to the Early Childhood Development Program, Department of Education, University of New Hampshire, Durham, New Hampshire.

Students wishing to apply for financial aid must submit their application for admission and for financial aid prior to February 15.

Loan and Work-Study Programs

National Defense Student Loans

To be eligible for consideration, a student must: carry at least one half the full-time academic load as defined by the University; be a U.S. citizen or a permanent resident of the U.S.; and establish need for a loan which is to be used for educational purposes only. A graduate student may request up to \$2500 annually to a maximum of \$10,000.

Loan and Work-Study Program

UNH Loans

To be eligible for consideration, a student must carry at least one half the full-time academic load as defined by the University. Financial need must be clearly established; and if approved, the loan may be used for educational purposes only. The maximum amount granted to a student is \$1000 during his undergraduate and/or graduate work.

College Work-Study Program

With the aid of federal funds, the University is able to provide employment opportunities on-campus or in various off-campus agencies. Eligibility is based upon financial need and is determined by the Financial Aid Office. Work during the academic year is usually on-campus and is limited to 15 hours per week.

Applications for the above programs may be obtained from the Financial Aid Office, Thompson Hall, and must be returned to that office not later than July 1.

Regulations of the Graduate School

Requirements for 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. The sex, race, religion, color, and national origin of applicants is not considered in the admissions process.

Applicants for admission must present evidence that they have had the necessary prerequisite training which will enable them to pursue the graduate program for which they are applying. Candidates for admission must have a superior undergraduate record. An applicant who has undertaken graduate work at another institution should have completed the courses or program undertaken with a record which is equivalent to that required for graduate students to remain in good academic standing at the University of New Hampshire.

Individual departments may specify special requirements which applicants must meet; such requirements may include the scores received on the aptitude and appropriate advanced sections of the Graduate Record Examination or the Aptitude Test for the Graduate Study of Business. The program descriptions listed in this catalog and the information sheet supplied with the application forms should be consulted for these special requirements.

Applicants seeking admission to programs leading to the Master of Science for Teachers degree must meet one of the following admission requirements: 1) completion of education courses sufficient for certification, 2) three years of teaching experience, or 3) currently holding a full-time teaching position.

Application Procedures

An applicant for admission must submit *directly to the Dean of the Graduate School, Social Science Center, University of New Hampshire, Durham, New Hampshire 03824, the following materials:*

Regulations of Graduate School

1) The official application for admission to graduate study. Application forms may be obtained by writing to the Dean of the Graduate School at the above address.

2) Two copies of official transcripts showing the grades earned in all of the applicant's previous academic work (graduate and undergraduate).

3) Three letters of recommendation from persons in a position to judge the applicant's preparation and fitness for graduate work.

4) A \$10 application fee. This fee is nonrefundable.

5) Any additional materials, such as scores achieved on the Graduate Record Examination or Aptitude Test for the Graduate Study of Business, which are required by the department or program to which the applicant is applying.

All application material becomes part of the permanent records of the University of New Hampshire and will not be returned.

Applicants from Foreign Countries

In addition to the material noted above, all applicants from non-English speaking countries must furnish proof of their proficiency in English by submitting scores achieved on the Test of English as a Foreign Language administered by Educational Testing Service. Arrangements for taking this examination should be made directly with Educational Testing Service, Box 899, Princeton, New Jersey, USA, 08540.

Because of the time involved in processing applications from residents of foreign countries completed applications and supporting documents should be received at the Graduate School four months prior to the semester for which admission is desired.

Application Deadlines

Completed applications and supporting documents 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. There is no guarantee that applications submitted after these deadlines can be acted upon in time to permit registration in the desired semester. Applicants for financial aid must submit completed applications and supporting documents for admission and financial aid 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 enrolling for courses for graduate credit. Such seniors should

follow the application procedure outlined above, and should file their applications by the specified dates.

Upon recommendation of the department, superior University of New Hampshire senior 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.

University of New Hampshire Employees

Members of the University of New Hampshire faculty with the rank of assistant professor or above will not be admitted to the graduate programs. Full-time staff employees of the University, who do not hold academic rank, will not ordinarily be admitted to doctoral programs in the department in which they are employed. The above regulations pertain even for individuals who resign their positions.

Types of Admission

Regular admission: Regular admission may be granted to those applicants whose academic records and supporting documents suggest that they are fully qualified to undertake graduate study in their chosen field.

Conditional Admission: Conditional admission may be granted to those applicants whose academic records indicate deficiencies but suggest some promise of success in graduate study. Students granted conditional admission must meet the specific requirements stated at the time of their admission. Conditional admission will not be granted to applicants residing in foreign countries.

Special Students

Individuals holding baccalaureate degrees who wish to register for courses, may do so with the approval of the instructor and Dean of the Graduate School. Such students are not admitted to the Graduate School and are not candidates for a graduate degree. Special students must complete the special student registration form which is available during the registration period each semester. This form must be filed by all special students whether they register for day courses at the University, courses offered by the Division of Continuing Education, at the Merrimack Valley Branch, or in the summer session. Special students are not required to file an application to the Graduate School.

If a special student is subsequently admitted to a degree program, a maximum of nine credits earned in the University system as a special student may, upon recommendation of the department, be applied to that program. Ordinarily, the nine credits would be selected from courses completed or in process on the date when the official letter of admission is written.

Degree Candidacy and Program Requirements

Honorary Fellows

Qualified scholars, who may temporarily desire the privilege of using 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 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 graduate work; and his program must be approved by his adviser and the Dean of the Graduate School. For the special requirements see the departmental statements in this catalog.

Graduate students will be admitted to candidacy for a degree only after they have been in residence a sufficient length of time to enable their instructors to judge their ability to carry on graduate work. Generally this period shall not be less than that required for the completion of 12 credits of graduate work for master's degrees 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 recommendation of the department concerned. The Dean will communicate his decision to the student.

A student who wishes to pursue a degree or program other than that to which admission was granted should file an application for a change in degree with the Graduate School. The Dean of the Graduate School will notify the student of his decision after consulting with the appropriate departments.

Master's candidates who intend to go on to the Ph.D. in the same department in which they were admitted for the master's degree should submit to the Graduate School a written recommendation from departmental chairman or director of graduate studies. This recommendation will be reviewed by the Dean of the Graduate School who will notify the student of the decision. A student who has received the master's degree before applying for admission to study for the Ph.D. degree will be required to submit a new application.

Graduate Credits and Grades

Credits

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

Upon recommendation of the department, superior senior 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.

In some departments or programs it is possible for students to do a part of their work during the Summer Session or in the Division of Continuing Education. Students should consult the Summer Session or Division of Continuing Education Office in Huddleston Hall concerning the courses offered and course schedules.

Admitted students should be aware that a maximum of 12 credits earned off the Durham campus may be applied toward a master's degree program. Of these 12 credits, only six may be from another graduate school.

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 complete and approved theses and dissertations.

An incomplete grade earned by a graduate student 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 theses.

Requirements for Master's Degree

Registration

Registration Procedure

Students admitted to the Graduate School must have their program approved by the chairman of their department or of their 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 the summer session (consult the calendar in this catalog for the date of registration.)

Failure to Register

Students who do not register during a twelve-month period and have not notified the Graduate School of their intention to continue in their degree programs must reapply for admission in order to resume their 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 Residences). When completed, the form should be filed with the Registrar.

Full-time Graduate Students

Full-time graduate students are those students who have reached either a conditional or regular admission and pay either full tuition or the doctoral research registration fee, or hold a graduate-assistantship or fellowship award.

The maximum graduate load allowed is sixteen semester credits for a regular semester, four credits for a four-week summer session, and eight credits for an eight-week summer session. Only under unusual circumstances will a student be allowed to exceed these limits, and then only with the recommendation of the student's adviser and the approval of the Dean of the Graduate School.

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

Requirements for Master's Degree

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.

Requirements for Doctor's Degree

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.

From six to ten thesis credits may be applied toward a master's degree, 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 disser-

tation 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

A guidance committee will be appointed by the Dean of the Graduate School upon the recommendation of the department as soon as possible after a student has begun study for the doctoral degree. The committee will have the responsibility of: assisting the student in outlining a program, and preparing for and administering the qualifying examination.

The qualifying examination may be written, oral, or both. This examination will test: 1) the student's general knowledge in the student's major and minor work and 2) 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.

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

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

Explanation of Course Numbering System

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.

Explanation of Course Numbering System

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 801 (801) 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, (804) 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.

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

- *51 Earth Science
- 58 Liberal Arts, non-departmental
- 59 The Arts
- 60 Biology
- *61 Education
- *62 English
- *63 French
- 64 Italian
- 65 Geography
- *66 German
- 67 Russian
- *68 History
- 69 Humanities
- *70 Microbiology
- *71 Music
- *72 Music Education
- 73 Philosophy
- 74 Physical Science
- *75 Political Science
- 81 Social Science
- *76 Psychology
- *77 Spanish
- 78 Classics
- 79 Greek
- 80 Latin
- *82 Sociology and Anthropology
- 83 Speech and Drama
- *84 Zoology

School of Health Studies

- 37 Medical Technology Program
- 38 Nursing
- 39 Occupational Therapy
- 40 Physical Education
- 41 Recreation and Parks

College of Life Sciences and Agriculture

- *17 Animal Science
- *18 Biochemistry
- *19 Botany
- *20 Entomology
- *21 Forestry (INER)†
- *22 Home Economics
- *23 Occupational and Extension
Education
- *24 Plant Sciences
- *25 Resource Economics (INER)†
- *26 Soil and Water Science (INER)†

† INER—Institute of Natural and Environmental Resources.

College of Technology

- 45 Technology, non-departmental
- *46 Chemical Engineering
- *47 Chemistry
- *48 Civil Engineering
- *49 Earth Sciences
- *50 Electrical Engineering
- *51 Mathematics
- *52 Mechanical Engineering
- *53 Physics
- *54 Ph.D. Engineering

Whittemore School of Business and Economics

- *30 Administration
- *31 Economics
- 33 Secretarial Studies
- 32 Hotel Administration

Separate Departments and Programs

- 96 Inter-College
- *97 Genetics Program
- 98 Military Science
- 99 Aerospace Studies



Departmental Requirements and Course Descriptions

Animal Sciences (17)

Chairman: *W. C. Skoglund*

PROFESSORS: Fred E. Allen, Hilton C. Boynton, Walter M. Collins, William R. Dunlop, Richard C. Ringrose, Winthrop C. Skoglund, Richard G. Strout

ASSOCIATE PROFESSORS: Alan C. Corbett, Thomas P. Fairchild, James B. Holter, James T. O'Connor, Gerald L. Smith, Samuel C. Smith

ASSISTANT PROFESSORS: Frank Repka, Larry L. Stackhouse

LECTURER: Sonia R. Wallman

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. Staff. 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.

Animal Sciences

709. Biochemistry of Nutrition

An indepth study of the intermediary metabolism of nutrients with emphasis on energy metabolism. Coverage includes transport mechanisms, biological oxidations, interrelationships of carbohydrate, fat and protein metabolism in normal and abnormal nutritional states, obesity, and control of hunger and appetite. Mr. Repka. 3 lectures; 1 laboratory; 4 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. Mr. Fairchild. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered in 1973-74.)

795-796. Investigations in Dairy, Livestock, Poultry, Light Horses

1. Genetics

Mr. Gerald Smith, Mr. Collins, Mr. Boynton, Mr. Fairchild.

2. Nutrition

Mr. Gerald Smith, Mr. Ringrose, Mr. Repka, Mr. Holter.

3. Management

Mr. Skoglund, Mr. Gerald Smith, Mr. Boynton.

4. Diseases

Mr. Allen, Mr. Corbett, Mr. Dunlop, Mr. Strout, Mr. Samuel Smith, Ms. Wallman.

5. Products

Mr. Gerald Smith.

6. Light Horsemanship

Ms. Briggs, Mr. O'Connor.

7. Physiology

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. Energy Metabolism and Nutrition

Incidental lectures, assigned reading, and laboratory practice in methods of research with major emphasis on protein and energy metabolism. Mr. Holter. 3 credits. (Alternate years; offered in 1972-73.)

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.

807-808. 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.

809. 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.

810. Biochemical Co-factors

Designed to provide the student with an understanding of the significant role of the vitamins and trace minerals in metabolism in man and animals. Mr. Ringrose. 2 lectures; 1 laboratory; 4 credits.

812. 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 1973-74.)

851. 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. Permission of instructor (also offered as Microbiology 851). 4 credits.

852. Advanced Cell Biology

A study of the ultrastructure and function of cell organelles followed by an analysis of various specialized animal cells to show how differences in form and location of various organelles lead to differences in function. Ms. Wallman. Prerequisite: Biochemistry, Physiology, and Vertebrate Anatomy or permission of instructor. 3 lectures; 4 credits.

897-898. Animal Science Seminar

A survey of recent literature and research in the animal sciences. Staff. 1 credit. May be repeated.

899. Thesis

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

Biochemistry

Biochemistry (18)

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.

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. 5 lectures; 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.

Biological Sciences Division

811. Biochemistry of Lipids

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

831. Cell Surfaces and Exoproducts

A study of the chemical and biochemical properties of cell surfaces and extra-cellular products and their functions. Mr. Ikawa. Prerequisite: general biochemistry. 2 lectures; 2 credits.

842. 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.

850. 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

Biological Sciences Division (60)

Chairman of Division: *Frank K. Hoornbeek*

Two of the graduate programs leading to the master's degree in biology are administered by the Biological Sciences Division: (1) The Master of Science in Biology is a general, non-thesis program for those teaching in junior or community colleges or in nature and conservation education programs and for others who wish to work in similar areas. (2) The Master of Science for Teachers (M.S.T.) in Biology is designed as an updating program for experienced and certified teachers in secondary schools; no thesis is required. (3) The Master of Arts in Teaching (MAT) in Biology is operated by the Department of Education in consultation with the Division and is restricted to students who have a strong undergraduate background in Biology and who need to fulfill the education certificate requirements.

Inquiries about admission to, and the requirements for, the M.S. and M.S.T. degree programs should be directed to the Chairman of the Division.

Botany

725. Man and His Natural Competitors

An examination of species that compete with man for limited resources and a study of their ecology and control. Some of the groups to be discussed are roundworms, snails and other mollusks, insects, birds and other mammals. Recommended for secondary school biology teachers for credit toward the M.S. in Biology. Prerequisite: 2 years of 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. Ms. Huffman, 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: Animal Sciences, Biochemistry, Botany, Entomology, Microbiology, Plant Science, and Zoology.

Botany (19)

Executive Committee: *Richard Schreiber* (Chairman),
Hugh Mulligan, *Avery Rich*

PROFESSORS: Albion Hodgdon, Lorne McFadden, Avery Rich, Richard Schreiber

ADJUNCT PROFESSOR: Alex Shigo

ASSOCIATE PROFESSORS: Arthur Mathieson, Hugh Mulligan

ASSISTANT PROFESSORS: May Biggs, Linn Bogle, Brian Chabot

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 meet the Graduate School's requirements for the degree and, in addition, will be required to defend a thesis based on field or laboratory research.

A student who is working toward the Doctor of Philosophy degree will be advanced to candidacy for the Ph.D. after a successful comprehensive examination and completion of the following language requirement: a doctoral student will be asked to demonstrate a mastery of one foreign language or a knowledge of two foreign languages or a knowledge of one foreign language and a cognate field such as statistics. He will be required to defend a thesis which is to be a substantial contribution to botanical knowledge.

All Botany graduate students without professional teaching experience will satisfy the following departmental teaching requirement: each student will assist a faculty member for one semester in teaching Botany 411 or Botany 503; a Ph.D. candidate will assist for one additional semester in an advanced Botany course. Each student will also register for one semester of Section 9 (Botanical Teaching) of either Botany 795(796) or Botany 895(896).

The Department's areas for graduate study include: Plant Physiology, Ms. Biggs; Plant Ecology, Mr. Chabot; Systematic Botany, Mr. Hodgdon; Phycology-Biological Oceanography, Mr. Mathieson, Mr. Mulligan; Plant Pathology, Mr. McFadden, Mr. Rich, and Mr. Shigo; Plant Morphology and Anatomy, Mr. Bogle; Mycology, Cell Biology, Mr. Schreiber and Ms. Biggs.

706. Plant Physiology

An introduction to the function of higher plants with an emphasis on water relations, metabolism, growth and development. Ms. Biggs. Prerequisite: Botany 411, 503 or Plant Science 421 and one year of chemistry or permission of the instructor. 3 lectures; 1 laboratory; 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; offered in 1972-73.)

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; offered in 1972-73.)

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. Cell Biology

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. Ms. Biggs. Prerequisites: one year general chemistry and one year of biological sciences; or permission of the instructor. 2 lectures; 2 laboratories; 4 credits.

741. Ecosystem Analysis

Description of ecosystems with respect to structure of population and community components, development, transfer of energy and materials, and evolutionary changes. Methods of analysis and interpretation of field data. Mr. Chabot. Prerequisite: Biology 641, General Ecology, or permission of instructor. 1 lecture; 1 laboratory; 1 colloquium; 4 credits.

Botany

742. Physiological Ecology

The physiological basis of plant-environment interactions will be considered for cellular, whole-plant, and population processes. Biometeorology, physiological adaptation and variation, evolution of ecotypes, growth and reproductive phenomena, as well as mathematical simulation of plant processes will be included. Mr. Chabot. Prerequisite: Botany 706 or permission of instructor. 1 lecture; 1 laboratory; 1 colloquium; 4 credits.

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; offered in 1972-73.)

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. 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.

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; not offered in 1972-73.)

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; offered in 1972-73.)

762. Morphology of the Vascular Plants

The life histories and evolution of the extinct and living vascular plants, including comparisons of general structure and sexual organs. Mr. Bogle. Prerequisite: Botany 411 or Botany 503. 2 lectures; 2 laboratories; 4 credits. (Alternate years; not offered in 1972-73.)

764. Microtechnique

A methods course in embedding, sectioning, and staining plant tissues, and an introduction to microscopy. Mr. Bogle. Prerequisite: permission of instructor. 2 lectures; 4 hours of laboratory; 4 credits. (Alternate years; offered 1972-73.)

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. (Alternate years; not offered in 1972-73.)

- 795-796. Investigations in:** 1) Systematic Botany, 2) Plant Physiology, 3) Plant Pathology, 4) Plant Anatomy, 5) Plant Ecology, 6) Mycology, 7) Cell Biology, 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 nutrition, photosynthesis and light effects, respiration, and growth regulator effects. Ms. 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 1972-73.)
- 822. Advanced Marine Phycology**
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; offered in 1972-73.)
- 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 1972-73.)
- 851. Advanced Plant Pathology**
Advanced theories and methods in plant pathology. Mr. McFadden. Prerequisite: Botany 751 or 753 and permission of professor. Assigned reading; conferences; laboratory; 4 credits. (Alternate years; not offered in 1972-73.)
- 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 trips; 4 credits. (Alternate years; not offered in 1972-73.)
- 895-896. Investigations in:** 1) Systematic Botany, 2) Plant Physiology, 3) Plant Pathology, 4) Plant Anatomy, 5) Plant Ecology, 6) Mycology, 7) Cell Biology, 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. 2-6 credits.
- 899. Master of Science Thesis**
6-10 credits.
- 999. Doctoral Dissertation**

Business Administration

Business Administration (30)

Dean: *Jan E. Clee*

PROFESSORS: Robert F. Barlow, John A. Beckett, Jan E. Clee, Carroll M. Degler, Herman Gadon, 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, R. Stephen Jenks, Robin D. Willits, Dwayne E. Wrightsman

ASSISTANT PROFESSORS: Thomas W. Bolland, Richard L. Mills, Linda G. Sprague, John Terninko, William E. Wetzel, Jr.

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 Admission 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. (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.

Business Administration

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, (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.

750. Marketing Management

The practical application of the theories taught in Business Administration 808. Topics covered include the planning, organization, and control of marketing activities in large corporations and in small business, 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 among 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: a basic Marketing course. 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.

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 Administration

Selected topics in the administration of firms, institutions, and organizations; topics to vary from term to term. Prerequisite: consent of adviser and the instructor. Credits to be arranged.

801. Data Analysis for Decision Making

The course is designed to acquaint students with the techniques and tools necessary to build and/or manipulate simple quantitative decision models—both mathematical and statistical in nature. Models used most frequently in the management of a firm are introduced and discussed. An ability to work problems using a time-sharing computer is developed early in the semester. Topics include: descriptive statistics; probability theory; modern statistical decision theory; simulation, other stochastic, and simple deterministic, management-science models. Prerequisite: college algebra. 4 credits.

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.)

Business Administration

805. Organization Theory for Managers

Overall objective is to provide the student with a conceptual framework by which he can effectively diagnose organizations and guide administrative decision-making by understanding organizations as social systems operating within a cultural context. Building upon concepts pertaining to the individual, interpersonal, and small group dynamics as explored in Administration 803, the course takes the overall organization as its unit of analysis. A number of organizational parameters, such as goals, structure, leadership, control, and change management are examined individually and in relation to their impact on one another and on the total organization. (Open to evening Master of Business Administration students only.) 4 credits.

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.)

821-822. Quantitative Analysis I and II

The techniques and tools necessary to build and/or manipulate simple quantitative decision models, both mathematical and statistical in nature; consideration of those models that have been used most often in the management of a firm;

development of the facility to work problems using the time-sharing computer. First semester topics: descriptive statistics, probability theory, data generating models, modern statistical decision theory, simulation, simple deterministic and/or stochastic management science models. Second semester topics: differential and integral calculus (theory and application), classical statistical inference, regression analysis, matrix algebra, marketing, production and financial models, the role of models in management information systems. Prerequisites: 821—a good, recent course in college algebra or permission of instructor; (Open to evening Master of Business Administration students only.) 4 credits.

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. 4 credits. (Open to evening Master of Business Administration students only.)

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 (46)

Chairman: *Stephen S. T. Fan*

ASSOCIATE PROFESSORS: R. Lee Byers, Stephen S. T. Fan

ASSISTANT PROFESSORS: Robert S. Torrest, Gail D. Ulrich

VISITING PROFESSOR: Yin-Chao Yen

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-

Chemical Engineering

quired for the degree of Bachelor of Science in Chemical Engineering in this University. 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, which must include Chemical Engineering 813, 815, 816, and 823, is required for the Master of Science degree in Chemical Engineering. The core-courses requirement can be waived only in special cases with permission from the department faculty. 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 85.

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 pollu-

tants, 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.

899. Master's Thesis

Original investigations in chemical engineering. 1-6 credits.

Chemistry

Chemistry (47)

Chairman: *Alexander R. Amell*

PROFESSORS: Alexander R. Amell, Kenneth K. Andersen, Albert F. Daggett, Helmut Max Haendler, Paul R. Jones, Robert E. Lyle Jr., Frank L. Pilar

ASSOCIATE PROFESSORS: David W. Ellis, Gloria G. Lyle, James D. Morrison, Charles W. Owens, Albert K. Sawyer, J. John Uebel, James H. Weber, Charles M. Wheeler Jr.

ASSISTANT PROFESSORS: Charles V. Berney, Colin D. Hubbard

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.

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; variable credit for graduate students with permission of instructor. 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 basic theoretical concepts of modern inorganic chemistry at a moderate level, and their applications to inorganic reactions and compounds. Prerequisite: Chemistry 683; Chemistry 684 pre- or corequisite; or permission of instructor. (May not be used for graduate credit by chemistry graduate students.) 4 credits, or 3 credits for graduate students by permission of instructor.

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.

Chemistry

847. Advanced Inorganic Chemistry

Modern theory applied to spectra, magnetism, kinetics, and thermodynamics of coordination compounds. The formation of and reactions of coordination compounds including catalytic reactions. Prerequisite: Chemistry 803 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

651-652. Organic Chemistry

The principal classes of organic compounds, aliphatic and aromatic, with emphasis on class reactions and structural theory. Laboratory exercises in the preparation and purification of selected organic compounds. Prerequisite: Chemistry 404 or 406 or permission of instructor. 3 lectures; 2 laboratories; 4 credits. Students receiving credit for Chemistry 651-652 may not receive credit for either Chemistry 545 or Chemistry 547-548.

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, or variable credits for graduate students with the permission of the instructor.

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, alkaloids, 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 electromotive 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.

Chemistry

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.

895, 896. Colloquium in Chemistry: (1) Inorganic Chemistry, (2) Organic Chemistry, (3) Theoretical Organic Chemistry, (4) Physical Chemistry, (5) Analytical Chemistry

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.

789. Atomic and Molecular Structure

The methods of determining atomic and molecular structure, including ultra-violet and infrared spectroscopy and radiochemistry. 4 credits.

Civil Engineering (48)

Chairman: *Louis H. Klotz*

PROFESSOR: J. Harold Zoller

ASSOCIATE PROFESSORS: Victor D. Azzi, Louis H. Klotz, Harold E. Langley Jr., John P. Nielsen, Robert P. Vreeland, Tung-Ming Wang

ASSISTANT PROFESSORS: C. Gorman Gilbert, Paul E. Bishop

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 area 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 Plan A or Plan B program. The Plan A program requires a minimum of 24 credits of graduate-level course work plus a thesis for which six graduate credits are 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 or Plan B paper is required by the Department for its files. Additional copies are usually presented to the library and the candidate's adviser.

All candidates for the master's degree are required to take an oral final examination. The Examination Committee, appointed by the Dean of the Graduate School

Civil Engineering

from nominations by the Department Chairman, will consist of at least two senior faculty members from within the Civil Engineering Department and an additional senior faculty member usually selected from another department within the College of Technology. The oral final examination will consist of a defense of the thesis or Plan B paper as well as an examination of the engineering fundamentals leading to the Master's Degree. The thesis or Plan B paper should be given to the Committee members at least two weeks prior to the date of the final oral examination.

The master's 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 one of four established areas of specialization. Most Ph.D. candidates with Civil Engineering backgrounds would 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 Engineering Ph.D. program is presented in the Engineering Ph.D. section of this catalog on page 85.

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 620 and 665. 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 I. 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 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.

768. Seepage through Earth Structures

Fundamentals of groundwater flow, Darcy's Law, flow nets, Dupuits theory and application, conformal mapping techniques, confined flow, flow through earth and rock structures, seepage towards wells. Prerequisite: Civil Engineering 665 and Civil Engineering 642. 2 lectures; 2 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. Structural Analysis by 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.

Civil Engineering

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 sub-structure 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. 2-4 credits.

867. Soil Dynamics

Vibrations of elementary systems, wave propagation, elastic waves in layered systems, behavior of dynamically loaded soils, vibrations of foundations, isolation of footings, field measurements and instrumentation, design procedures for dynamically loaded foundation. Prerequisites: Civil Engineering 765 and Civil Engineering 863. 2 lectures; 2 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, 897. Civil Engineering Problems

The study and investigations of problems selected to meet the needs of the students. 2-4 credits.

899. Master's Thesis

Hours and credits, 6-9, to be arranged.

Earth Sciences (49)

Chairman: *Herbert Tischler*

PROFESSORS: Donald H. Chapman, T. Ralph Meyers, Cecil J. Schnee, Herbert Tischler

ASSOCIATE PROFESSORS: Franz E. Anderson, Henri E. Gaudette, Glenn W. Stewart

ASSISTANT PROFESSORS: Wallace A. Bothner

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.

Earth Sciences

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. 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 II. 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.

- 795. Geological Problems:** (1) Areal Geology, (2) Geochemistry, (3) Geomorphology, Advanced, (4) Geophysics, (5) Glacial Geology, Advanced, (6) Groundwater Geology, (7) Historical Geology, Advanced, (8) Industrial Minerals, (9) Micropaleontology, (10) Mineral Fuels, (11) Mineralogy, Advanced, (12) Optical Crystallography, (13) Ore Deposits, (14) Paleontology, Advanced, (15) Petrology, Advanced, (16) Regional Geology, (17) Sedimentation, (18) Stratigraphy, (19) Structural Geology, Advanced, (20) Marine Geology, (21) Physical Oceanography, (22) History of Geology, (23) Earth Science Teaching Methods
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. (NLG)
- 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.)
- 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. Bothner. Prerequisite: graduate standing and permission of instructor. 3 credits. (Offered alternate years.)
- 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.)
- 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.)
- 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. (Offered alternate years.)

Economics

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 (31)

Dean: *Jan E. Clee*

PROFESSORS: Robert F. Barlow, Carroll M. Degler, 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, William R. Hosek, James H. Schulz, Dwayne E. Wrightsman

ASSISTANT PROFESSORS: Lawrence P. Cole, John V. Donovan, Richard L. Mills, Robert C. Puth, Heidemarie C. Sherman

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 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.

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

Economics

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.

Education

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*

PROFESSORS: Angelo V. Boy, Roland B. Kimball, Thomas O. Marshall, Carleton P. Menge, Gerald J. Pine

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

ASSISTANT PROFESSORS: Margaret D. Ackerman, Charles H. Ashley, Gilbert R. Austin, Ronald P. Curcio, Sidney Eder, Hubert A. Hardy, David D. Hebert, Edward Lawton, Judith A. Meagher, James W. Mittelstadt, Marvin Sepersen, Deborah E. Stone, W. Dwight Webb

LECTURER: Mary Pine

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	Reading
Secondary Education	Administration and Supervision
Counseling and Personnel Services	Early Childhood Education

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 Program

The Master of Arts in Teaching program is designed for candidates who have completed an undergraduate degree with some or no course work in professional education. The program is also open to people who wish to embark on a different career or who have finished college study some time ago. Also eligible are uncertified, relatively inexperienced teachers. Candidates in secondary education need a major which is usually taught in junior or senior high schools (e.g. English, history, mathematics, sciences, foreign language, and fine arts). Elementary MAT candidates may have an undergraduate major in any field.

During an academic year and two summers, candidates participate in a practicum, graduate seminars in education methodology and foundations, graduate courses in the fields of specialization or related fields, and a teaching internship. During the first summer, the practicum and related work and seminars are intended to help the candidates assess their career choice, the role of teacher, and themselves in regard to that role. Candidates make up the teaching staff of a nearby elementary summer school and a secondary summer school. During the academic year candidates serve a teaching internship in a nearby public or private school system or other agencies offering educational services. Generally, interns assume one-half a normal teaching load for the entire school year, although each internship may differ to fit the specific information of the cooperating school and the intern.

For further information, prospective elementary school teachers should write to Professor John G. Chaltas, director, MAT (Elementary), Department of Education. Prospective secondary school teachers should write to Professor Sidney Eder, director, MAT (Secondary), 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.

797. 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.

Education

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. Diagnosis and Remedial Reading in the Elementary School

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 at the Elementary Level

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.

811. Diagnostic and Remedial Reading in the Secondary School

Study of techniques for diagnosing the reading problems of secondary school students and developing appropriate remedial procedures. Emphasis will be given to reading problems encountered in the various content areas of the secondary school curriculum. Prerequisite: Education 807 or 810. 4 credits.

812. Practicum in Developmental and Remedial Reading and Language at the Secondary School Level

Supervised tutoring of secondary school students in order to develop techniques for improving reading skills. Seminars will focus upon corrective techniques and the integration of reading skills to the content areas. Prerequisite: Education 811 (may be taken concurrently) and permission of instructor at least one month before beginning of the course. 4 credits.

814. Seminar in Reading

Investigation of current research findings in reading and the related language arts. Seminars will focus on significant research projects, program designs, and analysis of the yield of reading research and ramifications for the reading specialist. Prerequisite: permission of instructor. 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.

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

Education

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)

Supervised Practicum: An exploratory summer practicum in a local summer elementary school designed to examine teaching as a career and to prepare for the internship in the fall. The summer includes: (a) a pre-practicum workshop focusing on interpersonal skill development; (b) a pre-practicum curriculum and instruction laboratory, (c) a six-week practicum in which candidates, with the help of the MAT staff, serve as the teaching staff in a local summer school, (d) seminars in curriculum and instruction. Opportunities for teaching high school students are available for candidates who wish to determine better what level of teaching they prefer. (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)

Supervised Practicum: An exploratory summer practicum in a local summer high school designed to examine teaching as a career and to prepare for the internship in the fall. The summer includes: (a) a pre-practicum workshop focusing on interpersonal skill development; (b) a pre-practicum curriculum and instruction laboratory, (c) a six-week practicum in which candidates, with the help of the MAT staff, serve as the teaching staff in a local summer school, (d) seminars in curriculum and instruction. Opportunities for teaching on elementary level are available for candidates who wish to determine better what level of teaching they prefer. (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 MAT staff. (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 MAT staff. (Second semester only.) Prerequisite: Education 836. 4 credits.

838. Sociology of Education: Social Organization of Schools and Community
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.

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,

Education

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.

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.

899. Thesis

Prerequisite: permission of the department. 4-8 credits.

Electrical Engineering (50)

Chairman: *Joseph B. Murdoch*

PROFESSORS: Fletcher A. Blanchard, Albert D. Frost, Joseph B. Murdoch, Alden L. Winn

ASSOCIATE PROFESSORS: Ronald R. Clark, Glen C. Gerhard, Filson H. Glanz, Donald W. Melvin, H. Richard Skutt, Kerwin C. Stotz

ASSISTANT PROFESSORS: Robert W. Goodrich, A. Kiefer Newman, John L. Pokoski, K. Sivaprasad, Michael M. Stern

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 85.

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

Electrical Engineering

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, optoelectronic 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

Electrical Engineering

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 non-sinusoidal 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.

Electrical Engineering

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

State-space representation of systems. Analysis using state transition matrix. Controllability and observability. Synthesis of optimum control systems, including calculus of variations and maximum principle. Introduction to nonlinear and stochastic control-systems including stability concepts using Liapunov and Popov criteria. Sampled-data systems. Prerequisite: Electrical Engineering 782. 3 credits.

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 (54)

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

ASSOCIATE PROFESSORS: Victor D. Azzi, R. Lee Byers, Ronald R. Clark, Stephen S. T. Fan, Glen C. Gerhard, Filson H. Glanz, Louis H. Klotz, Harold E. Langley, Donald W. Melvin, William Mosberg, John P. Nielsen, H. Richard Skutt, Kerwin C. Stotz, Russell L. Valentine, Tung-Ming Wang

ASSISTANT PROFESSORS: Robert W. Alperi, Robert J. Becherer, Barbaros Celikkol, David E. Limbert, John L. Pokoski, Kandagunta Sivaprasad, Robert S. Torrest, Gail D. Ulrich, John A. Wilson

ENGINEERING PH.D. COMMITTEE: Victor D. Azzi, Ronald R. Clark, Stephen S. T. Fan, 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-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, *Ronald R. Clark*, 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.

Engineering Ph.D. Program

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, theoretical soil mechanics, biomechanics, elastodynamics, and acoustics.

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, acoustic determination of the properties of layered media, Cosserat fields, and dislocation theories.

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.

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 tech-

nical 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 by the end of the second year of graduate study, and must 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 (62)

Chairman: *John C. Richardson*

PROFESSORS: Robert D. Hapgood, William B. Hunter Jr., Max S. Maynard, Donald M. Murray, Philip L. Nicoloff, John C. Richardson, Dale S. Underwood, Thomas A. Williams

ASSOCIATE PROFESSORS: Thomas A. Carnicelli, Carl Dawson, Lewis C. Goffe, Terence P. Logan, Edmund G. Miller, Mark R. Smith, John A. Yount

ASSISTANT PROFESSORS: Earl Briden, S. Anthony Caldwell, Elizabeth H. Hageman, John C. Pfordresher, Hugh M. Potter III, Alan H. Rose, Susan M. Schibanoff, David V. Siddall, Theodore Weesner

The Department of English offers three advanced degrees, Master of Arts, Master of Science for Teachers, and Doctor of Philosophy. All applicants are required to submit Graduate Record Examination scores for the Aptitude Test and the Advanced Test of Literature in English. 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 deficiencies in their undergraduate training.

COURSES: A Master's candidate must pass seven four-credit courses in English and American literature, language, and writing. 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.

English

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. A complete 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 (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 methods of teaching, either by attending a colloquium on college teaching, by teaching under supervision as a graduate assistant in the department, or by equivalent activities elsewhere. 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

A course designed especially for the English Teaching major in which students analyze essays and write non-fiction prose. The course will stress a variety of critical approaches and introduce several methods of teaching composition. 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 nonhistorical, 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. Haggood. 4 credits.

742. Puritanism and the Enlightenment in America

American literature and thought from the Colonial beginnings through the early republic. 4 credits.

743. American Transcendentalists

Emerson, Thoreau, and other transcendentalists. Mr. Nicoloff. 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, Dickinson, and others. 4 credits.

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, Jeffers, 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.

English

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. Pfordresher. 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. 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 | 8. The Twentieth Century |
| 2. Medieval Literature | 9. The Drama |
| 3. The Renaissance | 10. The Novel |
| 4. The Seventeenth Century | 11. Poetry |
| 5. The Eighteenth Century | 12. Non-fiction |
| 6. The English Romantic Period | 13. American Literature |
| 7. The Victorian Period | 14. A Literary Problem |
- Graduate faculty. 4 credits.
- 806. English Linguistics**
4 credits.
- 813, 814. Literary Criticism**
4 credits.
- 842. 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.

English

- 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.
- 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. 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 or Mr. Dawson. 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 (20)

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.

704. Medical Entomology

Insects and arachnids in relation to public health. The more important disease carriers, their biologies, 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. 2-4 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.

French and Italian

Forest Resources

See Institute of Natural and Environmental Resources

French and Italian (56)

Chairman: *Louis J. Hudon*

PROFESSOR: Louis J. Hudon

ASSOCIATE PROFESSORS: Samuel E. Stokes Jr., Jack Vrooman

VISITING ASSOCIATE PROFESSOR: Edna S. Hudon

ASSISTANT PROFESSORS: Rose Antosiewicz, 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 800 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 27.

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; offered in 1972-73.)

(842). French Literature of the Renaissance

Readings in the literature of the sixteenth century. 3 credits. (Alternate years; offered in 1972-73.)

859-860. French Literature of the Seventeenth Century

Readings in the literature of the seventeenth century. 3 credits. (Alternate years; not offered in 1972-73.)

861-862. Eighteenth Century French Literature and Thought

Readings in the Age of Enlightenment. 3 credits. (Alternate years; offered in 1972-73.)

867-868. Nineteenth Century French Literature

Readings in Romantic, Parnassian, and Realistic literature of the century. 3 credits. (Alternate years; not offered in 1972-73.)

(870). Introduction to Modern French Poetry

Studies in French poetry from Baudelaire to the present. 3 credits. (Alternate years; not offered in 1972-73.)

881-882. Contemporary French Novel and Theater

Readings in the French novel and theater of the twentieth century. 3 credits. (Alternate years; offered in 1972-73.)

888. Seminar in French Literature

A study of French authors chosen by the instructor. 3 credits. (Alternate years; not offered in 1972-73.)

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. Variable 1-4 credits.

899. Master's Thesis

6 credits.

Italian (59)

795, 796. Independent Study in Italian Language and Literature

Individual guided study in special topics in any area of Italian literature. Staff. Prerequisite: permission of the department chairman. 2 or 4 credits.

Genetics Program (97)

Chairman: *F. K. Hoornbeek*

PROFESSORS: Walter M. Collins, Gerald M. Dunn, D. MacDonald Green, Lincoln C. Peirce, Richard W. Schreiber

ADJUNCT PROFESSORS: Peter W. Garrett, Ernst J. Schreiner

ASSOCIATE PROFESSORS: James P. Barrett, Harold W. Hocker Jr., Frank K. Hoornbeek, Owen M. Rogers, Willard E. Urban Jr.

ASSISTANT PROFESSORS: J. Brent Loy, Yun Tzu Kiang, Robert M. Zsigray

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.

Genetics Program

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.

The core curriculum in Genetics requires students in the Ph.D. program to take a minimum of one course from each of the following groups of courses: 1) Population Genetics—Introductory course (Genetics 705); 2) Molecular Genetics—Biochemical Genetics (Genetics 770); Microbial Genetics (Microbiology 804), Developmental Genetics (Plant Science 832); 3) Classical Genetics—General and Comparative Genetics (Genetics 703), Plant Genetics (Plant Science 851), Cytogenetics (Plant Science 853), Quantitative Genetics (Animal Science 811).

The requirements for the M.S. candidates will be a minimum of one course from each of any two of the above three groups of courses.

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 courses designated in 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. Consideration will also be given to techniques useful in statistical and experimental approaches to analyses of diploid inheritance. Mr. Hoornebeek. Prerequisite: Zoology 604, Principles of Genetics, or equivalent. 4 credits. (Alternate years, not offered in 1972-73.)

705. Population Genetics

The population growth and regulation; the distribution of genes in populations; factors affecting gene frequency such as mode of inheritance, mating systems, mutation, migration, genetic drift, selection, and linkage disequilibrium; genetic load, cost of natural selection, and ecological genetics. Mr. Kiang. Prerequisite: Zoology 604 (Principles of Genetics) and Forest Resources 528 (Applied Statistics I), or equivalents, or permission of instructor. 4 lectures; 4 credits.

740. Organic Evolution

The synthetic theory of evolutionary processes in the origin of life, species, and higher groups; sources of genetic variability, population structure, causes of evolution; ecological adaptations in animals, plants, and man; evolution of communities; molecular evolution and rate of evolution. Mr. Kiang. Prerequisite: Zoology 604, or equivalent, or permission of instructor. 4 lectures; 4 credits. (Alternate years; not offered 1972-73.)

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 cross-over designs. Mr. Urban. Prerequisite: Forest Resources 711; and Mathematics 410, Digital Computer Systems, or permission of instructor. 3 credits. (Alternate years; not offered in 1972-73.)

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; offered in 1972-73.)

(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 (17)

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. 3 lectures; 1 laboratory; 4 credits.

812. Quantitative Genetics and Selection

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. (Alternate years; not offered in 1972-73.)

Botany (19)

732. Cell Biology

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 microscopy. Mr. Bogle. Prerequisite: Botany 411 or 503. 2 lectures; 4 hours of laboratory; 4 credits. (Alternate years; offered in 1972-73.)

Genetics Program

Forest Resources (21)

711. Statistical Methods II

An intermediate course in statistics. Topics include basic concepts of sampling, linear models and analyses for one-way and multiway 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; not offered in 1972-73.)

Microbiology (70)

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. Zsigray. Prerequisite: permission of instructor. 2 lectures; 2 laboratories; 4 credits.

Plant Science (24)

732. Developmental Genetics

Fundamental concepts concerning gene action in relation to development, with emphasis on plant organisms. Topics will include isozymes and differentiation, chromosomal proteins and gene regulation, temporal specificity of gene action, nuclear-cytoplasmic interactions, chemical gradients and gene activation, and gene control of differentiation. Prerequisite: Introductory Genetics and Organic Chemistry or Physiology. Mr. Loy. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered spring 1973.)

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; offered in 1972.)

851. Plant Genetics

Linkage, euploidy, aneuploidy, cytoplasmic inheritance, mutation, and genetics of disease resistance. Mr. Dunn. Prerequisite: Genetics. 3 credits. (Alternate years; not offered in 1972.)

853. Cytogenetics

Chromosome aberrations and their behavior. Effect of radiation on chromosomes. Mapping and laboratory technique in cytogenetic analysis. Mr. Rogers. Prerequisite: Genetics and Cytology. 2 lectures; 1 laboratory; 3 credits. (Alternate years; offered in 1972.)

Zoology (84)

706. Genetics Laboratory

Experiments and demonstrations in classical, developmental, and population genetics and cytogenetics, utilizing a wide range of organisms and techniques. Genetics faculty. Prerequisite or concurrent: Zoology 604 or equivalent, and permission of instructor. 2 credits.

German and Russian (66)

Chairman: *Marron C. Fort*

ASSOCIATE PROFESSORS: Marron C. Fort, Helmut F. Pfanner

ASSISTANT PROFESSORS: Jane K. Brown, 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 Salzburg. To this end he should consult with the Director of Studies Abroad.

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.

741. German Lyrics from Gryphius to George

A critical survey of German lyrics including problems of prosody and poetics. 4 credits.

742. History of the German Drama

A study of the changes in dramatic form from "Peter Squenz" to "Marat/Sade." 4 credits.

743. Introduction to Middle High German

The phonology and grammar of Middle High German. The reading of selected texts. 4 credits.

744. Medieval Literature

German literature from the earliest movements until 1500. Longer works will be read in modern German translation. 4 credits.

German and Russian

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.

755. Renaissance and Baroque

Literature of the 16th and 17th centuries, including works by Brant, Murner, Luther, Fischart, Biedermann, Opitz, Gryphius, Lohenstein, Grimmelshausen. 4 credits.

756. German Enlightenment Literature

Literature and criticism of the 18th century, including Gottsched, the Swiss critics, Lessing, Wieland, and the "Sturm und Drang." 4 credits.

757-758. The Age of Goethe

Goethe, Schiller, Holderling, Kleist, and their times. 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 Post-Romantic Literature

A study of the works of Grillparzer, Morike, Stifter, Heine, Buchner, and of other writers of "Biedermeier," "Junges Deutschland," and "Vormarz." 4 credits.

772. The Age of Realism

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

777. Bibliography and Methodology

Tools and methods of bibliographical research with an introduction to the techniques of literary interpretation. 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.

785. German Literature from Naturalism to Expressionism

Major literary movements between 1810 and 1925 including such authors as Hauptmann, Wedekind, Mann, Hesse, Kafka, Rilke, Benn. 4 credits.

786. German Literature from 1918 until 1948

The literature of Germany between the two world wars as well as German exile literature including Brecht, Doebelin, Zuckmayer, Musil, Broch, Graf, 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

Independent and in-depth investigation of a vast range of subjects; barring duplication of material, may be repeated for credit; presumes a sound background in Germanic studies. 1-4 credits.

862. Contemporary German Literature

Literary trends since 1948 in the two German states as well as in Austria and Switzerland including such authors as Boll, Johnson, Celan, Frisch, Durrenmatt, Weiss. 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 Salzburg, Austria, for students who have been admitted to the Graduate School of the University of New Hampshire. Students should consult with the Department Chairman. 3 credits.

887. Seminar in Germanic Linguistics

An intensive study of a specific topic in Germanic philology involving the preparation of a research paper. 3 credits.

888. Seminar in German Literature

An intensive study of a literary group or figure. 3 credits.

889. Seminar in German Literature

An intensive study of a literary group or figure. 3 credits.

895, 896. Special Studies in German Language and Literature

Presuming a sound background in Germanic studies, this 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 (68)

Chairman: *Douglas L. Wheeler*

PROFESSORS: Thomas N. Bonner, H. Trevor Colbourn, William Greenleaf, Hans Heilbronner, Charles A. Jellison, William R. Jones, David F. Long, Darrett B. Rutman, Cecil J. Schneer

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

ASSISTANT PROFESSORS: Thomas M. Kemnitz, J. Brad Lentz, Allen B. Linden, Frank D. McCann, 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, Proseminar: 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 proseminar 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. 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.

History

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. Seminar format. 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 multi-disciplinary. 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. Heilbronner (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

(1) Early American History, (2) American National History, (3) Canada, (4) Latin America, (5) Medieval History, (6) Early Modern Europe, (7) Modern European History, (8) Ancient History, (9) Far East and India, (10) Near East and Africa, (11) European Historiography, (12) American Historiography, (13) Russia, (14) World History, (15) English History, (16) Historical Methodology. Staff. Prerequisite: permission of instructor. 3 credits.

(899). Master's Thesis

(999). Doctoral Research

Home Economics (22)

Acting Chairman: *Maynard C. Heckel*

PROFESSOR: Marjory Wybourn

ASSOCIATE PROFESSORS: Earl O. Goodman Jr., Mary Holder, Elizabeth M. Rand, Elizabeth Snell

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.
3. Research—a minimum of 4 semester credits, including Home Economics 897, Research Seminar, and Home Economics 898, Research Project, or Home Economics 899, Thesis.

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.

Institute of Natural and Environmental Resources

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*

PROFESSORS: James R. Bowring, Paul E. Bruns, Gordon L. Byers, William H. Drew, Francis R. Hall, Otis F. Hall, William F. Henry, John L. Hill, Allen B. Prince

ADJUNCT PROFESSORS: George E. Frick, Ernst J. Schreiner

ASSOCIATE PROFESSORS: Richard A. Andrews, James P. Barrett, Owen B. Durgin, Bennett B. Foster, Harold W. Hocker Jr., Edmund F. Jansen Jr., David P. Olson, Nobel K. Peterson, R. Marcel Reeves, Oliver P. Wallace Sr., Richard R. Weyrick

ADJUNCT ASSOCIATE PROFESSORS: C. Anthony Federer, Nelson L. LeRay, Robert S. Pierce

ASSISTANT PROFESSORS: Glendon W. Gee, Robert D. Harter, William W. Mautz, Sherrill B. Nott

ADJUNCT ASSISTANT PROFESSORS: Peter W. Garrett, William B. Leak

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 (21)

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; not offered in 1972-73.)

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

Forest Resources

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. Drew 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 and Mr. Mautz. 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.

895, 896. Investigations in (1) Forest Ecology, (2) Photogrammetry, (3) Wood Utilization, (4) Game Management, (5) Mensuration, (6) Forest Economics, (7) Forest Management, (8) Operations Control and Analysis; (9) Recreation, (10) Policy, (11) Wildlife Physiology

Elective only after consultation with the instructor in charge. 14 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 (25)

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.

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.

Resource Economics

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. Prerequisite: Intermediate Economic Theory, Elementary Statistics, Elementary Calculus, Elementary Linear Programming, or permission of instructor. 4 credits. (Alternate years; offered in 1973-74.)

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. 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 relationships, 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. 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. 4 credits.

895-896. Investigations in Resource Economics

Human-resource development, legal problems in resource development, economics of outdoor recreation, community development. Staff. 2 to 4 credits.

899. Thesis

To be arranged. 6-10 credits.

Soil and Water Science (26)

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.

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; housing, recreation, sewage-effluent disposal, conservation, transportation, surface runoff, and other soil-use problems common to many rural and urban

Soil and Water Science

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.

735. Pollution of Water: Causes and Control

A combination of individual study and guided classroom discussion to explore problems in environmental pollution. Major emphasis is on the scientific and technological aspects of pollution and pollution control. Topics include the sources, effects, and control of water pollution; as well as its social, economic, and legal implications. Mr. Harter. Prerequisites: graduate standing or permission of instructor. One lecture and weekly papers, 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. Chemistry of Soil Colloids

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; 3 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-net 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;

Interdisciplinary Options and Programs

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

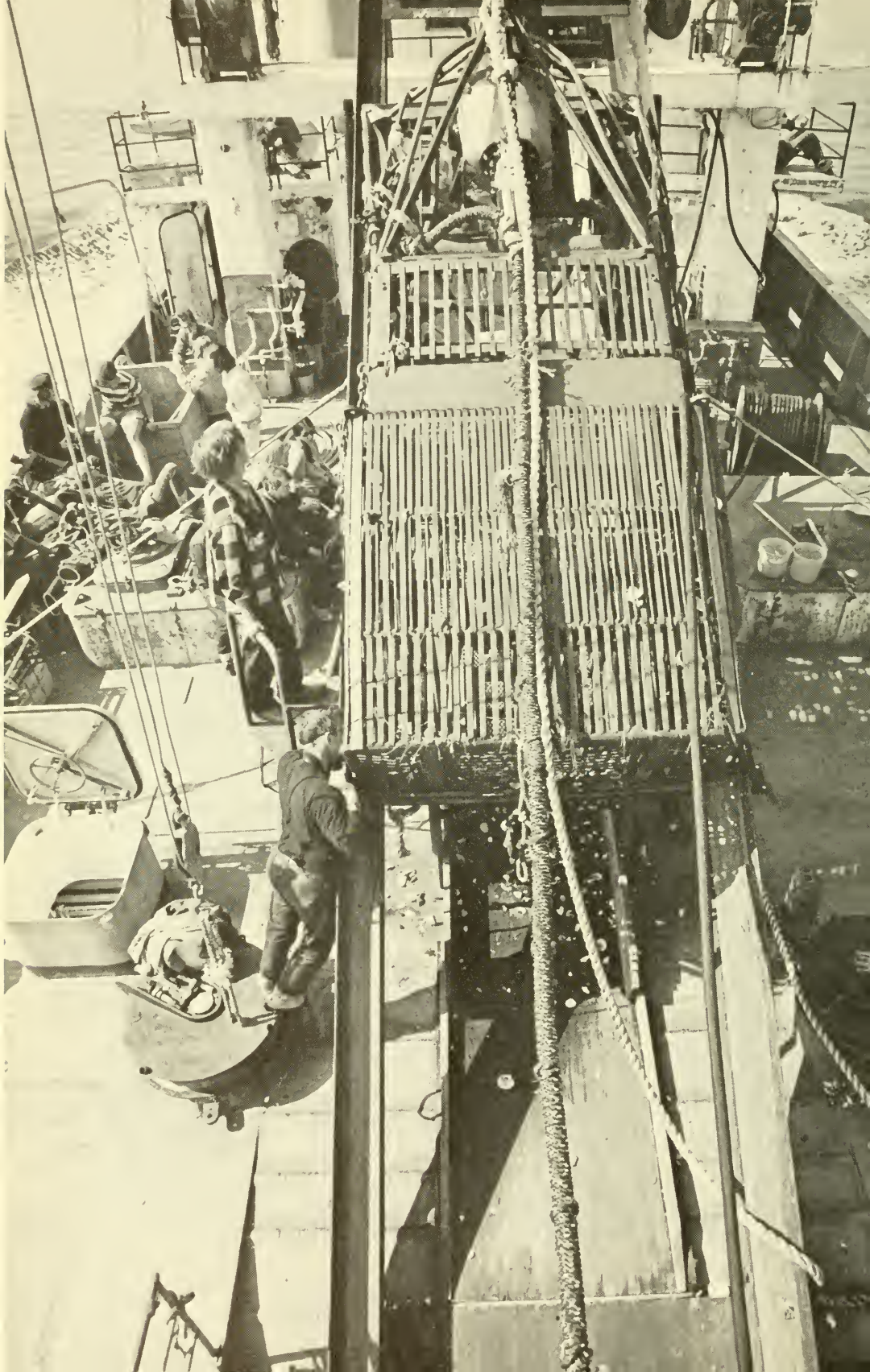
Doctor of Philosophy candidates in Chemistry may elect to enter the Chemical Physics program, an interdisciplinary program offered jointly with the Department of Physics. In this option the doctoral student, with the advice of his guidance committee, elects courses in chemistry and physics (or, in some 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, earth sciences, 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, Earth Sciences, 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 students 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 (51)

Chairman: *M. Evans Munroe*

PROFESSORS: Richard H. Balomenos, Edward H. Batho, Arthur H. Copeland, A. Robb Jacoby, Richard E. Johnson, Shan S. Kuo, M. Evans Munroe, James A. Radlow, Shepley L. Ross, Robert J. Silverman

ASSOCIATE PROFESSORS: Homer F. Bechtell, William E. Bonniece, David M. Burton, Eric A. Nordgren, Samuel D. Shore

ASSISTANT PROFESSORS: Albert B. Bennett, Kenneth L. Lange, Loren Meeker, Berrien Moore III, Albert O. Shar, Donovan Van Osdol

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 in 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.

Oceanography Students Obtaining Biological Specimens
by dragging the Ocean Floor.

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 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.

630. Mathematics for Social Sciences

Difference and differential equations, linear algebra, linear programming, game theory. Applications to the social sciences will be stressed throughout the course. Prerequisite: Mathematics 415. 4 credits.

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, cononical 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.

645-646. Analysis for Applications

Real functions; uniform convergence; matrix algebra; special functions; second order ordinary differential equations; Sturm-Liouville problems; Green functions; Fourier expansions. Prerequisites: Mathematics 527 and 528. 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

This course will cover topics in systems programming, including the use and implementation of assemblers, loaders, macros, compilers, and operating systems. Machine language, assembler language, subroutine linkage, debugging, conditional assembly, job control language, I/O programming. Memory, processor, device, and information management. Structure of compilers and other system components. Selected problems will be programmed and run on a computer in the Computation Center. Prerequisite: Mathematics 410 (Digital Computer Systems). 4 credits.

711. Programming Languages and Compiler Construction

Introduction to recursive processes; a sketch of PL/I and ALGOL. Formal syntax and Backus-Naur form, syntax directed compilers, semantic routines, symbol table structures, resource allocation, parsing algorithm, code generation, and optimization of translator writing systems. Associated computer laboratory work. Prerequisite: Mathematics 710. 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.

Mathematics

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.

810. Mathematics Education

1.) Current Developments and Issues in Mathematics Education. A workshop focused on selected mathematics curriculum development projects such as SMSG, UICSM, the Madison Project, SIV-CSMP, the Nuffield Project, and issues such as those represented by the Cambridge Conference, the role of mathematics laboratories, the integration of science and mathematics courses, computer-assisted instruction, the role of computers. 2.) Teaching of Mathematics. A seminar focused on the introduction of mathematical ideas from the subject-matter courses (801-802, 805-806, 807-808, 826, 829) into the school curriculum with particular emphasis placed on teaching in the secondary school. 14 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.

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.

Mathematics

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.

999. Doctor of Philosophy Thesis

Mechanical Engineering

Mechanical Engineering (52)

Acting Chairman: *John A. Wilson*

PROFESSORS: Robert W. Corell, Godfrey H. Savage, Charles K. Taft, Asim Yildiz
ASSOCIATE PROFESSORS: E. Eugene Allmendinger, Victor D. Azzi, Frederick G. Hochgraf, William Mosberg, Russell L. Valentine
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 85.

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. Macroscopic 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.

716. Propulsion Systems

Application of basic engineering sciences to the engineering problems of propulsion systems. 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, gyroscopic 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.

Mechanical Engineering

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 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.

781. Mathematical Methods in Engineering Science I

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; inhomogeneous, 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

Mechanical Engineering

loading functions. Special emphasis on ideal plasticity, strain-hardening, creep, limit analysis, and limit design. 4 credits.

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.

838. Theoretical Acoustics

Fundamentals are presented with emphasis on theory and applications in underwater acoustics and in the acoustic determination of dynamic material properties. Topics include: a review of vibration theory; derivation of nonlinear acoustic field equations; linearization; Green's function techniques and solution of boundary value problems; scattering, reflection theories of boundary roughness; development of ray theory (geometric optics) from field equations; and Eikonal approximations. 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

Mathematical groundwork for applied group theory, transformation groups, affine groups and affine geometry. Coordinate transformations and point transformations. Affinors, tensors, and their algebraic properties. Invariant differential operators. Lie derivative, holonomic and anholonomic coordinate systems. Curvature tensor, Bianchi identity, tensor densities. Green's theorem, Green's functions, potential functions, Pfaff's problem. 4 credits.

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 168.

Microbiology (70)

Chairman: *Theodore G. Metcalf*

PROFESSORS: William R. Chesbro, Galen E. Jones, Theodore G. Metcalf, Lawrence W. Slanetz

ASSISTANT PROFESSORS: Thomas G. Pistole, 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.

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. Chesbro, Mr. Zsigray. 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. Pistole. 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. Pistole. Prerequisite: Microbiology 702. 2 lectures; 2 laboratories; 4 credits.

Microbiology

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 phosphorous; 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 1972-73.)

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 Microbiology

Procedures and methods for the classification of microorganisms; 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. (Prokaryotic 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. Zsigray. 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 (71) (72)

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

Music

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 (71)

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 of Europe 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.

732. The Art Song

A study of the history and literature of the solo song with piano accompaniment. The course is intended to provide a broad background in the various national styles of the 19th and 20th centuries as well as a deeper study of the central core of the art song—the German *lied*. 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.

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.

755, (755). Performance Studies in Medieval Music

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, rebee, 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, Ms. Rasmussen. 2 to 4 credits.

757, (757). Performance Studies in Baroque Music

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. Ms. Rasmussen, Mr. Wicks. 2 to 4 credits.

758, (758). Performance Studies in Classical Music

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, Ms. Rasmussen. 2 to 4 credits.

759, (759). Performance Studies in Nineteenth-Century Music

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,

Music

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 permission 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 exemplified 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 reflecting the student's compositional interests. Guidance and advice of the instructor as appropriate to each individual project. Mr. Williams. Prerequisite: permission 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 expected to study appropriate scores, to write arrangements utilizing these various 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 masterworks 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 synthesis. 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 opportunity 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 investigate 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.

Applied Music for Graduate Credit

The following courses offer further development of technique, music interpretation, and repertory on the various instruments. Emphasis may also be directed toward the functional use of the instrument in the school room. Prerequisite: student must exhibit sufficient proficiency to warrant graduate study and permission of the Department Chairman and the student's graduate adviser. Audition required. A student may register for credit in the same courses in successive semesters with the approval of his major adviser. Music staff. 1-2 credits.

- 841, (841). Graduate Voice
- 842, (842). Graduate Piano
- 843, (843). Graduate Harpsichord
- 844, (844). Graduate Organ
- 845, (845). Graduate Violin, Viola
- 846, (846). Graduate Violoncello, String Bass
- 847, (847). Graduate Woodwind
- 848, (848). Graduate Brass
- 849, (849). Graduate Percussion
- 850, (850). Graduate Harp

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. Ms. Rasmussen, Mr. Wicks. 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, Mr. Wicks. 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, Mr. Wicks. Prerequisite: permission of instructor. 3 credits.

Music

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 (72)

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. Ms. Edwards. 2 credits.

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. Hettinger. 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. Ms. 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 (39)

Chairman: *William H. Annis*

PROFESSOR: Maynard Heckel

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.

Occupational Education

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.

796. Investigations in Occupational Education: (1) Secondary Education, (2) Post Secondary Education, (3) Adult Education, (4) Extension Education, (5) Exemplary Programs, (6) Cooperative Education Programs, and (7) Disadvantaged and Handicapped Education Programs

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

A systematic approach to the development of course materials for Occupational Education. Topics included are: occupational analysis, establishing performance objectives, selection of content, development of supplemental material, and evaluation. Prerequisite: a course in teaching methods or permission of instructor. 3 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 (53)

Chairman: *Lyman Mower*

PROFESSORS: Edward L. Chupp, Robert E. Houston Jr., John A. Lockwood, Robert H. Lambert, Lyman Mower, John E. Mulhern Jr., William R. Webber

ASSOCIATE PROFESSORS: Roger L. Arnoldy, L. Christian Balling, David G. Clark, Richard L. Kaufmann, Robert E. Simpson

ASSISTANT PROFESSORS: John F. Dawson, Edmond C. Roelof, 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.

All graduate students in Physics, except M.S.T. degree students, are required to take a preliminary, comprehensive, written qualifying exam at the beginning of the fall semester of their second year. This exam will emphasize quantum mechanics, electricity and magnetism, and classical mechanics at the undergraduate and first-year graduate level. It will be given on two days, each part being approximately four hours in duration.

On the basis of their performance on this examination students may qualify at the M.S. or Ph.D. levels. Students who fail to qualify at either level must take the written examination a second time in February of the same academic year. Students are allowed two attempts to pass the qualifying exam. Ph.D. students qualifying in the written exam will be required to take an oral exam within one month of passing the written examination.

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 27) 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

Physics

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.

M.S.T. students are not required to take the qualifying examination. 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. All M.S. students are required to take the qualifying examination. 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. 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 as specified above. 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:

- a) Satisfactory performance on the Educational Testing Service foreign language examination.
- 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

An introduction to quantum mechanics with applications to atomic and molecular spectra. Prerequisite: permission of instructor. 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. Prerequisite: permission of instructor. 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.

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.

Physics

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 (24)

Chairman: *Lincoln C. Peirce*

PROFESSORS: Gerald M. Dunn, C. A. Langer, Lincoln C. Peirce, Douglas G. Routley

ASSOCIATE PROFESSORS: Owen M. Rogers, Otho S. Wells

ASSISTANT PROFESSORS: George O. Estes, Yun-Tzu Kiang, David W. Koch, J. Brent Loy,
James E. Pollard

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 University programs in statistics and genetics. 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. (Alternate years; offered Spring 1974.)

Plant Science

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. 2 lectures; 2 laboratories; 4 credits. (Alternate years; offered fall 1973.)

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 Genetics (See Genetics Program)

705. Population Genetics

The population growth and regulation; the distribution of genes in populations; factors affecting gene frequency such as mode of inheritance, mating systems, mutation, migration, genetic drift, selection and linkage disequilibrium; genetic load, cost of natural selection and ecological genetics. Mr. Kiang. Prerequisite: Zoology 604 (Principles of Genetics) and Forest Resources 528 (Applied Statistics I), or equivalents, or permission of instructor. 4 lectures; 4 credits.

732. Developmental Genetics

Fundamental concepts concerning gene action in relation to development, with emphasis on plant organisms. Topics will include isozymes and differentiation, chromosomal proteins and gene regulation, temporal specificity of gene action, nuclear-cytoplasmic interactions, chemical gradients and gene activation, and gene control of differentiation. Prerequisite: Introductory Genetics and Organic Chemistry or Physiology. Mr. Loy. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered spring 1973.)

740. Organic Evolution

The synthetic theory of evolutionary processes in the origin of life, species, and higher groups; sources of genetic variability, population structure, causes of evolution; ecological adaptation in animals, plants, and man; evolution of communities; molecular evolution and rates of evolution. Mr. Kiang. Prerequisite: Zoology 604 or equivalent, or permission of instructor. 4 lectures; 4 credits. (Alternate years; offered spring 1972.)

Plant Science

773. Methods and Theory of Plant Breeding

Theory and use of plant breeding systems with emphasis on improving quantitative traits. Mr. Peirce. Prerequisite: Genetics, Statistics. 3 lectures; 1 laboratory; 4 credits. (Alternate years; offered fall 1972.)

851. Plant Genetics

Linkage, euploidy, aneuploidy, cytoplasmic inheritance, mutation, and genetics of disease resistance. Mr. Dunn. Prerequisite: Genetics. 3 credits. (Alternate years; offered fall 1973.)

853. Cytogenetics

Chromosome aberrations and their behavior. Effect of radiation on chromosomes. Mapping and laboratory techniques in cytogenetic analysis. Mr. Rogers. Prerequisite: Genetics, Cytology. 2 lectures; 1 laboratory; 3 credits. (Alternate years; offered fall 1972.)

General Offerings and Independent Studies

706. Plant Physiology

An introduction to the function of higher plants with an emphasis on water relations; metabolism; growth and development. Botany and Plant Science staff. Ms. Biggs (Botany) and Mr. Pollard (Plant Science). Prerequisite: Botany 411, 503 or Plant Science 421 and one year of chemistry or permission of instructor. 3 lectures; 1 laboratory; 4 credits.

776. Radioisotope Techniques for Life Sciences

Fundamental concepts and laboratory practice on the application of radioisotopes to biological systems. Techniques include detection and measurement principles, liquid scintillation spectrometry and autoradiography, gamma-ray spectrometry, radiochromatogram scanning, and tissue distribution of radioisotopes 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, Koch, Pollard, Routley

R-2 Genetics — Mssrs. Dunn, Kiang, Loy, Peirce, Rogers

R-3 Plant Utilization — Staff

895-896. Research in Plant Science

Advanced investigations in a research subject, exclusive of thesis. Staff. 14 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

Political Science (75)

Chairman: *Bernard K. Gordon*

PROFESSORS: Robert B. Dishman, Bernard K. Gordon, George K. Romoser

ASSOCIATE PROFESSORS: Erwin A. Jaffe, David L. Larson, John Woodruff, Frederic W. Wurzburg

ASSISTANT PROFESSORS: Robert E. Craig, 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 normally is expected to have majored in Political Science or in a field closely related, and to have achieved an undergraduate academic record of some distinction. In unusual and exceptional cases and where undergraduate preparation has been insufficient, a candidate may be admitted provided that he follows without credit a program of study approved by the chairman. In all cases the Graduate Record Exam is required of candidates who seek to be considered for admission. The Department offers the Master of Arts in Political Science and the Master of Public Administration.

Master of Arts (M.A.) in Political Science

The program leading to the Master of Arts in Political Science is normally to be completed in a single calendar year (an academic year plus the following summer) and is based on three elements: the development of advanced knowledge in at least three fields of the discipline in which the Department offers its courses and seminars; the ability to conduct and complete an individual program of research at a high level; and familiarization with modern methodology in the discipline. Accordingly, every candidate will complete a suitably arranged program consisting of eight courses and seminars (32 credits) and a master's thesis (which carries four credits), for a total of 36 credits. Of the eight courses, one must be Political Science 893 (Contemporary Political Analysis); and the second, Political Science 899 Sec. 1 (Directed Research and Study), normally to be taken in the second semester of the candidate's residence. The master's thesis is expected to be within the field in which the candidate has undertaken Directed Study and Research, and generally is expected to derive from the same topic. Topics must be approved by a committee selected by the chairman.

An essential requirement is that each candidate must arrange his program so that it includes at least one seminar in each of three or more fields of the discipline as offered by the Department (Political Thought; American Politics; Comparative Politics; Public Administration; and International Politics). The remaining courses may be chosen according to the candidate's interests and needs, and two may be taken in a related field outside the Department. Where a candidate lacks proficiency in tools of quantitative analysis or a foreign language essential to his program of study and research, he will be required to attain and demonstrate to his thesis adviser proficiency in the needed skill.

Master of Public Administration (M.P.A.)

The Master of Public Administration is an interdisciplinary degree designed principally for individuals intending to pursue careers in local, state, or national government service in the U.S. or other governments. Candidates will be expected to complete eight full courses (32 credits) and a six-week internship program, normally during the summer after the completion of formal course work. Candidates who have had prior appropriate responsibility in public administration may apply for a waiver of the internship requirement.

Of the eight courses, at least two shall be chosen from the courses and seminars in public administration offered by the department, and three from other Political Science courses according to the needs and interests of the candidate. In addition, one course shall be in statistics (Resource Economics 701 is recommended but other statistics offerings may fill this requirement with approval of the program adviser). Those candidates who have successfully completed comparable undergraduate work in statistics may be exempted from this requirement. The remaining two courses shall be chosen from those available outside the Department in the fields of economics, administration, resource economics, and sociology.

Candidates for advanced degrees are expected to take courses at the 800 level in Political Science, and to maintain a passing grade (B) in all courses.

Courses which have an asterisk (*) preceding the number are often alternate-year offerings. Consult the department for schedule of courses offered in a particular semester.

Political Thought

700./800. Political Thought and Culture

The relation between man's artistic and social endeavors and forms and his political thought. Study of politics and literature through figures such as Aristophanes, Swift, Shakespeare, and contemporary writers. 4 credits.

701./801. The Scientific Study of Politics: Its Philosophical Development

An analysis of scientific political science, considering formulations and criticisms of this approach. The course begins with Aristotle and reviews the development of modern scientific method from Bacon to the present. 4 credits.

*702./802. Ideologies and Dissent in America and the West

Movements of commitment, dissent, and protest since the late 19th century, particularly attacks upon liberal theory and practice in America and Europe. 4 credits.

797, 798./897, 898. Seminar: (1) Seminar in Political Thought

4 credits.

Scope and Methods

793./893. Contemporary Political Analysis

Various forms of contemporary political analysis, with attention both to methods of empirical inquiry and explanation and to modes of justification. Intended for advanced students; normally open to seniors and graduate students only, except upon permission of instructor. 4 credits.

American Politics

730./830. Administrative Process

The administrative and bureaucratic process in public life. Principal concepts of administration and the relationship of group behavior and policy development to the administrative process. 4 credits.

731./831. Urban and Metropolitan Politics

Planning and management of the urban community. Attention to intergovernmental relations, administrative functions, and general urban problems. 4 credits.

Political Science

732./832. Psychology of Political Behavior

Cultural, social, economic, and emotional forces molding the citizen's political activity. 4 credits.

733./833. Intergovernment Relations and Federalism

Interrelationship of national, state, and local governments in the context of the American federal system. Patterns of regionalism, interstate cooperation, and conflict, and the evolution of federal relations. 4 credits.

735./835. American Pluralism

Analysis and critique of theories of American pluralism. Attention to the role of private power in American politics and alternative elitist models of decision-making. 4 credits.

797, 798./897, 898. Seminar: (2) Seminar in American Politics

4 credits.

Comparative Politics (A. Area Studies)

750./850. Politics in West Europe

Examination of the politics of major continental powers. 4 credits.

751./851. Major Commonwealth States: Britain, Canada, Australia

Comparison and analysis of major governments influenced by the British parliamentary system, but with special emphasis on the nature of federal systems and ethnic diversity, as illustrated, for example, by French Canada. 4 credits.

752./852. Politics in the USSR and East Europe

Comparative analysis of the background, structure, and underlying issues of the political systems of the Soviet Union and selected East European states. Includes examination of ideological bases and political history as well as contemporary trends. 4 credits.

753./853. Major Governments of East Asia: China and Japan

4 credits.

754./854. Government and Politics in the Middle East

4 credits.

755./855. Government and Politics in Southeast Asia

4 credits.

797, 798./897, 898. Seminar: (3) Seminar in Comparative Politics of Nations

Advanced treatment of the politics of a nation or region (e.g., France, China, Germany, USSR, Southeast Asia). 4 credits.

Comparative Politics (B. Problems in Comparative Politics and Development)

757./857. Political Development and Political Decay

4 credits.

758./858. Comparative Judicial Processes

Comparative court systems and their relationships to: political life; political, social, and structural influence on judicial behavior; law; and human behavior. 4 credits.

***759/859. Comparative Legislative Behavior**

Role, organization, operation, and conduct of legislatures in various national political systems. 4 credits.

***760./860. Comparative Communist Systems**

Use of comparative methods in analysis of selected aspects of Communist systems. Emphasis on interest groupings, elites, and decision-making. Attention to political behavior within Communist international organizations and to intra-party distinctions between ruling and non-ruling Communist parties. 4 credits.

761./861. Political Sociology

The impact of social structure and change upon political behavior, including elite/mass relationships, integration, and instability. Attention to major empirical findings and theoretical contributions, from Marx and Weber to the present. 4 credits.

797, 798./897, 898. Seminar: (4) Seminar in Comparative Politics

Advanced treatment of theoretical problems and aspects of comparative politics, normally in the fields of administration, foreign policy, political parties, and governmental institutions. 4 credits.

International Politics

775./875. Theories of International Politics and Integration

Examination of general explanations for the behavior of nations and of the theory and practice of supranational integration. The development of theories of international peace and security, with attention to the concept of linkage between domestic and international politics. Concepts and practices of arms limitation and conflict resolution and of integration and community building at the international level. 4 credits.

***776./876. Strategy and National Security Policy**

Defense and deterrence considerations among the United States and other major powers, including consideration of the levels of armed violence affecting international politics and changes in the nature of war, including impact of modern weapons systems and corollary arms limitation problems. Attention also given to the development of defense policy and the role of armed force establishments in shaping defense policy in the U.S. and elsewhere. 4 credits.

777./877. International Law

Formalized processes for regularizing state behavior, as reflected especially in the development of norms based on custom, precedent, and formal institutions, as in treaties and cases. Attention given to arms reduction and limitation arrangement, inspection, and other formal arrangements designed to preserve peace. 4 credits. (Alternate years.)

778./878. International Organization

Collective security and other forms of cooperation among nations through international organizations such as the United Nations and its predecessors and through regional bodies. 4 credits.

***779./879. Foreign Policies in Europe**

The interaction of major European states, with attention to East-West relations, security alliances, forms of economic and political cooperation, and the impact of domestic change and superpower relationships on international politics in Europe. 4 credits.

Psychology

780/880. Foreign Policies of the USSR and the Soviet Bloc

The development of Soviet foreign policy and strategy in its national and European coalition context, with attention to Soviet-American and Sino-Soviet relations. 4 credits.

*781./881. International Politics of East Asia

Foreign and defense policies of the major East Asian states, with emphasis on Japan, China, and selected Southeast Asian nations. Special attention to the issues and problems where the separate states' interests interact. 4 credits.

797, 798./897, 898. Seminar: (5) Seminar in International Politics

Small-group discussion, including individual research, on problems in international politics with emphasis on developments in theory. 4 credits.

899. Section 1: Directed Research and Study

4 credits.

899. Section 2: Master's Thesis

4 credits.

Psychology (76)

Chairman: *Gordon A. Haaland*

PROFESSORS: Raymond L. Erickson, George M. Haslerud, Frederick M. Jervis, Robert I. Watson

ASSOCIATE PROFESSORS: Robert G. Congdon, Peter S. Fernald, G. Alfred Forsyth, Gordon A. Haaland, Earl C. Hagstrom, Ronald E. Shor

ASSISTANT PROFESSORS: Gregory J. Bertsch, Peter Cimboric, James R. Davis, Kirk E. Farnsworth, Leslie A. Fox, Burton I. Klinger, John E. Limber, Stephen J. Weber, 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. In addition, a concern with the 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 (in conjunction with the Department of Sociology). 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, 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 super-

vision of a staff member. Psychology 895, 896, Reading and Research in Psychology, is specifically designed to serve this purpose.

Social psychology is an interdisciplinary program operated in conjunction with the Sociology Department. Students are admitted by and meet the requirements of their respective departments. Their work in social psychology, however, is coordinated by an advisory committee with representatives from both departments and includes course work in both departments.

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 upon the successful completion of a program approved by the department and Dean of the Graduate School including original research at the master's level. 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.

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. Psychology of Personality

An examination of the major theories of personality regarding questions of the acquisition, maintenance, and modification of individual behavior. Relevant research and the nature of theorizing are also considered. Specific details of the course for a given semester should be obtained from the instructor responsible for the course in that semester. Prerequisite: Psychology 601 (Statistics and Methodology in Psychology). 4 credits.

752. Social Psychology

The behavior of individuals is studied as it is affected by the behavior of other individuals, by groups, and by society. Topics typically discussed are attitude

Psychology

change and social influence, conformity, social interaction, and research, though other types of data are regularly introduced. Descriptions of individual sections will be on file in the psychology offices during registration. Prerequisite: Psychology 601 (Statistics and Methodology in Psychology). 4 credits.

753. Abnormal Psychology

This course will examine various kinds of disturbing behaviors in terms of: (1) historical developments; (2) viewpoints of etiology; (3) identifying and understanding disruptive behavior; and (4) diagnostic implications for treatment as a function of varying theoretical viewpoints. Descriptions of individual sections will be on file in the psychology offices during registration. Prerequisite: Psychology 601 (Statistics and Methodology in Psychology). 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). Advanced Topics

The instructor presents advanced material in an area in which he has developed specialized knowledge through research and study. Taught by different staff members each year. Students may repeat the course, but may not duplicate areas of specialization. Descriptions of courses to be taught under this listing will be on file in the psychology offices during registration. Section One would be offered every semester as a seminar focusing on contemporary topics which signal new directions for psychology. An attempt will be made to broaden the scope of psychology by considering the limitations of the traditional questions asked by behavioral scientists and the methods they use and by exploring recent developments in theory and method. Prerequisite: 16 credits of psychology or permission of instructor. 4 credits.

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 psy-

chology 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.

838. 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.

841. 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.

842. 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.

Psychology

843. 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.

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. Staff. Prerequisite: Psychology 752 or its equivalent. 4 credits. (Also offered as Sociology 851.)

852. 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.

853. 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.

859. 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.

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-process, 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.

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. Therapeutic Psychology

The course will orient itself around the following three areas: *issues* which include various aspects of the human condition, essential ingredients in the therapeutic process and in therapy outcomes, effective qualities of therapists, and a full range of ethical considerations; *involvement* through participation in a group for the presentation of a particular therapeutic approach, comparison of two or more therapists or kinds of therapy, or application of therapeutic psychology to a particular problem area of institutional setting; *integration* of personal reading, participation in class discussions, and comparison of group presentations. Mr. Farnsworth. 4 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 825 (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. Students 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 (82)

Chairman: *Arnold S. Linsky*

PROFESSORS: Walter Buckley, Richard S. Dewey, Stuart Palmer, Solomon Poll, Murray 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, Amnon Orent, Howard M. Shapiro

DIRECTOR OF GRADUATE STUDIES: Murray A. Straus

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 Philosophy. 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, comparative institutional analysis, and social psychology.

Social Psychology is an interdisciplinary program operated in conjunction with the psychology department. Students are admitted by and meet the requirements of their respective departments. Their work in Social Psychology, however, is coordinated by an advisory committee with representatives from both departments and includes course work in both departments.

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 tailored 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 dissertation topics is thus limited only by the areas of expertise available among Departmental faculty members.

Upon establishing residence the student shall inform himself about any modifications 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 end of the semester. The proposal or an abstract must be circulated to all department faculty. (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.

Sociology

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 reading level proficiency in a foreign language or a research tool appropriate to the overall program of the student. If the research tool option is chosen, it must not be part of the other degree requirement for graduate students in sociology. Examples of such research tools include computer programming, symbolic logic, historiography, econometric techniques, and mathematical statistics. At the time they are admitted to the Ph.D. program, students must submit for approval by the Graduate Committee a statement indicating how they intend to meet the language/research tool requirement. (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 permitted 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.

731, 732. Area Studies in Archaeology

Courses in the archaeology of different areas of the world will be offered as staff is available and student needs dictate. Section 1: South America: An introduction to the archaeology of South America beginning with earliest known remains and progressing up to the level of the various cultural groups which existed at the time of European contact. Particular emphasis will be placed on the changing relationship of culture and environment through time. Prerequisite: Sociology 412 (Physical Anthropology and Prehistoric Archaeology) or permission of instructor. 4 credits.

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 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.

Sociology

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.

747. Native Cultures of South America

A survey of the indigenous cultures of South America. Selected groups of people from the major ecological areas of South America will be studied with an emphasis on the relationship of environment and culture. Where there are adequate historical data, changes in culture and social organization since the 16th century will be considered. 4 credits.

749. Peoples and Cultures of Oceania

A survey of the traditional cultures of Melanesia, Polynesia, and Micronesia in terms of the geographical, ecological, historical, and cultural factors which have influenced their development. Several societies will be selected for detailed examination. Prerequisite: Sociology 411 (Cultural Anthropology) or permission of instructor. 4 credits. (Offered in alternate years.)

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 socio-cultural 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.

775. Anthropological Theory

An examination of the major theoretical approaches in anthropology viewed in historical perspective. Prerequisite: Sociology 411 (Physical Anthropology and Prehistoric Archaeology) or permission of instructor. 4 credits. (Offered in alternate years.)

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.

790. Applied Sociology

The practical application of sociological research, including: (1) current level of use of sociological knowledge; (2) the advocate, consultant, and researcher roles in applied settings; (3) techniques of applied research; (4) implications of applied sociology, including ethical problems. Each student will focus on a social problem of his choice and write a paper covering the above issues. Students will be involved in applied projects where possible. Prerequisite: Sociology 601 (Methods of Research). 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.

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.

Sociology

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) 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 intraaction 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 conceptual 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-culturally 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.

Spanish and Classics

899. Master's Thesis

Usually 6 credits, but up to 10 credits when the problem warrants.

999. Doctoral Research

Soil and Water Science

See Institute of Natural and Environmental Resources

Spanish and Classics (77)

Chairman: *Michael S. Pincus*

PROFESSOR: R. Alberto Casás

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 (77)

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.)

Technology

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 Sánchez, 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: intermediate 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. Prerequisite: permission of Department Chairman. Variable credit.

899. Master's Thesis

6 credits.

Technology (45)

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 engineering 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 participate. 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. 4 credits.

Zoology (84)

Chairman: *Langley Wood*

PROFESSORS: Wilbur L. Bullock, Lorus J. Milne, Philip J. Sawyer, Emery F. Swan, Langley Wood, Paul A. Wright

ASSOCIATE PROFESSORS: Arthur C. Borrer, Robert A. Croker, Frank K. Hoornbeek, Marcel E. Lavoie, John J. Sasner, Paul E. Schaefer, Edward K. Tillinghast

ASSISTANT PROFESSORS: John E. Foret, Edward N. Franco, Larry G. Harris, E. H. Wheeler Jr.

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.

Zoology

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—should 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. Wright and staff. 4 credits.

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. Consideration will also be given to techniques useful in statistical and experimental approaches to analyses of diploid inheritance. 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.

706. Genetics Laboratory

Experiments and demonstrations in classical, developmental, and population genetics and cytogenetics, utilizing a wide range of organisms and techniques. Genetics faculty. Prerequisite or concurrent: Zoology 604 (Principles of Genetics) or equivalent, and permission of instructor. 2 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. (Alternate years; not offered in 1972-73.)

(713). Animal Behavior

Individual and group behavior of animals, including the role of anatomy, physiology, and prior experience, and the ecological significance of behavioral mechanisms. Techniques and the practical application of the study of animal behavior. Mr. Francq. Prerequisite: one year of zoology. 4 credits.

715. Natural History of Marine Invertebrates

A field and laboratory course designed to acquaint the student with the in-shore 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 1972.)

721. Parasitology

A study of 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.

724. Marine Parasitology

A study of the diseases and parasites of marine fish and shellfish with particular reference to the local estuarine environment. Mr. Bullock. Prerequisite: Zoology 508 (Human Anatomy and Physiology) or 518 (Vertebrate Morphology) or equivalent and a course in invertebrate zoology. 4 credits. (Not offered in 1972-73.)

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 Embryology

The fundamental principles of vertebrate growth and development, including metamorphosis, regeneration, and aging as well as embryonic development. Mr. Foret. Prerequisites: Zoology 518 (Vertebrate Morphology), 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.

774. Introduction to Marine Science

Daily lectures, laboratory, and field work. No formal examinations. Staff. Prerequisite: at least a full year of college biology. 4 credits.

Zoology

795, 796. Special Problems in Zoology

Election of one or more sections of this course provides opportunity for advanced study. Section numbers and subject-matter fields are: (1) Biological Oceanography, (2) Ecology, (3) Endocrinology, (4) Evolution, (5) Developmental Biology, (6) Genetics, (7) Morphology, (8) History of Zoology, (9) Invertebrate Zoology, (10) Physiology, (11) Vertebrate Biology, (12) Zoogeography, (13) Zoological Techniques, (14) Parasitology, (15) Histochemistry, (16) Protozoology, (17) Systematics, (18) Animal Behavior, (19) Teaching Practices. Work may involve reading, laboratory work, organized seminars, and/or conferences. Prerequisite: permission of staff concerned. 2 or 4 credits. (Limit of 12 credits from the sections of this course.)

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. (Offered in 1973-74.)

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. (Offered in 1972-73.)

817. Zooplankton

Oceanic and estuarine populations of zooplankton: their zoogeography, their ecological relationships within marine food chains, and their adaptations to the pelagic environment. A research problem will be undertaken aboard R/V "Eastward" in waters of the Gulf Stream and western Sargasso Sea. Mr. Wheeler. Prerequisites: Invertebrate Zoology and instructor's permission. 4 credits. (Offered in 1974-75.)

(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.

(822). Protozoology

The general biology of Protozoa, with particular emphasis on morphology, natural history, and economic importance. Mr. Borrer. 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.

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 726 or 723. 4 credits.

828. Experimental Embryology

An examination of cellular differentiation during development. Laboratories will illustrate important techniques in experimental morphogenesis. Mr. Foret. Prerequisite: Zoology 729 or equivalent. 4 credits.

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. (Not offered in 1972-73.)

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

Ackerman, Margaret D.

Assistant Professor of Education
B.S., University of Arizona, 1961; M.A.,
ibid., 1967; PH.D., University of Pennsylvania, 1971. Appointed 1971.

Allen, Fred E.

Professor of Animal Science and Veterinarian
B.S., University of New Hampshire, 1932;
D.V.M., Ohio State University, 1936.
Appointed 1940.

Allmendinger, E. Eugene

Associate Professor of Mechanical Engineering
B.S., University of Michigan, 1941; M.S.,
University of New Hampshire, 1950.
Appointed 1958.

Alperi, Robert W.

Assistant Professor of Mechanical Engineering
B.S., Michigan Technical University, 1958;
M.S., Rensselaer Polytechnic Institute,
1961; PH.D., University of Connecticut,
1968. Appointed 1967.

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
B.S., Rutgers University, 1955; PH.D., Uni-
versity of Minnesota, 1959.
Appointed 1960.

Anderson, Franz E.

Associate Professor of Geology
B.A., Ohio Wesleyan University, 1960;
M.S., Northwestern University, 1962;
PH.D., University of Washington, 1967.
Appointed 1967.

Andrew, Michael D.

Associate Professor of Education
B.S., Cornell University, 1960; A.M.T.,
Harvard University, 1961; ED.D., *ibid.*,
1969. Appointed 1966.

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
B.S., University of Maine, 1951;
M.AGRICULT., University of New Hampshire,
1959; ED.D., Cornell University, 1961.
Appointed 1962.

Antosiewicz, Rose T.

Assistant Professor of Italian
A.B., Brown University, 1954; PH.D., Uni-
versity of California at Los Angeles, 1971.
Appointed 1970.

Arnoldy, Roger L.

Associate Professor of Physics
B.S., St. Mary's College, 1956; M.S., Uni-
versity of Minnesota, 1959; PH.D., *ibid.*,
1962. Appointed 1967.

Ashley, Charles H.

Assistant Professor of Education
A.B., Dartmouth College, 1957; M.ED.,
University of New Hampshire, 1960;
ED.D., Boston University, 1969.
Appointed 1969.

Austin, Gilbert R.

Assistant Professor of Education and Director, Bureau of Educational Research and Testing

B.S., Central Connecticut College, 1953; M.A.L.S., Wesleyan University, 1956; C.A.G.S., University of Hartford, 1959; PH.D., University of Connecticut, 1965. Appointed 1965.

Azzi, Victor D.

Associate Professor of Mechanics

B.S., University of New Hampshire, 1955; D.ENG., Yale University, 1961. Appointed 1965.

Balling, L. C.

Associate Professor of Physics

B.A., Oberlin College, 1960; M.A., Harvard University, 1961; PH.D., *ibid.*, 1965. Appointed 1967.

Balomenos, Richard H.

Professor of Mathematics Education

B.S., United States Merchant Marine Academy, 1952; M.A., New York University, 1956; ED.D., Harvard University, 1961. Appointed 1961.

Barlow, Robert F.

Professor of Economics and Administration

B.A., Colby College, 1950; M.A., Fletcher School of Law and Diplomacy, Tufts University, 1951; PH.D., *ibid.*, 1960. Appointed 1962.

Barrett, James P.

Associate Professor of Forest Biometrics

B.S., North Carolina State University, 1953; M.F., Duke University, 1957; PH.D., *ibid.*, 1962. Appointed 1967.

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

B.S., Fordham University, 1950; M.S., University of Wisconsin, 1952; PH.D., *ibid.*, 1955. Appointed 1960.

Beasley, Wayne M.

Research Associate Professor, Center for Institutional and Industrial Development, and Adjunct Associate Professor of Materials Science

S.B., Harvard College, 1946; S.M. Massachusetts Institute of Technology, 1965. Appointed 1957.

Becherer, Robert J.

Assistant Professor of Mechanical Engineering

B.C.E., University of Dayton, 1966; M.S., Northwestern University, 1968; PH.D., *ibid.*, 1971. Appointed 1970.

Bechtell, Homer F., Jr.

Associate Professor of Mathematics

B.S., Grove City College, 1951; M.A., University of Wisconsin, 1956; PH.D., *ibid.*, 1963. Appointed 1966.

Beckett, 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

B.S., Maine Maritime Academy, 1954; B.S., University of Maine, 1958; M.A., *ibid.*, 1959; ED.D., University of Michigan, 1966. Appointed 1967.

Berney, Charles V.

Assistant Professor of Chemistry

B.S., Whitman College, 1953; PH.D., University of Washington, 1962. Appointed 1965.

Bertsch, Gregory J.

Assistant Professor in Psychology

B.A., Boston College, 1966; M.A., University of Vermont, 1968; PH.D., *ibid.*, 1970. Appointed 1970.

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; PH.D., The Catholic University of America, 1971.

Appointed 1969.

Bishop, Paul L.

Assistant Professor of Civil Engineering

B.S.C.E., Northeastern University, 1968; M.S.C.E., Purdue University, 1970.

Appointed 1971.

Blanchard, Fletcher A., Jr.

Professor of Electrical Engineering

B.S., Union College, 1948; M.S., Lehigh University, 1950. Appointed 1950.

Blickle, 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.

Bobick, Melvin T.

Associate Professor of Sociology

A.B., University of Illinois, 1949; A.M., *ibid.*, 1952; PH.D., *ibid.*, 1958.

Appointed 1958.

Boehme, Linda

Assistant Professor of Home Economics

B.S., Purdue University, 1964; M.S., Pennsylvania State University, 1966; PH.D., *ibid.*, 1970. Appointed 1970.

Bogle, Alfred Linn

Assistant Professor of Botany

B.S., University of Washington, 1958; M.S., *ibid.*, 1961; PH.D., University of Minnesota, 1968. Appointed 1970.

Bolland, Thomas W.

Assistant Professor of Business Administration

B.B.A., University of Cincinnati, 1953; M.B.A., University of Chicago, 1957; PH.D., *ibid.*, 1966. Appointed 1967.

Bonner, Thomas N.

President of the University and Professor of History

B.A., University of Rochester, 1947; M.A., *ibid.*, 1948; PH.D., Northwestern University, 1952. Appointed 1971.

Bonnie, William E.

Associate Professor of Mathematics

B.A.E., Syracuse University, 1951; M.S., University of Washington, 1960; PH.D., *ibid.*, 1962. Appointed 1962.

Borrer, Arthur C.

Associate Professor of Zoology

B.S., Ohio State University, 1956; M.S., *ibid.*, 1958; PH.D., Florida State University, 1961. Appointed 1961.

Bothner, Wallace A.

Assistant Professor of Geology

B.A., Harpur College, 1963; PH.D., University of Wyoming, 1967.

Bowring, James R.

Professor of Resource Economics

B.S.A., University of Manitoba, 1936; M.A., University of Alberta, 1941; PH.D., Iowa State University, 1944. Appointed 1948.

Boy, Angelo V.

Professor of Education

A.B., University of Notre Dame, 1953; ED.M., Boston University, 1955; ED.D., *ibid.*, 1960. Appointed 1965.

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.

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Braff, Allan J.

Associate Professor of Economics and Business

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Briden, Earl F.

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Professor of Forest Resources

A.B., New York University, 1937; M.F., Yale University, 1940; PH.D., University of Washington, 1956. Appointed 1958.

Buckley, Walter

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Bullock, Wilbur L.

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B.S., Queens College, 1942; M.S., University of Illinois, 1947; PH.D., *ibid.*, 1948. Appointed 1948.

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Byers, Gordon L.

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B.S., South Connecticut State University, 1951; M.A., Columbia University, 1953; ED.D., *ibid.*, 1957. Appointed 1967.

Chapman, Donald H.

Professor of Geology

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Clark, David G.

Associate Professor of Physics

B.A., Park College, 1938; M.S., Texas Agricultural and Mechanical College, 1940; PH.D., Pennsylvania State College, 1947. Appointed 1947.

Clark, Ronald R.

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B.A., Social Academy, 1953; M.S., Case Institute, 1963; PH.D., *ibid.*, 1967. Appointed 1967.

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A.B., Amherst College, 1959; M.B.A., Harvard Graduate School of Business Administration, 1961; D.B.A., *ibid.*, 1967. Appointed 1967.

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Cole, Lawrence P.

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B.ED., Keene Teachers College, 1959; M.S., Purdue University, 1964; PH.D., *ibid.*, 1969. Appointed 1966.

Collins, Walter M.

Professor of Poultry Science

B.S., University of Connecticut, 1940; M.S., *ibid.*, 1949; PH.D., Iowa State University, 1960. Appointed 1951.

Congdon, Robert G.

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Copeland, Arthur H., Jr.

Professor of Mathematics

B.S., University of Michigan, 1949; M.A., *ibid.*, 1950; PH.D., Massachusetts Institute of Technology, 1954. Appointed 1968.

Corbett, Alan C.

Associate Professor of Poultry Science

B.S., University of Maine, 1936; M.S., *ibid.*, 1937; D.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.

Associate Professor of Zoology

A.B., Adelphi College, 1958; M.S., University of Miami, 1960; PH.D., Emory University, 1966. Appointed 1966.

Curcio, Ronald P.

Assistant Professor of Education

B.A., Boston College, 1960; M.A., Fordham University, 1962; ED.D., Rutgers University, 1969. Appointed 1968.

- 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
B.A., Northern Illinois University, 1965; M.A., *ibid.*, 1966; PH.D., University of Wisconsin, 1969. Appointed 1970.
- Davis, Richard S.**
Dean of the College of Technology and Professor of Materials Science
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- Dawson, Carl**
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- Dawson, John F.**
Assistant Professor of Physics
B.S., Antioch College, 1958; PH.D., Stanford University, 1963. Appointed 1968.
- Degler, Carroll M.**
Professor of Business and Economics
A.B., University of Kansas, 1925; M.B.A., New York University, 1927. Appointed 1928.
- DeVoto, Mark B.**
Assistant Professor of Music
A.B., Harvard College, 1961; M.F.A., Princeton University, 1963; PH.D., *ibid.*, 1967. Appointed 1968.
- Dewey, Richard S.**
Professor of Sociology
A.A., Pasadena Junior College, 1934; A.B., College of Wooster, 1936; M.A., Oberlin College, 1939; PH.D., University of Wisconsin, 1941. Appointed 1958.
- Dishman, Robert B.**
Professor of Political Science
A.B., University of Missouri, 1939; A.M., *ibid.*, 1940; PH.D., Princeton University, 1948. Appointed 1951.
- Dodge, Peter**
Associate Professor of Sociology
B.A., Swarthmore College, 1948; A.M., Harvard University, 1950; PH.D., *ibid.*, 1961. Appointed 1964.
- Downs, Richard E.**
Associate Professor of Anthropology
S.B., Harvard University, 1942; CERT. OF ETHN., University of Paris, 1949; PH.D., University of Leiden, 1956. Appointed 1962.
- Draves, David D.**
Associate Professor of Education
B.A., University of Wisconsin, 1948; M.A., *ibid.*, 1949; PH.D., *ibid.*, 1957. Appointed 1964.
- Drew, William H.**
Associate Dean of the Graduate School and Professor of Resource Economics
B.S., Pennsylvania State College, 1947; M.S., Rutgers University, 1949; PH.D., Vanderbilt University, 1961. Appointed 1956.
- Dunlop, William R.**
Professor of Poultry Science
D.V.M., V.S., Ontario Veterinary College, 1938. Appointed 1950.
- Dunn, Gerald M.**
Professor of Plant Science
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
B.S., Gorham State Teachers College, 1946; M.A., University of New Hampshire, 1951. Appointed 1950.
- Durnall, Edward J.**
Director of the Division of Continuing Education
B.S., Hofstra University, 1947; M.A., Colorado College, 1948; ED.M., Harvard University, 1952; ED.D., Oregon State University, 1953. Appointed 1966.

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B.A., University of California at Los Angeles, 1957; M.Ed., University of Arizona, 1961; Ph.D., Arizona State University, 1971. Appointed 1971.

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Professor of Psychology
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Estes, George O.

Assistant Professor of Plant Science
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Faiman, Robert N.

Vice Provost for Research and Special Program Administration and 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.

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Associate Professor of Dairy Science
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Associate Professor of Chemical Engineering
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Farnsworth, Kirk E.

Psychologist, Counseling and Testing Center, and Assistant Professor of Psychology
B.S., Iowa State University, 1962; M.S., *ibid.*, 1966; Ph.D., *ibid.*, 1968. Appointed 1968.

Federer, C. Anthony

Adjunct Associate Professor of Micrometeorology
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Fernald, Peter S.

Associate Professor of Psychology
A.B., Amherst College, 1958; M.S., Springfield College, 1959; Ph.D., Purdue University, 1963. Appointed 1966.

Fink, Stephen L.

Associate Professor of Organizational Development, and Psychologist, Counseling and Testing Center
B.S., Union College, 1954; Ph.D., Western Reserve University, 1959. Appointed 1969.

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
A.B., University of New Hampshire, 1962; M.S., *ibid.*, 1963; A.M., Princeton University, 1965; Ph.D., *ibid.*, 1966. Appointed 1967.

Forsyth, G. Alfred

Associate Professor of Psychology
B.A., Dickinson College, 1961; M.S., North Carolina State University, 1963; Ph.D., Purdue University, 1967. Appointed 1967.

Fort, Marron C.

Associate Professor of German
A.B., Princeton University, 1961; Ph.D., University of Pennsylvania, 1965. Appointed 1969.

Foster, Bennett B.

Associate Professor of Forest Resources
B.S.F., Colorado State University, 1952; M.F., Oregon State University, 1957; Ph.D., Duke University, 1966. Appointed 1964.

Fox, Leslie A.

Assistant Professor of Psychology
B.S., University of Washington, 1963; Ph.D., *ibid.*, 1968. Appointed 1968.

- Franeq, Edward N.**
Assistant Professor of Zoology
 B.S., University of Maryland, 1956; M.S., University of Idaho, 1962; PH.D., Pennsylvania State University, 1967.
 Appointed 1965.
- Frick, George E.**
Adjunct Professor of Resource Economics
 B.S., University of Connecticut, 1943; M.S., *ibid.*, 1947. Appointed 1957.
- Frost, Albert D.**
Professor of Electrical Engineering
 B.S., Tufts College, 1944; A.M., Harvard University, 1947; sc.D., Massachusetts Institute of Technology, 1952.
 Appointed 1957.
- 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
 B.S., Michigan State University, 1958; M.S., University of Michigan, 1962; PH.D., *ibid.*, 1969. Appointed 1970.
- Gaudette, Henri E.**
Associate Professor of Geology
 B.A., University of New Hampshire, 1959; M.S., University of Illinois, 1962; PH.D., *ibid.*, 1963. Appointed 1965.
- Gee, Glendon W.**
Assistant Professor of Soil and Water Science
 B.S., Utah State University, 1961; PH.D., Washington State University, 1966.
 Appointed 1966.
- Gerhard, Glen C.**
Associate Professor of Electrical Engineering
 B.E.E., Syracuse University, 1956; M.Sc., Ohio State University, 1958; PH.D., *ibid.*, 1963. Appointed 1967.
- Gilbert, C. Gorman**
Assistant Professor of Civil Engineering
 B.S.C.E., University of Cincinnati, 1966; M.S.C.E., University of Minnesota, 1968.
 Appointed 1971.
- Gilman, Paul A.**
Associate Professor of Occupational 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.**
Associate Professor of Electrical Engineering
 E.S., Stanford University, 1956; M.S., *ibid.*, 1957; PH.D., *ibid.*, 1965.
 Appointed 1965.
- Goffe, Lewis C.**
Associate Professor of English
 B.S., University of New Hampshire, 1935; M.A., *ibid.*, 1946; PH.D., Boston University, 1961. Appointed 1946.
- Goodman, Earl O., Jr.**
Associate Professor of Home Economics
 A.B., Baylor University, 1953; B.D., Southern Baptist Seminary, 1957; ED.D., Teachers College, Columbia University, 1962. Appointed 1963.
- 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.
- Gordon, Bernard K.**
Professor of Political Science
 B.A., New York University, 1953; A.M., *ibid.*, 1955; PH.D., University of Chicago, 1959. Appointed 1971.

- Grant, Clarence L.**
Professor of Chemistry
B.S., University of New Hampshire, 1951; M.S., *ibid.*, 1956; PH.D., Rutgers University, 1960. Appointed 1952-58, 1961.
- Green, D. MacDonald**
Professor of Biochemistry
A.B., Oberlin College, 1954; PH.D., University of Rochester, 1958. Appointed 1967.
- Greenleaf, William**
Professor of History
B.S.S., City College, New York, 1942; M.A., Columbia University, 1948; PH.D., *ibid.*, 1955. Appointed 1958.
- Grishman, Alan**
Associate Professor of Music
B.S., Mannes College of Music, 1965; M.A., New York University, 1967. Appointed 1967.
- Haaland, Gordon A.**
Associate Professor of Psychology
A.B., Wheaton College, 1962; PH.D., State University of New York at Buffalo, 1966. Appointed 1965.
- Haendler, Helmut M.**
Professor of Chemistry
B.S., Northeastern University, 1935; PH.D., University of Washington, 1940. Appointed 1945.
- Hageman, Elizabeth**
Assistant Professor of English
B.S., Simmons College, 1963; M.A., Columbia University, 1964; PH.D., University of North Carolina, 1971. Appointed 1971.
- Hagstrom, Earl C.**
Associate Professor of Psychology
B.S., Tufts University, 1952; sc.M., Brown University, 1954; PH.D., *ibid.*, 1957. Appointed 1965.
- Hall, Francis R.**
Professor of Hydrology
B.S., Stanford University, 1949; M.A., University of California at Los Angeles, 1953; PH.D., Stanford University, 1961. Appointed 1964.
- Hall, Otis F.**
Director of the Institute of Natural and Environmental Resources, Professor of Forest Resources
A.B., Oberlin College, 1943; M.F., Yale University, 1948; PH.D., University of Minnesota, 1954. Appointed 1968.
- 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 Education
A.A., San Diego Junior College, 1954; A.B., George Washington University, 1958; M.A., *ibid.*, 1963; PH.D., University of Oklahoma, 1966. Appointed 1968.
- Harris, Larry G.**
Assistant Professor of Zoology
A.B., University of California, 1965; PH.D., *ibid.*, 1970. Appointed 1969.
- Harter, Robert D.**
Assistant Professor of Soil Chemistry
B.S., Ohio State University, 1961; M.S., *ibid.*, 1962; PH.D., Purdue University, 1966. Appointed 1969.
- 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 State University, 1967. Appointed 1967.
- Heckel, Maynard C.**
Associate Dean of the College of Life Sciences and Agriculture; Director, Cooperative Extension Service; and Professor of Adult Education
B.S., Rutgers University, 1949; M.S., Cornell University, 1956; ED.D., *ibid.*, 1961. Appointed 1971.

- Heilbronner, Hans**
Professor of History
 A.B., University of Michigan, 1949; A.M.,
ibid., 1950; PH.D., *ibid.*, 1954.
 Appointed 1954.
- Held, Warren H., Jr.**
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.
- Hill, John L.**
*Professor of Wood Science and
 Technology*
 B.S., Colorado State University, 1942;
 M.S., Yale University, 1947; D.F., *ibid.*,
 1954. Appointed 1964.
- 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;
 D.F., Duke University, 1955.
 Appointed 1955.
- Hodgdon, Albion R.**
Professor of Botany
 B.S., University of New Hampshire, 1930;
 M.S., *ibid.*, 1932; PH.D., Harvard Uni-
 versity, 1936. Appointed 1930-32, 1936.
- Hogan, John A.**
Carter Professor of Economics
 A.B., University of Washington, 1932;
 A.M., *ibid.*, 1934; M.A., Harvard Uni-
 versity, 1948; PH.D., *ibid.*, 1952.
 Appointed 1947.
- 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
 Teaching Diploma, Nova Scotia Provin-
 cial Normal College, 1935; B.S., Mount
 Allison University, 1939; M.S., Michigan
 State University, 1949. Appointed 1967.
- Holter, James B.**
Associate Professor of Dairy Science
 B.S., Pennsylvania State University, 1956;
 M.S., University of Maryland, 1958; PH.D.,
 Pennsylvania State University, 1962.
 Appointed 1963.
- Hoornbeek, Frank K.**
Associate Professor of Zoology
 B.S., Oregon State College, 1952; M.S.,
 Oregon State University, 1962; PH.D.,
ibid., 1964. Appointed 1964.
- Horrigan, James O.**
*Associate Professor of Business
 Administration*
 B.S.C., University of Notre Dame, 1952;
 M.B.A., University of Chicago, 1956;
 PH.D., *ibid.*, 1967. Appointed 1966.
- Hosek, William R.**
Associate Professor of Economics
 B.A., University of California, 1964; PH.D.,
ibid., 1967. Appointed 1967.
- 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*
 B.S., University of New Hampshire, 1948;
 M.ENG., Yale University, 1949; PH.D., Uni-
 versity of Illinois, 1955. Appointed 1949.

Hubbard, Colin D.

Assistant Professor of Chemistry
B.S., University of Sheffield, 1961; PH.D.,
ibid., 1964. Appointed 1967.

Hudon, Edua S.

Visiting Associate Professor of French
B.A., Bryn Mawr College, 1942; PH.D.,
Yale University, 1955. Appointed 1961.

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.

Irwin, Manley R.

Professor of Economics
A.B., Michigan State College, 1950; M.A.,
University of Michigan, 1954; PH.D.,
Michigan State University, 1963.
Appointed 1963.

Jacoby, Robb

Professor of Mathematics
S.B., University of Chicago, 1941; S.M.,
ibid., 1942; PH.D., *ibid.*, 1946.
Appointed 1961.

Jaffe, Erwin A.

Associate Professor of Political Science
B.A., Rutgers University, 1949; M.A., *ibid.*,
1958; PH.D., *ibid.*, 1961. Appointed 1963.

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
B.A., University of New Hampshire, 1940;
M.A., Radcliffe College, 1949; PH.D., *ibid.*,
1955. Appointed 1955.

Jansen, Edmund F., Jr.

*Associate Professor of Resource
Economics*
B.S., University of Illinois, 1960; M.S.,
North Carolina State University, 1964;
PH.D., *ibid.*, 1966. Appointed 1969.

Jellison, Charles A., Jr.

Professor of History
A.B., Stanford University, 1947; M.A.,
ibid., 1948; PH.D., University of Virginia,
1956. Appointed 1956.

Jenks, R. Stephen

*Associate Professor of Organizational
Behavior*
B.A., College of Wooster, 1961; M.S., Case
Institute, 1963; PH.D., *ibid.*, 1966.
Appointed 1967.

Jervis, Frederick M.

Professor of Psychology
B.A., University of New Hampshire, 1948;
M.A., *ibid.*, 1949; PH.D., Columbia Uni-
versity, 1958. Appointed 1952.

Johns, Ray E.

*Visiting Professor Whittemore School
of Business and Economics*
B.S., George Williams College, 1924;
M.S.W., University of Michigan, 1940;
PH.D., Columbia University, 1946.
Appointed 1970.

Johnson, Richard E.

Professor of Mathematics
B.A., Intermountain Union College, 1934;
M.A., University of Washington, 1938;
PH.D., University of Wisconsin, 1941.
Appointed 1966.

Jones, Galen E.

*Professor of Microbiology and Director
of the Jackson Estuarine Laboratory*
B.A., Dartmouth College, 1950; M.A.,
Williams College, 1952; PH.D., Rutgers
University, 1956. Appointed 1966.

Jones, Paul R.

Professor of Chemistry
B.A., Albion College, 1952; PH.D., Uni-
versity of Illinois, 1956. Appointed 1956.

Jones, William R.

Professor of History

A.B., Harvard University, 1951; M.A., *ibid.*, 1952; PH.D., *ibid.*, 1958.
Appointed 1962.

Kayser, John R.

Assistant Professor of Political Science

B.A., University of New Hampshire, 1962; M.A., Ohio State University, 1964; PH.D., Claremont Graduate School and University Center, 1969. Appointed 1969.

Keener, Harry A.

Dean of the College of Life Sciences and Agriculture, Director of the Agricultural Experiment Station, and Professor of Dairy Science

B.S., Pennsylvania State College, 1936; M.S., West Virginia University, 1938; PH.D., Pennsylvania State College, 1941. Appointed 1941.

Kemnitz, Thomas M.

Assistant Professor of History

A.B., University of Michigan, 1964; PH.D., University of Sussex, 1969.
Appointed 1969.

Khleif, Bud B.

Associate Professor of Education and Sociology

Certificate, British Government Arab College, Jerusalem, 1948; B.A., Hebrew University, 1952; M.A., University of Michigan, 1954; PH.D., Johns Hopkins University, 1957. Appointed 1967.

Kiang, Yun Tzu

Assistant Professor of Plant Science and Genetics

B.S., Taiwan Normal University, 1957; M.A., Ohio State University, 1962; PH.D., University of California, 1970.
Appointed 1970.

Kimball, Roland B.

Professor of Education

B.S., University of New Hampshire, 1942; M.ED., *ibid.*, 1949; ED.D., Harvard School of Education, 1958. Appointed 1963.

Klinger, Burton I.

Assistant Professor of Psychology

B.A., Hobart College, 1959; M.S., Pennsylvania State University, 1961; PH.D., *ibid.*, 1966. Appointed 1967.

Klippenstein, Gerald L.

Assistant Professor of Biochemistry

B.S., Wheaton College, 1962; PH.D., Northwestern University, 1967. Appointed 1967.

Klotz, Louis H.

Associate Professor of Civil Engineering

B.S.C.E., Pennsylvania State University, 1951; M.C.E., New York University, 1952; PH.D., Rutgers University, 1967.
Appointed 1965.

Koch, David W.

Assistant Professor of Plant Science

B.S., Kansas State University, 1964; M.S., *ibid.*, 1966; PH.D., Colorado State University, 1971. Appointed 1971.

Korbel, John

Professor of Economics and Business

S.B., Harvard College, 1939; M.B.A., Harvard Business School, 1941; PH.D., Harvard University, 1959. Appointed 1966.

Kuo, Shan S.

Professor of Applied Mathematics

B.S., National Chung Chen University, 1944; M.S., Ohio State University, 1948; M.E., Harvard University, 1954; D.ENG., Yale University, 1958. Appointed 1964.

Ladd, Dwight R.

Professor of Business Administration

A.B., Brown University, 1943; M.B.A., Harvard University, 1949; D.B.A., *ibid.*, 1956. Appointed 1964.

Lambert, Robert H.

Professor of Physics

B.S., St. Lawrence University, 1952; M.S., Harvard University, 1954; PH.D., *ibid.*, 1963. Appointed 1961.

Lange, Kenneth L.

Assistant Professor of Mathematics

B.S., Michigan State University, 1967; M.S., Massachusetts Institute of Technology, 1968; PH.D., *ibid.*, 1971.
Appointed 1971.

Langer, Clarence A.

Professor of Horticulture

B.S., Michigan State University, 1933; M.S., *ibid.*, 1948; PH.D., *ibid.*, 1952.
Appointed 1962.

Langley, Harold E., Jr.

Associate Professor of Civil Engineering
B.S., University of New Hampshire, 1949;
S.M., Massachusetts Institute of Technology, 1955; M.S., University of New Hampshire, 1956; SC.D., Massachusetts Institute of Technology, 1957.
Appointed 1961.

Larson, David L.

Associate Professor of Political Science
A.B., Dartmouth College, 1952; A.M., Fletcher School, Tufts University, 1957; M.A.L.D., *ibid.*, 1958; PH.D., *ibid.*, 1963.
Appointed 1965.

Lavoie, Marcel E.

Associate Professor of Zoology
B.A., St. Anselm's College, 1940; M.S., University of New Hampshire, 1952; PH.D., Syracuse University, 1956.
Appointed 1950-52, 1955.

Leak, William B.

Adjunct Assistant Professor of Forest Resources
B.S., S.U.N.Y., College of Forestry, Syracuse University, 1953; M.F., *ibid.*, 1956.
Appointed 1967.

Leighton, Charles H.

Associate Professor of Spanish
A.B., Harvard College, 1951; A.M., Harvard University, 1953; PH.D., *ibid.*, 1961.
Appointed 1956.

Lentz, Jacob B.

Instructor in History
A.B., Wabash College, 1962; M.A., Harvard University, 1963. Appointed 1967.

LeRay, Nelson L., Jr.

Adjunct Associate Professor of Resource Economics
B.S., Louisiana State University, 1952; M.A., *ibid.*, 1953; ED.D., Cornell University, 1965. Appointed 1966.

Limber, John E.

Assistant Professor of Psychology
B.A., University of Illinois, Urbana, 1962; PH.D., *ibid.*, 1968. Appointed 1971.

Limbirt, David E.

Assistant Professor of Mechanical Engineering
B.S., Iowa State University, 1964; M.S., Case Western Reserve University, 1965; PH.D., *ibid.*, 1969. Appointed 1969.

Linden, Allen B.

Assistant Professor of History
B.A., Wayne State University, 1957; M.A., Columbia University, 1960; PH.D., *ibid.*, 1969. Appointed 1963.

Linsky, Arnold S.

Associate Professor of Sociology
A.B., Dartmouth College, 1954; M.A., University of Washington, 1963; PH.D., *ibid.*, 1966. Appointed 1966.

Lockwood, John A.

Professor of Physics
A.B., Dartmouth College, Thayer School of Engineering, 1941; M.S., Lafayette College, 1943; PH.D., Yale University, 1948. Appointed 1948.

Logan, Terence P.

Associate Professor of English
A.B., Boston College, 1959; M.A., University of Wisconsin, 1961; PH.D., Harvard University, 1966. Appointed 1968.

Long, David F.

Professor of History
A.B., Dartmouth College, 1939; A.M., Columbia University, 1948; PH.D., *ibid.*, 1950. Appointed 1948.

Loy, James B.

Assistant Professor of Plant Science
B.S., Oklahoma State University, 1963; M.S., Colorado State University, 1965; PH.D., *ibid.*, 1967. Appointed 1967.

Lyle, Gloria G.

Associate Professor of Chemistry
B.A., Vanderbilt University, 1944; M.S., Emory University, 1946; PH.D., University of New Hampshire, 1958.
Appointed 1951.

Lyle, Robert E., Jr.

Professor of Chemistry
B.A., Emory University, 1945; M.S., *ibid.*, 1946; PH.D., University of Wisconsin, 1949. Appointed 1951.

Marschner, Donald C.

Professor of Business Administration
B.A., Brown University, 1929; PH.D., Columbia University, 1964. Appointed 1964.

Marshall, Grover E.

Assistant Professor of French and Italian
A.B., Bowdoin College, 1951; M.A., Princeton University, 1954; PH.D., *ibid.*, 1971. Appointed 1965.

Marshall, Thomas O.

Professor of Education
A.B., Colgate University, 1929; ED.M., University of Buffalo, 1933; ED.D., Harvard University, 1941. Appointed 1947.

Mathieson, Arthur C.

Associate Professor of Botany
B.A., University of California, 1960; M.A., *ibid.*, 1961; PH.D., University of British Columbia, 1965. Appointed 1965.

Mautz, William W.

Assistant Professor of Forest Resources
B.S., Wisconsin State University, 1965; M.S., Michigan State University, 1967; PH.D., *ibid.*, 1969. Appointed 1969.

Maynard, Max S.

Professor of English
B.A., University of British Columbia, 1937. Appointed 1946.

McCann, Francis D., Jr.

Assistant Professor of History
A.B., Niagara University, 1960; M.A., Kent State University, 1962; PH.D., Indiana University, 1967. Appointed 1971.

McFadden, Lorne A.

Professor of Plant Pathology
Diploma, Nova Scotia Agriculture College, 1947; B.S., McGill University, 1949; M.S., Cornell University, 1953; PH.D., *ibid.*, 1956. Appointed 1963.

Meagher, Judith A.

Assistant Professor of Education
B.S.ED., Salem Teachers College, 1960; M.ED., Boston University, 1962; ED.D., *ibid.*, 1968. Appointed 1968.

Meeker, Loren David

Assistant Professor of Mathematics
B.A., Oregon State University, 1959; B.S., *ibid.*, 1959; M.S., Stanford University, 1962; PH.D., *ibid.*, 1965; M.Sc., University of Aston, England, 1969. Appointed 1970.

Melvin, Donald W.

Associate Professor of Electrical Engineering
B.S., University of New Hampshire, 1955; M.E., Yale University, 1957; PH.D., Syracuse University, 1970. Appointed 1957.

Menge, Carleton P.

Professor of Education
B.S., Springfield College, 1939; M.A., University of Chicago, 1940; PH.D., *ibid.*, 1948. Appointed 1948.

Mennel, Robert M.

Assistant Professor of History
B.A., Denison University, 1960; M.A., Ohio State University, 1965; PH.D., *ibid.*, 1969. Appointed 1969.

Metcalf, Theodore G.

Professor of Microbiology
B.S., Massachusetts College of Pharmacy, 1940; PH.D., University of Kansas, 1950. Appointed 1956.

Meyers, T. Ralph

Professor of Geology
B.A., Ohio State University, 1926; M.A., *ibid.*, 1929. Appointed 1927.

Miller, Edmund G.

Associate Professor of English
A.B., Dartmouth College, 1943; M.A., Columbia University, 1947; PH.D., *ibid.*, 1955. Appointed 1951.

Mills, Eugene S.

Provost and Professor of Psychology
A.B., Earlham College, 1948; M.A., Claremont Graduate School, 1949; PH.D., *ibid.*, 1952. Appointed 1962.

Mills, Richard L.

Assistant Professor of Economics and Business
B.S., Rose Polytechnic Institute, 1962; M.A., Indiana University, 1964; PH.D., *ibid.*, 1967. Appointed 1967.

Milne, Lorus J.

Professor of Zoology

B.A., University of Toronto, 1933; M.A., Harvard University, 1934; PH.D., *ibid.*, 1936. Appointed 1948.

Mittelstadt, James W.

Assistant Professor of Education

B.S., Mankato State College, 1961; M.S., *ibid.*, 1965; ED.D., Wayne State University, 1969. Appointed 1969.

Moore, Berrien, III

Assistant Professor of Mathematics

B.S., University of North Carolina, 1963; PH.D., University of Virginia, 1969. Appointed 1969.

Morrison, James D.

Associate Professor of Chemistry

B.S., Franklin and Marshall College, 1958; PH.D., Northwestern University, 1963. Appointed 1965.

Mosberg, William

Associate Professor of Mechanical Engineering

B.S.M.E., Columbia University, 1956; M.ENG., Yale University, 1960. Appointed 1958.

Mower, Lyman

Professor of Physics

B.S., University of California, 1949; PH.D., Massachusetts Institute of Technology, 1953. Appointed 1957.

Mulhern, John E., Jr.

Professor of Physics

B.S., Oklahoma Agricultural and Mechanical College, 1948; M.A., Boston University, 1949; PH.D., *ibid.*, 1954. Appointed 1954.

Mulligan, Hugh F.

Associate Professor of Botany

B.S., Salem State College, 1958; M.S.T., Cornell University, 1962; PH.D., *ibid.*, 1966. Appointed 1970.

Munroe, M. Evans

Professor of Mathematics

B.A., University of Texas, 1940; SC.M., Brown University, 1941; PH.D., *ibid.*, 1945. Appointed 1959.

Murdoch, Joseph B.

Professor of Electrical Engineering

B.S., Case Institute of Technology, 1950; M.S., University of New Hampshire, 1955; PH.D., Case Institute of Technology, 1962. Appointed 1952.

Murray, Donald M.

Professor of English

B.A., University of New Hampshire, 1948. Appointed 1963.

Newman, Anthony K.

Assistant Professor of Electrical Engineering

B.E.E., Ohio State University, 1959; M.S.C., *ibid.*, 1960; PH.D., *ibid.*, 1964. Appointed 1970.

Nicoloff, Philip L.

Professor of English

B.A., University of California at Los Angeles, 1949; M.A., Columbia University, 1952; PH.D., *ibid.*, 1959. Appointed 1954.

Nielsen, John P.

Associate Professor of Civil Engineering

B.S., San Jose State College, 1957; M.S.C.E., University of Wyoming, 1958; PH.D., Colorado State University, 1961. Appointed 1969.

Nielson, Melville

Associate Dean of the College of Liberal Arts, and Associate Professor of Sociology

B.S., Bowling Green State University, 1942; M.A., Ohio State University, 1947; PH.D., *ibid.*, 1955. Appointed 1950.

Nordgren, Eric A.

Associate Professor of Mathematics

B.C.H.E., Polytechnic Institute of Brooklyn, 1956; PH.D., University of Michigan, 1964. Appointed 1964.

Northway, Philip E.

Assistant Professor of Education

A.B., Harvard, 1949; A.M.T., *ibid.*, 1951; M.A.L.S., Simmons College School of Library Science, 1961. Appointed 1965.

Nott, Sherrill B.

Assistant Professor of Resource Economics

B.S., University of Vermont, 1962; M.S., Cornell University, 1963; PH.D., *ibid.*, 1968. Appointed 1968.

O'Connell, Lawrence W.

Assistant Professor of Political Science

B.A., University of New Hampshire, 1956; PH.D., Syracuse University, 1968. Appointed 1966.

O'Connor, James T., Jr.

Associate Professor of Animal Science

D.V.M., University of Pennsylvania, 1941. Appointed 1969.

Olson, David P.

Associate Professor of Forest Resources

B.S., University of Minnesota, 1954; M.S., University of Maine, 1958; PH.D., University of Minnesota, 1964. Appointed 1964.

Orent, Amnon

Assistant Professor of Anthropology

B.A., Brooklyn College, 1960; M.A., University of Arizona, 1963; PH.D., Boston University, 1968. Appointed 1968.

Owens, Charles W.

Associate Professor of Chemistry

B.S., Colorado College, 1957; PH.D., University of Kansas, 1963. Appointed 1963.

Palmer, Stuart H.

Professor of Sociology

B.A., Yale College, 1949; M.A., Yale University, 1951; PH.D., *ibid.*, 1955. Appointed 1955.

Peirce, Lincoln C.

Professor of Plant Science

B.S., Cornell University, 1952; PH.D., University of Minnesota, 1958. Appointed 1964.

Peterson, Nobel K.

Associate Professor Soil and Water Science

B.S., Kansas State College, 1948; M.S., Purdue University, 1950; PH.D., Rutgers University, 1957. Appointed 1957.

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Associate Professor of Education

B.A., University of New Hampshire, 1947; ED.M., *ibid.*, 1952; ED.D., Harvard University, 1960. Appointed 1964.

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Associate Professor of German

Teaching Credential, Teachers Training College, Austria, 1952; M.A., Stanford University, 1961; PH.D., *ibid.*, 1965. Appointed 1969.

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Assistant Professor of English

B.A., Georgetown University, 1965; PH.D., University of Minnesota, 1970. Appointed 1970.

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Professor of Chemistry

B.S., University of Nebraska, 1951; M.S., *ibid.*, 1953; PH.D., University of Cincinnati, 1957. Appointed 1957.

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Associate Professor of Spanish

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B.A., University of Pennsylvania, 1960; M.A., New York University, 1961; PH.D., Indiana University, 1970. Appointed 1969.

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Associate Professor of Sociology

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Professor of Mechanical Engineering

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Associate Professor of Chemistry

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Professor of Zoology

B.S., University of New Hampshire, 1940; M.S., *ibid.*, 1948; PH.D., University of Michigan, 1956. Appointed 1952.

Schibanoff, Susan

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Adjunct Professor of Forest Resources

B.S., Syracuse University, 1926; PH.D., Columbia University, 1930. Appointed 1964.

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Appointed 1938-39, 1941.

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Appointed 1968.

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Assistant Professor of History

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Associate Professor of French

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Associate Professor of Forest Resources

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Appointed 1937.

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Appointed 1969.

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Appointed 1963.

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Appointed 1950.

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1963. Appointed 1965.

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Appointed 1970.

White, Susan O.

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ty, 1937; M.A., State University of Iowa,
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Associate Professor of Music
A.B., Harvard University, 1944; A.M.,
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Appointed 1956.

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Assistant Professor of Psychology
B.A., Northwestern University, 1966;
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Associate Professor of Music
A.B., University of California at Berkeley,
1954; M.A., *ibid.*, 1965. Appointed 1965.
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Professor of English
B.A., University of New Hampshire, 1950;
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Administration*
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Engineering*
B.S., Tufts University, 1958; M.S., North-
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1970. Appointed 1960.
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Professor of Electrical Engineering
B.S., University of New Hampshire, 1937;
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nology, 1948. Appointed 1948.
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Professor of Zoology
B.S., College of William and Mary, 1949;
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Associate Professor of Political Science
B.A., Pomona College, 1949; M.A.,
Fletcher School of Law and Diplomacy,
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University, 1961. Appointed 1966.
- Wright, John J.**
Assistant Professor of Physics
B.S., Worcester Polytechnic Institute,
1965; PH.D., University of New Hamp-
shire, 1969. Appointed 1969.
- Wright, Paul A.**
Professor of Zoology
S.B., Bates College, 1941; A.M., Harvard
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Appointed 1958.
- Wrightsman, Dwayne E.**
Associate Professor of Finance
M.S., Manchester College, 1958; M.B.A.,
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gan State University, 1964.
Appointed 1964.
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Associate Professor of Political Science
B.S., Columbia University, 1956; PH.D.,
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Professor of Home Economics
B.S., University of Washington, 1944;
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Appointed 1962.
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*Visiting Professor of Chemical
Engineering*
B.S., National Taiwan University, 1951;
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Appointed 1965.
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Professor of Mechanics
B.S., M.S., Technical University of Istan-
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Appointed 1967.
- Yount, John A.**
Associate Professor of English
B.A., Vanderbilt University, 1960; M.F.A.,
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Appointed 1962-64, 1965.
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Professor of Civil Engineering
B.S.C.E., University of Wyoming, 1941;
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Appointed 1958.
- Zsigray, Robert M.**
Assistant Professor of Microbiology
A.B., Miami University, 1961; M.S.,
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Index

- Administrative Officers 8
- Admission 27, 72
- Agricultural Experiment Station 16
- Alumni Association 21
- American Politics 149
- Animal Sciences 39
- Anthropology 159
- Application 27, 28, 29
- Applied Music for Graduate Credit 137
- Apprenticeship, History 102
- Assistantships 23

- Babcock House 19
- Background 13
- Biochemistry 42
- Biology 43
- Botany 44
- Bureau of Educational Research and Testing 16
- Business Administration 48

- Calendar 2
- Campus Map 4, 5
- Center for Industrial and Institutional Development 16
- Certificate of Advanced Graduate Study 73
- Chemical Engineering 53
- Chemical Physics Option 117, 143
- Chemistry 56
- Civil Engineering 61
- Classics 166
- Committees of the Graduate School 9
- Comparative Politics 150
- Comprehensive exam 73
- Computation Center 15
- Continuing Education, Division of 16
- Continuing Education, New England Center for 16
- Cooperative Extension Service 16
- Counseling and Testing Center 18
- Counselor Education 73
- Course descriptions 39
- Course numbering system 36
- Credits 31
- Cultural activities 17

- Deadlines 2, 25, 28
- Degree candidacy 30, 33, 34
- Degree programs 11
- Departmental requirements 39-173
- Description of courses 39

- Dining services 19
- Dissertation 36
- Dissertation fellowships 24
- Doctor of Philosophy 11, 56, 62, 68, 80, 85, 88, 96, 101, 110, 117, 120, 131, 142, 152, 159, 169
- Doctor's Degree requirements 34
- Division of Continuing Education 16

- Earth Sciences 65
- Economics 68
- Education 72
- Electrical Engineering 79
- Engineering Design and Analysis Laboratory 16, 119
- Engineering Ph.D. 85
- English 87
- Entomology 93
- Environmental Resources, Institute of Natural and 109

- Facilities 14
- Faculty 26, 175
- Faculty Fellowship Selection Committee 10
- Fellowships 23
- Financial information 22
- Foreign students 28
- Forest Resources 110, 111, 113
- French and Italian 94

- Genetics 95, 146
- German and Russian 99
- Grades 31
- Graduate assistantships 23
- Graduate associates 23
- Graduate council 9
- Graduate credits 31
- Graduate faculty 175
- Graduate school committees 9

- Health services 18
- History 101
- Home Economics 107
- Honorary Fellows 30
- Housing 19
- Hydrology 110

- IBM key codes 37
- Industrial and Institutional Development, Center for 16
- Institute of Natural and Environmental Resources 109

- Interdisciplinary Options and Programs 117
- International Politics 151
- Italian 94
- Jackson Estuarine Laboratory 17
- Key codes 37
- Loan and Work-Study Programs 25
- Map, campus 4, 5
- Marine Science—Oceanography 117
- Married graduate student housing 21
- Martin Luther King Awards 24
- Master of Arts 11, 33, 69, 87, 94, 99, 101, 133, 148, 153, 159, 166
- Master of Arts in Teaching 11, 73
- Master of Business Administration 11, 33, 48
- Master of Education 11, 72
- Master of Occupational Education 11, 33, 139
- Master of Public Administration 11, 33, 148
- Master of Science 11, 56, 61, 65, 93, 95, 107, 110, 119, 126, 131, 133, 141, 145, 169
- Master of Science for Teachers 11, 27, 33, 57, 88, 94, 99, 119, 141, 166
- Master's Degree requirements 27, 33
- Mathematics 119
- Mechanical Engineering 126
- Memorial Union 18
- Microbiology 131
- Music 133
- Music Education 133, 138
- National Defense Education Act Title IV Fellowships 25
- Natural and Environmental Resources, Institute of 109
- New England Center for Continuing Education 16
- Occupational Education 139
- Ocean Engineering—EDAL 119
- Oceanography 117
- Off-campus housing 21
- Officers of the University 7
- Ph.D. requirements 34
- Physics 141
- Placement Service 19
- Plant Physiology 145
- Plant Science 145
- Political Science 148
- Political Thought 149
- Program requirements 30
- Psychology 152
- Public Administration Service 16
- Registration 32
- Regulations 27
- Requirements, departmental 39-173
- Requirements, Doctor's Degree 34
- Requirements, Master's Degree 33
- Research 15
- Research Council 9
- Research facilities 15
- Residence 19
- Resource Economics 110, 113
- Resources Development Center 16
- Ritzman Animal Nutrition Laboratory 15
- Russian 99
- Scholarships 23
- Sociology 159
- Soil and Water Chemistry Option 117
- Soil and Water Science 110, 115
- Soils 110
- Space Science Center 15
- Spanish and Classics 166
- Special Students 29
- Student activities 15
- Student Fellowship Selection Committee 10
- Summer fellowships 24
- Summer Session 31
- Teaching, Service, and Research 15
- Technology 168
- Thesis 34, 73
- Traineeships 24
- Trustees 7
- Tuition 22
- Tuition Scholarship Selection Committee 10
- Tuition scholarships 24
- University calendar 2
- University Health Service 18
- UNH faculty 29, 175
- UNH fellowships 24
- UNH seniors 28
- University Placement Service 19
- University Theater 17
- Water Resources Research Center 16
- WENH-TV 16
- Wildlife Management 110
- Withdrawal 32
- Zoology 98, 117, 169

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