Clemson Graduate Announcements

Graduate Studies

1975

Clemson Graduate School Catalog, 1975-1976

Clemson University

Recommended Citation

CLEMSON
UNIVERSITY

THE GRADUATE SCHOOL
ANNOUNCEMENTS
1975-76   1976-77

DEADLINE DATES

For those who expect to receive the Master's degree or Doctor of Philosophy degree on:

	August 9, 1975	December 18, 1975	May 7, 1976	August 7, 1976	December 16, 1976	May 6, 1977
Last Day For:						
Filing GS4, Admission to Candidacy for a degree and diploma order	June 6, 1975	September 11, 1975	January 28, 1976	June 4, 1976	September 9, 1976	January 26, 1977
Oral and/or written examinations	July 18, 1975	December 1, 1975	April 16, 1976	July 16, 1976	November 29, 1976	April 15, 1977
(Optional)						
Preliminary review of completed (signed) theses, prior to printing, by the Graduate School Office	July 25, 1975	December 5, 1975	April 23, 1976	July 23, 1976	December 2, 1976	April 22, 1977
Final submission of theses and dissertations to the Graduate School Office	August 1, 1975	December 12, 1975	April 30, 1976	July 30, 1976	December 9, 1976	April 29, 1977

CHECK LIST ON GRADUATE SCHOOL PROCEDURES

The graduate student should carefully note this check list as well as deadline dates on inside front cover.

1. Select in consultation with the appropriate Department Head a major advisor and advisory committee. (See page 26)

2. Submit Plan for Graduate Study (GS Form 2). (See page 27)

3. If necessary, submit request for changes in Plan for Graduate Study. Minor changes may be accomplished by memorandum signed by the advisory committee, department head and college dean.

4. Satisfy any prescribed language requirement and qualifying examination prerequisite to admission to candidacy. (See pages 34, 35, 39, 40 and 41)

5. Apply for admission to candidacy for a degree (GS Form 4) after completing at least half the prescribed course work. (See pages 27 and 28)

6. Submit completed thesis (if required) or dissertation to advisory committee chairman and arrange for final examination by the advisory committee. (See pages 31, 32, 35 and 41)

7. Pay binding fee to the Bursar and submit approved copies of thesis to the Graduate School. Doctoral candidates pay for abstract publication in **Dissertation Abstracts.** (See page 32)

The final responsibility for following Graduate School procedures rests with the graduate student. Special problems should be referred to the Graduate Dean.

CLEMSON
UNIVERSITY

R E C O R D

ANNOUNCEMENTS OF
THE GRADUATE SCHOOL

FOR

1975-1976
AND
1976-1977

Clemson University offers equal educational opportunity to all persons without regard to sex, race, creed, color or national origin. This policy applies in all matters including:

1. Admission and education of students.

2. Availability of student loans, grants, scholarships and job opportunities.

3. Employment and promotion of teaching and non-teaching personnel.

4. Student and faculty housing situated on premises owned or occupied by the University.

5. Off-campus housing not owned by the University but listed with the University for referral purposes.

6. Activities conducted on premises owned or occupied by the University.

TABLE OF CONTENTS

3

COURSES OF STUDY*

*The courses listed in this Bulletin in the 600 series are described in the general University Catalog, but as 300 and 400 level courses A copy of the general Catalog may be obtained from the Director of Admissions. Graduate credit can be earned only for courses numbered 600 or above.

*The **Master of Business Administration degree** is offered jointly by Furman University and Clemson University. Courses in this program are taught on the Furman University campus, Greenville, S. C., by the faculty of both Universities. Requests for information concerning this program should be addressed to the Director, Clemson-Furman MBA Program, Furman University, Greenville, S. C. 29613.

CLEMSON UNIVERSITY CALENDAR — SESSION 1975-76

FALL SEMESTER

August 18-19	Monday-Tuesday a.m—Orientation, new students
August 20	Wednesday—Registration, all students
August 21	Thursday—Late registration
August 22	Friday—Late registration fee applies
August 22	Friday—Classes begin regular schedule
August 28	Thursday—Last day for registration
August 28	Thursday—Last day to add a subject
September 11	Thursday—Last day to order diploma for mid-year graduation
September 18	Thursday—Last day to drop a subject without record of drop
October 13	Monday—Preliminary reports due
October 29	Wednesday—Last day to drop a subject or withdraw from the University without receiving final grades
November 10-14	Monday-Friday—Preregistration
November 26	Wednesday—Thanksgiving holidays begin after last class
December 1	Monday—Classes resume
December 8	Monday—Examinations begin
December 18	Thursday—Mid-year graduation

SPRING SEMESTER

January 5	Monday—Orientation, new students
January 6	Tuesday—Registration, all students
January 7	Wednesday—Late registration
January 8	Thursday—Late registration fee applies
January 8	Thursday—Classes begin regular schedule
January 14	Wednesday—Last day for registration
January 14	Wednesday—Last day to add a subject
January 28	Wednesday—Last day to order diploma for May graduation
February 4	Wednesday—Last day to drop a subject without record of drop
March 1	Monday—Preliminary reports due
March 12	Friday—Last day to drop a subject or withdraw from the University without receiving final grades
March 12	Friday—Spring holidays begin after last class
March 22	Monday—Classes resume
April 7	Wednesday—Honors and Awards Day; classes suspended at 12 noon
April 12-16	Monday-Friday—Preregistration
April 26	Monday—Examinations begin
May 7	Friday—Commencement

SUMMER SESSIONS 1976

FIRST SESSION

(Classes meet Monday-Friday)

May 17	Monday—Registration
May 18	Tuesday—Classes begin
June 23-24	Wednesday-Thursday—Examinations

SECOND SESSION

(Classes meet Monday-Friday except as indicated)

June 28	Monday—Orientation, new students
June 29	Tuesday—Registration
June 30	Wednesday—Classes begin
July 5	Monday—Classes suspended
July 10	Saturday—Classes meet
July 31	Saturday—Classes meet
August 4-5	Wednesday-Thursday—Examinations
August 7	Saturday—Graduation

6

CLEMSON UNIVERSITY CALENDAR — SESSION 1976-77

FALL SEMESTER

August 16-17	Monday-Tuesday a.m.—Orientation, new students
August 18	Wednesday—Registration, all students
August 19	Thursday—Late registration
August 20	Friday—Late registration fee applies
August 20	Friday—Classes begin regular schedule
August 26	Thursday—Last day for registration
August 26	Thursday—Last day to add a subject
September 9	Thursday—Last day to order diploma for mid-year graduation
September 16	Thursday—Last day to drop a subject without record of drop
October 11	Monday—Preliminary reports due
October 27	Wednesday—Last day to drop a subject or withdraw from the University without receiving final grades
November 8-12	Monday-Friday—Preregistration
November 24	Wednesday—Thanksgiving holidays begin after last class
November 29	Monday—Classes resume
December 6	Monday—Examinations begin
December 16	Thursday—Mid-year graduation

SPRING SEMESTER

January 3	Monday—Orientation, new students
January 4	Tuesday—Registration, all students
January 5	Wednesday—Late registration
January 6	Thursday—Late registration fee applies
January 6	Thursday—Classes begin regular schedule
January 12	Wednesday—Last day for registration
January 12	Wednesday—Last day to add a subject
January 26	Wednesday—Last day to order diploma for May graduation
February 2	Wednesday—Last day to drop a subject without record of drop
February 28	Monday—Preliminary reports due
March 11	Friday—Last day to drop a subject or withdraw from the University without receiving final grades
March 11	Friday—Spring holidays begin after last class
March 21	Monday—Classes resume
April 6	Wednesday—Honors and Awards Day; classes suspended at 12 noon
April 11-15	Monday-Friday—Preregistration
April 25	Monday—Examinations begin
May 6	Friday—Commencement

SUMMER SESSIONS 1977

FIRST SESSION

(Classes meet Monday-Friday)

May 16	Monday—Registration
May 17	Tuesday—Classes begin
June 22-23	Wednesday-Thursday—Examinations

SECOND SESSION

(Classes meet Monday-Friday except as indicated)

June 27	Monday—Orientation, new students
June 28	Tuesday—Registration
June 29	Wednesday—Classes begin
July 4	Monday—Classes suspended
July 9	Saturday—Classes meet
July 30	Saturday—Classes meet
August 3-4	Wednesday-Thursday—Examinations
August 6	Saturday—Graduation

8

PERSONNEL

OFFICERS OF ADMINISTRATION

Robert Cook Edwards, B.S., LL.D. _____ President

Victor Hurst, Ph.D. _____ Vice-President for Academic Affairs
and Dean of the University

Stanley Gosanko Nicholas, B.S.M.E. _____ Vice-President for Development

Joseph Bryan McDevitt, J.D. _____ Vice-President for Executive
Affairs and University Counsel

Walter Thompson Cox, B.S. _____ Vice-President for Student Affairs

Melford A. Wilson, B.S. _____ Vice-President for Business and Finance
and Comptroller

Claud Bethune Green, Ph.D. _____ Dean of Undergraduate Studies

Arnold Edward Schwartz, Ph.D. _____ Dean of Graduate Studies
and University Research

Samuel Marsh Willis, Ph.D. _____ Dean of University Extension

Luther Perdee Anderson, Ph.D. ___ Dean, College of Agricultural Sciences

Harlan Ewart McClure, M.Arch. _____ Dean, College of Architecture

Harold Fochone Landrith, Ed.D. _____ Dean, College of Education

Lyle Chester Wilcox, Ph.D. _____ Dean, College of Engineering

William Henry Davis McGregor, Ph.D. _____ Dean, College of Forest
and Recreation Resources

Wallace Dabney Trevillian, Ph.D. _____ Dean, College of Industrial
Management and Textile Science

Headley Morris Cox, Ph.D. _____ Dean, College of Liberal Arts

Geraldine Labecki, Ed.D. _____ Dean, College of Nursing

Henry Elliott Vogel, Ph.D. _____ Dean, College of Sciences

9

THE GRADUATE COUNCIL

Arnold E. Schwartz, Ph.D., Professor of Civil Engineering and Dean of Graduate Studies and University Research, Chairman, ex-officio

Term Expires 1978

Marvin W. Dixon, Ph.D., Associate Professor of Mechanical Engineering

Warren W. Menke, Ph.D., Associate Professor of Industrial Management

Gloria A. Tanner, Ed.D., Assistant Professor of Nursing

Term Expies 1977

Edward L. Falk, M.R.P., Professor of Planning Studies

Donald M. Henricks, Ph.D., Associate Professor of Food Science and of Biochemistry

John H. Rodgers, Ph.D., Professor of Agricultural Education

Term Expires 1976

Sidney A. Gauthreaux, Ph.D., Associate Professor of Zoology

Lawrence W. Gahan, Ph.D., Associate Professor of Recreation and Parks Administration

Jerome H. Mandel, Ph.D., Associate Professor of English

One Year Term

Faculty Senate Representative:

James D. Maxwell, Ph. D., Associate Professor of Agronomy and Soils

Student Representatives:

Kitty C. Barkley, B.A.

M. Sloan Crayton, B.A.

GENERAL INFORMATION

INTRODUCTION

Clemson is the land-grant university of South Carolina, and is fully accredited by the Southern Association of Colleges and Schools. The graduate curriculums under the Colleges of Agricultural Sciences, Engineering, Architecture, Education, Forest and Recreation Resources, Industrial Management and Textile Science, Liberal Arts, Nursing, and Sciences form a background of education for the hundreds of occupations which Clemson graduates enter.

The government of the University is vested in a Board of Trustees. In accord with the Thomas G. Clemson will, the Board includes six members elected by the Legislature and a self-perpetuating group of seven life members. The function of the Board is legislative. The Board determines the general policy of the University and directs the expenditure of its funds.

The President of the University is the chief executive and administrative officer.

The Dean of Graduate Studies and University Research coordinates all graduate programs and university research. He advises the Dean of the University on policies and regulations pertaining to graduate study and research. Matters concerning graduate admissions policies, graduate student programs, and the granting of graduate degrees are coordinated through his office. He chairs the Graduate Council and the University Research Council and is administratively responsible for the Computer Center, the Division of Administrative Programming Services, and the Division of Information Systems Development.

The academic deans are responsible for the programs and personnel in their individual colleges and report directly to the Dean of the University. At the direction of the Dean of the University, the academic deans coordinate undergraduate programs, graduate programs and research, and extension programs respectively with the Deans of Undergraduate Studies, Graduate Studies and University Research, and University Extension.

11

Graduate Council. This council consists of the Dean of the Graduate Studies and University Research, ex officio, one member of the Faculty Senate, one faculty member from each college having a graduate program, one officially designated alternate from each college who will attend and vote in the regular council member's absence, and two graduate students. The Faculty Senator shall be nominated by the Faculty Senate and appointed by the Dean of the University for one year. The faculty members shall be nominated by the dean of the college and appointed by the Dean of the University for a term of three years. The graduate students shall be nominated by the Graduate Student Association, and appointed by the Dean of the University for a term of one year.

All policies and regulations affecting graduate curricula and requirements leading to graduate credits, certification, and degrees shall be approved by this council and recommended to the Dean of the University.

The Graduate Council also serves as an appeal board for decisions regarding admission and/or degree requirements or other policy decisions affecting the welfare of graduate students. The appeal must be presented in writing to the Graduate Dean or to any member of the Graduate Council. Graduate students and faculty members who are not members of the council may be invited to attend its meetings.

THE GRADUATE SCHOOL

The Graduate School exists to formulate policies and standards, and to unify administrative procedures concerning all graduate work at Clemson.

The aims of graduate programs at Clemson are to provide comprehensive training in special fields, to offer instruction in the methods of independent investigation, and to foster the spirit of research scholarship. Graduate study is much more than a continuation of undergraduate work. Its true spirit is one of inquiry and the desire to add to human knowledge. Graduate study should therefore be contemplated only by students who have already demonstrated in their undergraduate programs unusual intellectual attainments and the power of independent thought and investigation.

THE UNIVERSITY LIBRARY

The Robert Muldrow Cooper Library is essentially a consolidation of special libraries, agricultural and biological sciences, science and technology and carefully selected smaller collections in the social sciences and the humanities. The collection consists of 550,000 volumes of books, periodicals and government publications. In addition to the main library there are departmental libraries.

Seventy-one newspapers and 10,000 serial titles — periodicals, reports, bulletins and the like — are received regularly. Microfilm and microcard readers are provided for consulting material in microtext.

Library service is maintained in the Main Library as indicated below. With the exception of adjustments in the scheduling during holiday periods, the library hours are as follows:

Monday through Friday .... 7:45 a.m. to 11:00 p.m.
Saturday .... 8:00 a.m. to 6:00 p.m.
Sunday .... 1:00 p.m. to 11:00 p.m.

The new library building which was occupied in 1966 is modern in every respect and was designed for quiet reading, convenient reference service and easy access to research materials.

The library policy governing undergraduate students applies to graduate students also, and students must present validated I.D. cards to check out library materials. However, a graduate student may be granted the privilege of extended loan for one semester subject to recall. In the application of this privilege the following points are important:

1. The privilege is not given automatically but must be requested for each book — otherwise a two-week due date will be stamped in the book.

2. Graduate students must have a graduate Validation Sticker (which he must obtain from the Graduate School Office) attached to his I.D. card if he wishes to have the privilege of extended loans.

3. The date stamped in the book indicates the date the book is due. After that date overdue fines apply. Since overdue notices

are sent as a favor to the borrower, failure to receive such a notice does not excuse him from the payment of fines. Circumstances may prevent the library from sending overdue notices.

4. If a book is recalled, regulations apply the same as for undergraduate students.

5. The privilege applies **only to those books in which his major research is concentrated.** This privilege should be used with a very great deal of discretion.

COMPUTER CENTER

The Clemson University Computer Center operates an IBM System 370/Model 158 with three megabytes of core storage, which is available to graduate students for course work and research. Both the main center in the basement of the Plant and Animal Science Building and the remote centers in Martin Hall and Riggs Hall are open from 7:45 A.M. to 11:00 P.M., Monday through Friday, 8:00 A.M. to 6:00 P.M. Saturday, and 2:00 P.M. to 11:00 P.M. Sunday. Shorter hours are observed during holiday periods. Every effort is made to provide rapid turnaround to users. Processing of short student jobs is accomplished within three minutes; turnaround for all but the very longest jobs is completed within a few hours. Programming assistance is available when needed.

The Center supports FORTRAN, COBOL, PL/I, ALGOL, BASIC, ASSEMBLER and a number of simulation and special-purpose languages. A large library of statistical and mathematical routines is also available to users.

In addition to batch facilities the University has over 50 time sharing terminals on campus. Interactive computational facilities are available for faculty and student use on both a private line and dial up basis.

STUDENT HEALTH SERVICE

Cost per Semester $35.00. Payment of the Student Health Service fee is required of all students living in University residence halls and all full-time students even though they do not reside in University housing.

14

The Student Health Service is housed in the Redfern Health Center and is complete with outpatient department and a 34-bed hospital. The staff consists of four full-time physicians (including the director), two psychiatrists, 13 full-time registered nurses, a full-time registered laboratory technician, a full-time registered X-ray technician, and a full-time registered pharmacist. In addition, a sufficient number of nurses' aides, secretarial workers, orderlies and maids for 24-hour-a-day operation are employed. The best of modern equipment is available for student use. Regular office hours are maintained, plus the services of the nursing staff for minor ailments after hours. One physician is on call at night for emergencies whenever the school is open. The Health Service is closed between semesters.

The Student Health Service at Clemson University has several important functions. All of these are aimed at keeping the student in good health so that he may effectively pursue his school work. There is, of course, the basic function of medical care for the ill and injured. This is a vital part of its work. In addition to this, the Student Health Service attempts to put strong emphasis on health rather than illness. This begins with the entrance medical form. In laying out this form an attempt is made to get information, examinations, and preventive medical procedures carried out to better equip the staff in protecting the student from illness and to serve as a guide for the care of preexisting medical problems.

As the student progresses through his academic experiences, other procedures may be required or highly recommended. These are primarily an effort to teach the individual self-responsibility for maintenance of his own health, protection of the health of those around him, and locate possible hidden diseases. The Health Service also has the position as the source of medical information as well as responsibility for indicated medical action: diagnostic, therapeutic, and preventive.

The medical fee paid by each student covers the services of the University physicians, the health service staff, and equipment for most illnesses and injuries occurring on or around the campus. This coverage is given under conditions similar to that of one's own physician.

15

The fee does not cover routine physical examinations for employment or transfer to another school, fees for specialists when called in for consultation, medical or surgical services performed away from the University, or for accidents occurring off the campus.

A complete pharmacy is maintained, and dispenses medications to students as prescribed by the staff physicians.

Ambulance transportation to a general hospital for serious illnesses or injuries occurring on campus will be arranged, however, expenses for this service is the responsibility of the student. Transportation for less urgent ailments and routine visits can be arranged through the Health Service at the expense of the student.

The Student Government with full approval of the administration, offers a plan of accident and sickness insurance to full-time students. Each year prior to the beginning of the fall semester, complete information on this insurance plan will be sent to students. This insurance is inexpensive and is designed to cover major medical expense not covered by the Health Service. It is highly recommended.

FOREIGN STUDENTS AND EXCHANGE VISITORS

The Foreign Student Office located at Clemson University assists foreign students in academic, social, financial, and personal matters. It serves as a liaison office between Clemson University and the U. S. Immigration Service. All foreign students should report immediately to this office upon arrival at Clemson. Students wishing to transfer to Clemson from another institution in the United States are required to send photocopies of their I-94 forms directly to the Graduate School before form I-20 will be issued. Failure to maintain status with the Immigration Service will result in foreign students forfeiting their opportunity of attending Clemson University. Health and accident insurance is required and may be obtained from this office.

HOUSING

Residence Halls. Residence halls located on the main campus provide excellent accommodations at economical rates for graduate and undergraduate students. All rooms are equipped with clothes lockers, study desks, chairs, and single or convertible bunk beds with inner spring mattresses. Two students are assigned to a room.

Graduate students interested in residence hall accommodations should write directly to the Residence Halls Office, Clemson University, Clemson, South Carolina 29631, to obtain information regarding assignments. This should be accomplished promptly for there is a critical shortage of on-campus housing. To be assured of a space, the Residence Halls Office must be notified at least three (3) months prior to the date scheduled for enrollment.

For official holidays which occur during the course of a semester, the University reserves the right to close certain halls and to require students remaining on the campus to move to another hall for the duration of the holiday period. For the period between semesters the University reserves the right to close the dormitories.

University Housing for Married Students. Clemson provides comfortable and economical housing for its married students. There are three housing areas consisting of 100 single Prefab units, 100 East Campus apartments contained in 50 duplex buildings, and 50 Littlejohn apartments in 11 buildings.

All married student housing units have two bedrooms, living room, kitchen and bath. East Campus apartments are the newest and are equipped with stove and refrigerator. The Littlejohn apartments and Prefabs are not equipped with stoves and refrigerators.

Booklets describing these facilities are available and will be furnished upon request by the Housing Office of the University. Monthly rental fees are: Prefabs, $41; Littlejohn, $56, for interior and $54 for end units; East Campus, $74.

Graduate assistants and graduate fellows are given priority over undergraduate students in assignments to married student housing. To qualify for this priority their applications must be received at the Housing Office before April 20 for first semester housing;

before November 1 for second semester housing; or before March 1 for summer housing.

Off-Campus Housing. Commercial housing in the surrounding community accommodates the majority of the graduate students, both married and single. A listing of realty companies and other contacts has been compiled by the Graduate Student Association and is available at no cost from the Graduate School should the applicant request.

Housing for International Students. The Foreign Student Office assists international students in finding housing in the local community as well as dormitory space. Reservations, along with a $75 fee, should be made well in advance of one's arrival at Clemson. Should the student not enroll at Clemson, the fee is refunded.

STUDENT FOOD SERVICE

The University Dining Halls provide several food service plans for the students:

(1) A 5-Day Board Plan (15 meals) Monday through Friday — holidays excluded. The fee for this plan is $440 per year and may be paid in two installments — one-half at the beginning of the first semester and the remainder at the beginning of the second semester.

(2) A 7-Day Board Plan (21 meals) Monday through Sunday — holidays excluded. The fee for this plan is $550 per year and may be paid in two installments — one-half at the beginning of the first semester and the remainder at the beginning of the second semester.

Both the 5-day and 7-day Board Plans will begin immediately after a student obtains a meal ticket and will terminate on the day scheduled for graduation. (Five-Day Board Plan tickets will not be issued on Saturdays or Sundays.)

(3) Students who are not on a board plan may purchase individual meals at prevailing prices.

A la carte service will be offered in student dining halls only on special occasions.

GRADUATE EXPENSES

Full-Time Students. The 1975-1976 semester charges for regular full-time graduate students are shown below:

Tuition	$ 75.00*
Matriculum Fee (non-refundable)	5.00
University Fee	205.00
Medical Fee	35.00
Room Fee	175.00-230.00
Board	240.00-295.00
Total for Semester	$735.00-845.00*

Part-Time Students. Graduate students taking less than 12 credit hours during a semester will be charged for each of the items in the following schedule:

Tuition (per semester hour)	$ 6.00*
Matriculation Fee (non-refundable)	5.00
University Fee (per semester hour)	16.00*
Medical Fee (optional for non-dormitory students)	35.00

Students who elect not to pay the hospital fee are responsible for arranging their own medical care.

Graduate Assistants and Staff. Graduate assistants and staff members will pay a total charge of $11.00 per semester hour. These charges are in lieu of tuitions, matriculation, maintenance, university and library fees. Graduate assistants receive medical treatment by paying the medical fee of $35.00. A graduate assistant is defined as a student with a baccalaureate degree from an approved institution who is enrolled in a degree program and devotes a minimum of ten working hours per week to the University for at least a full semester.

All graduate students, with the exception of full-time employees must enroll as full-time equivalent students in order to qualify

---

*Subject to increase.

for any financial aid from the University. The University reserves the right to withdraw financial aid at any time due to failure to meet this requirement.

Graduation Fees. The thesis binding fee, diploma fee, fee for rental of cap and gown, and fee for publication of dissertation abstract are not included in the above charges.

Athletic Contests and University Concerts. Part-time students taking less than 12 hours and graduate assistants may be admitted to home athletic games upon payment of the faculty rate and to the University concerts upon purchase of a student season ticket.

Settlement of University Fees. The entire semester's expenses are due and payable at the beginning of each semester, and no student is officially enrolled until all semester expenses have been satisfied. In special cases the University will accept at the beginning of a semester a non-interest bearing promissory note for a portion of the semester residence-hall rent and semester-plan board fee. Amounts up to $75 for room rent and $110 for board fee may be included in the note. In such cases, a note for the first semester charges will be due October 10, and a note for the second semester charges will be due March 1.

A $75 advance payment of room rent is required for a room reservation for the fall semester. This payment must be made by cash, check or money order and should be sent to the Residence Halls Manager's Office with the completed "Student Application for Room Reservation" card not later than July 1. The $75 advance payment of room rent will be deducted from the amount otherwise due for the first semester's expenses. All other transactions relating to payments should be conducted with the Accounting Division. All checks and money orders should be made payable to Clemson University. A personal check given in payment of University expenses which is returned by the bank unpaid, immediately creates an indebtedness to the University.

Past Due Student Accounts. Any indebtedness to the University which becomes past due immediately jeopardizes the student's en-

20

rollment, and no such student will be permitted to graduate or register for a subsequent semester or summer school term. Further, any student who fails to pay all indebtedness to the University may not be issued an honorable discharge, transcript, or diploma.

Establishment of University Fees. The annual State Appropriation Act imposes the general requirement that student fees be fixed by the University Board of Trustees. The Act imposes two specific requirements on the Board: (1) in fixing fees applicable to academic and general maintenance and operation costs the Board must maintain a minimum student fee not less than the fee charged the previous year; (2) in fixing fees applicable to dormitory rental, dining halls, laundry, infirmary and all other personal subsistence expenses, the Board must charge students an amount sufficient to fully cover the cost of providing such facilities and services.

REGULATIONS AND PROCEDURES

The provisions of this publication are not to be regarded as an irrevocable contract between the student and Clemson University. Changes are effected from time to time in the general regulations and in the academic requirements. There are established procedures for making changes, procedures which protect the institution's integrity and the individual student's interest and welfare. A curriculum or graduation requirement, when altered, is not made retroactive unless the alteration is to the student's advantage and can be accommodated within the span of years normally required for graduation. When the actions of a student are judged by competent authority, using established procedure, to be detrimental to the interest of the University community, that person may be required to withdraw from the University.

Every graduate student and every prospective graduate student is expected to make himself thoroughly familiar with these regulations and the requirements for degrees. Failure to follow the regulations and requirements almost inevitably results in complications which cause a great deal of inconvenience to the student.

21

In addition to the general regulations, the candidate for an advanced degree will comply with the specific requirements of the department in which he is pursuing his advanced studies.

Except as they apply to undergraduate students only, graduate students are subject to the usual procedures and regulations of the University and to those outlined on the following pages.

MEDICAL REQUIREMENT

Submission of a medical history is required of all full-time graduate students entering Clemson University for the first time. Prior to or during the registration period, the student will receive a medical questionnaire which is to be completed and returned for data processing to the sponsoring agency who will forward the information to the Director of Student Health Services. The cost for this service is $7.00 payable to the agency, and the entire procedure is in lieu of a medical examination. Students who fail to submit the medical questionnaire will not be allowed to remain enrolled.

The medical questionnaire, once submitted, is valid for the duration of the student's continuous enrollment. A formerly enrolled student who has not registered for a period of three years or who has withdrawn due to health reasons will be required to submit a new questionnaire.

The University further requires that all new students have a current tetanus toxoid series or toxoid series or booster (within ten years).

GENERAL REQUIREMENTS FOR ADMISSION

Applications for admission should be submitted at least four weeks prior to the first date for matriculation listed on pages 6 and 7. International students and other applicants to programs requiring standardized test scores should complete these examinations at least eight weeks prior to matriculation.

New Applicants. For enrollment in the University's graduate programs, a student must hold a bachelor's degree from an institution whose scholastic rating is satisfactory to the University and must have the approval of the head of the department in which

the major work is planned. A satisfactory score on the aptitude portion of the Graduate Record Examination (GRE) is also required for admission to all M.A., M.S., and Ph.D. degree programs and some advanced professional programs. This examination is required of all international students prior to admission regardless of the program they plan to enter. Satisfactory scores on the Test of English as a Foreign Language (TOEFL) is also required of international students but this requirement **may** be waived when the applicant has earned a four-year bachelor's degree in the United States. The Graduate School also reserves the right to require additional quantitative and aptitude examinations as well as personal interviews and/or oral examinations prior to reaching an admission decision.

Admission in all programs is restricted to those students whose academic records clearly indicate that they are prepared to benefit from graduate study. Neither an academic record exceeding minimum requirements nor satisfactory scores on standardized tests alone will assure a student's admission. Rather, the total record must indicate the likelihood of successful graduate study.

Notice of admission is frequently given to applicants prior to graduation from their undergraduate institution; however, all requirements for the bachelor's degree must be completed before enrolling in a graduate program. Applicants who do not enroll in courses within one year after the date of their acceptance will normally be required to reapply for admission. Credentials submitted for admission become the property of the University and are not returned.

Applicants Presently Enrolled. Students enrolled in a master's degree program who wish to continue their studies in a doctoral program may apply by submitting GS Form 10. This form is in lieu of a complete application but must be endorsed by the student's advisory committee chairman and department head or other faculty designated by the Graduate Dean who are associated with the applicant's present or proposed programs.

Students holding both bachelor's and master's degrees from Clemson University are encouraged to pursue doctoral programs at other institutions.

Enrollment in Graduate Level Courses. Enrollment in any graduate course is subject to approval by the department offering the course and requires permission of the instructor whether or not such is specifically stated in the course description. In order to enroll in, or receive credit for, any courses of the 600 series or above, the student **must** have been officially admitted to the Graduate School as described in the following section.

Students may not enroll in 600 level courses for which undergraduate credit has been awarded, nor can graduate credit be awarded retroactively for undergraduate courses already completed.

ADMISSION CLASSIFICATIONS

Admission to a Degree Program. This is the ordinary classification of acceptable students and must become the eventual status of anyone receiving an advanced degree from Clemson University. In addition to the minimum requirements for degree programs listed under "Degrees", the student must also meet any special departmental requirements.

Those potentially acceptable applicants who already hold the bachelor's degree but who have a significant number of undergraduate deficiencies will not be admitted to the Graduate School in any classification. Such applicants who choose to remove the deficiencies at Clemson University will enroll as a postgraduate student and may reapply to the Graduate School subsequent to removal of the deficiencies. Postgraduate students are not eligible to enroll in any graduate level courses or to receive graduate assistantships or fellowships.

Admission as a Non-Degree Student. Admission in this category is restricted primarily to public school teachers who are required to complete graduate courses for certification or recertification and to other applicants whose profession may require additional study at the graduate level. No degrees are awarded while the student is in this status. Should the student subsequently be admitted to a degree program, no more than 12 semester credit hours taken at any campus (non-degree and/or transfer) can be applied toward the degree. In all cases the non-degree student must receive per-

mission from the head of the department before enrolling in courses. This classification is not to be interpreted as a temporary one for those found ineligible for admission to a degree program and **is not open to international students.**

Admission of Clemson University Seniors. An undergraduate student lacking less than a full semester of work to complete the requirements for his baccalaureate degree may apply for admission to a graduate program and, if admitted, be allowed to enroll in courses for graduate credit. The admission criteria are the same as those for any applicant to the particular degree program except for receipt of the baccalaureate degree. These courses must be over and above those required for the baccalaureate degree and should not cause the total course work to exceed 18 semester hours.

Students with a cumulative grade-point ratio of 3.0 or higher may enroll in 700 and/or 800 level courses during their senior year and may choose to use these courses to meet requirements for the Bachelor's degree. However, courses used for this purpose may not later be counted toward an advanced degree. Alternatively, students who take such courses in excess of the requirements for their undergraduate degrees may request that these courses be included as a part of their graduate program if they are subsequently admitted to the Graduate School at Clemson.

Enrollment in any graduate course is subject to approval by the department offering the course and the Graduate Dean. This approval is required prior to registration and may be obtained by completing and returning the appropriate form (GS Form 6) available at the Graduate School.

Admission as a Transient Graduate Student. A student who has been admitted to a degree program at another institution and who wishes to take courses for transfer to that institution may be admitted on receipt of the Certification of Transient Graduate Admission (GS Form 8) which may be obtained from the Graduate School at Clemson University. This form and a completed application form must be presented prior to registration. A student may earn no more than 12 total semester hours while in transient status.

Admission of University Employees to Pursue Graduate Study.
With the approval of his Dean or Director, a qualified employee of
Clemson University may pursue graduate work for credit. How-
ever, no member of the faculty or staff who has a rank higher than
Instructor or its equivalent may be considered as a candidate for
an advanced degree at this institution. Limitations on the num-
ber of hours taken per semester are explained in the section en-
titled "Credit Loads."

PROGRAM OF STUDY

As soon as a student enrolls he should acquaint himself thor-
oughly with the degree requirements and the regulations of the
Graduate School published in the graduate catalog **particularly** the
deadline dates. Each advisor and student should by all means
have a current copy of the graduate catalog.

The Major Advisor. Before the student registers he must, with
the aid and approval of the department head, select a major ad-
visor. In departments with large faculties it may be advisable
to assign all new graduate students to one professor until the
student decides upon his particular interest. This advisor recom-
mends and approves courses to be taken during the student's first
semester. The course work selected should be of a fundamental
or "core" nature so that the advisory committee will have maxi-
mum flexibility to formulate the remainder of the student's pro-
gram of study.

The Advisory Committee. An advisory committee will approve
the student's preliminary study plans, supervise his graduate pro-
gram, administer his preliminary and/or final comprehensive ex-
amination, and initiate the recommendation for the awarding of
the degree. One member of the committee will be designated as
chairman and normally he will direct the student's dissertation or
thesis, if required. This committee is selected by the department
head and student. Prior to the submission of a plan of study, the
department head will forward his recommendations to the dean
of his college, who will, if he approves, then transmit the recom-
mendation to the Graduate Dean. A minimum of three faculty

members shall be selected for a student seeking a Master's degree and a minimum of four faculty members shall be selected for a student seeking a Ph.D. degree. Qualifications of faculty for membership on the advisory committee should be discussed with the college dean. The student and faculty members are notified of the committee appointments by the Graduate Dean.

Filing of Preliminary Study Plan. Preliminary study plans (GS Form 2) must be filed with the Graduate School by those students who are in degree programs. Since fixed curriculums normally do not exist for graduate degrees, the preliminary plan of study represents the formulation of an individual student's curriculum as recommended by the advisory committee. It must adhere to departmental as well as Graduate School policies. Courses taken in excess of those required by the advisory committee for the degree should **not** be listed on the plan of study. Graduate credit is received only for courses numbered 600 or above and no student shall receive both undergraduate and graduate credit for the same course.

Candidates for master's degrees should submit the plan of study by the middle of their second semester* and Ph.D. candidates no later than the beginning of their second year* of study. Before a plan of study is approved, it must be reviewed and signed by the advisory committee. The plan of study is then submitted to the college dean for his approval and is forwarded to the Graduate Dean for appropriate distribution of copies.

Admission to Candidacy for a Degree. Admission to the Graduate School does not qualify a student as a candidate for an advanced degree. Such candidacy depends upon the acceptance by the Graduate Dean of a written request for admission to candidacy. This request (GS Form 4) may be filed by the student as follows: for the Master's degree, after completion of fifteen hours of course work; for the Ph.D. degree, after completion of a major share of course work and successful completion of preliminary or qualifying examinations.

---

*An academic semester is defined as a minimum of nine credit hours of course work taken during a given semester. An academic year is defined as the total of two academic semesters.

All students desiring admission to candidacy must have received full status admission to the Graduate School, have a satisfactory academic standing, and have on file an approved preliminary plan of study.

Multiplication of Higher Degrees. The duplication of higher degrees is discouraged on the same basis as the duplication of the Bachelor's degree. Thus a student holding a Master's degree may not as a rule become a candidate for another Master's degree of the same designation, regardless of the field of study; nor may the holder of an M.A. or M.S. degree in a given field, received at another institution, become a candidate for a different Master's degree in the same field at Clemson.

Continuous Enrollment. Although continuous enrollment is not a formal requirement for an advanced degree, graduate students are expected to pursue their degrees with a minimum of interruption. Only students who are enrolled are eligible to utilize University facilities and/or receive any form of financial aid. Students who have completed all required work and who find it necessary to be enrolled during a given semester so as to utilize facilities may enroll in **GS 799** for a minimum of one credit.

Credit Loads. University upper limits on graduate student loads per semester are (in credit hours):

	Semester	6 Weeks Session	3 Weeks Session*
Persons employed full time	6	3	1
Graduate assistants (half-time)	12	4	2
Graduate assistants (quarter-time)	15	6	3
Full-time students	18	6	3

* Should the 6 weeks and 3 weeks sessions run concurrently, the total credit load will not be permitted to exceed the upper limit for the 6 weeks session.

A person employed full time is defined as anyone employed 5 full working days per week regardless of the employer(s). Half-time and quarter-time graduate assistants are defined, respectively, as those who contribute 20 and 10 clock hours per week, or

equivalent, of service to the University. Graduate students employed less than 10 hours per week by the University are not classified as graduate assistants.

Academic Standards. Graduate students are graded on the same A-B-C-D-F scale as undergraduates. Nonetheless, a graduate student is expected to do superior work and the only satisfactory grades for graduate students are A and B. Thesis and dissertation research grades are on a "Pass-Fail" basis only and are not included in the academic average, however, they are recorded on the student's permanent record. Only credit hours for which a grade of "Pass" is achieved will apply toward the number of research credit hours required for the degree.

A minimum grade of C must be made on all course work to obtain graduate credit. A cumulative B average must be achieved on all work taken (including courses to satisfy undergraduate deficiencies and courses not listed on the plan of study) exclusive of languages or ROTC while enrolled in the Graduate School before a student can become a candidate for an advanced degree. Candidates who fail to maintain a cumulative B average become ineligible for graduation and are placed on probation. Students who remain on probation for two consecutive semesters will not be permitted to continue a graduate program without the written approval of the Graduate Dean.

A grade lower than the specified minimum can be raised to count toward an advanced degree only by repetition of the course. A re-examination is not permitted.

A graduate student must understand that he or she can be dropped from the Graduate School at any time for failure to maintain an adequate academic status.

Incomplete Graduate Course Work. The grade of I may be given for incomplete work for any graduate course in which work remains undone and the student is unable to fulfill all requirements because of circumstances beyond his or her control. This grade is **not** given in lieu of unsatisfactory or failing grades (for completed courses) with an opportunity of improving the grade later.

It is the student's responsibility to contact the instructor regarding the work required to complete the course. Upon request by the student, the instructor shall provide a written statement of the work to be completed.

The grade of I will be valid for only 30 days after the beginning of the next semester or summer session. Within this period, (1) the student must complete his or her work, or (2) the student must request approval from the Graduate Dean for an extension of time by means of a petition which has been endorsed by the instructor, department head, and college dean which states the reason for the request and the length of time needed. Only one request for an extension of time for each grade of I will be considered by the Graduate Dean.

A graduate student will not be permitted to repeat any portion or reregister for any course for which the grade of I has been given or register in any other course for the purpose of removing the grade of I. Should any work remain incomplete at the time the deadlines described above expire, a grade of F will be recorded on the student's permanent record. Although the Graduate Dean will attempt to bring the above deadlines to the attention of the student and department head, it is the sole responsibility of the graduate student to comply with these regulations.

Students who receive a grade of "Incomplete" while enrolled in the Graduate School at Clemson University remain ineligible for graduation until the incomplete work has been made up and a letter grade submitted to the Office of Admissions and Registration.

Auditing by Graduate Students. Audited courses do not carry credit and the fact that a course has been audited is not noted on the graduate student's official record. Audited courses do not count against allowable credit-hour loads.

Graduate auditors are not required to stand tests or examinations. However, the instructor, at his own discretion, may demand or deny the auditor's participation in class to whatever extent he deems desirable.

A graduate student may not by audit satisfy a stated prerequisite for a graduate course. Additionally, a graduate student may not

establish credit through examination in any course for which he was previously registered as an auditor.

Acceptance of Transfer Credit. A maximum of 12 semester credit hours of work may be transferred from an accredited institution for purposes of meeting the requirements for a master's degree. **Credits earned in a non-degree status are considered as transfer** as they were earned prior to admission to a degree program at Clemson University. For the doctoral degree as many as 48 semester credit hours of work may be transferred.

In all cases, the use of transfer credits must be recommended by the student's advisory committee and be approved by the Graduate Dean. Transfer credit will not be awarded for research or for courses in which a grade lower than B, or its equivalent, has been received. Quality points for courses taken at institutions other than Clemson University will not be included in the student's academic average.

Credits may be transferred for work completed at off-campus centers of accredited institutions provided such courses are acceptable, **without reservation,** in degree programs at those institutions. No credit will be given for correspondence, extension, inservice, or field courses.

All transfer credits must be verified by an official transcript from the institution at which the work was completed. Course work completed outside the six-year time limit may not be transferred to Clemson University or validated for graduate credit.

It is the student's responsibility to request a transcript of transfer credits to be sent directly to the Graduate School. The degree will not be conferred at the close of the term during which the student has been registered elsewhere.

Theses and Dissertations. A candidate for an advanced degree in each curriculum requiring a thesis or a dissertation must prepare this document under the direction of a major advisor. Six (6) hours of credit are required for research leading to the Master of Science or Master of Arts thesis when required. Fifteen (15) hours of credit are required for theses in the Master of Architec-

ture and Master of Fine Arts degrees while nine (9) hours of credit are required for the Master of City and Regional Planning degree. Eighteen (18) hours of research credit are required for the Doctor of Philosophy degree.

Three copies of the thesis must be presented to the chairman of the student's advisory committee in sufficient time for the chairman to arrange for a final examination to be held at least three weeks prior to the date on which the degree is expected. A doctoral dissertation must be completed and delivered to the student's advisory committee at least two weeks prior to the final examination. Three copies of the master's thesis and four copies of the doctoral dissertation must be submitted to the Graduate School by the deadline for the date on which the degree is conferred. A binding fee of $18.00 must be paid to the Bursar and the Bursar's receipt submitted to the Graduate School Office at the time the thesis or dissertation is submitted. If the student desires he may have additional copies bound for himself at a cost of $6.00 a copy. The responsibility for placing the thesis or dissertation in proper final form rests with the student and the chairman of his advisory committee. A guide for the preparation of theses and dissertations at Clemson University may be obtained from the Graduate School.

The student will prepare two additional copies of the abstract and title sheet to be submitted to the Graduate School. Ordinarily this abstract should not exceed 500 words in length. It should be written and edited in such a way that it will be suitable for publication.

Doctoral students are required to pay a fee of $25.00 to the Bursar for publication of the **Dissertation Abstract.** An additional fee of $15.00 is required if copyright is desired.

Restriction on Use of Theses and Dissertations. Unpublished theses and dissertations submitted to the Graduate School in partial fulfillment of the requirements for graduate degrees and deposited in the University Library are, as a rule, open to the public for reference purposes. However, extended quotations or summaries may be published only with the permission of the author and the Graduate Dean.

Application for a Diploma. A formal application for a diploma is placed by the student with the Dean of Admissions and Registration in accordance with the deadlines on the inside front cover.

Graduate Degrees and Teachers' Certificates. Prospective students should understand that the material in this bulletin applies only to requirements for graduate degrees and has no direct relation to certificates for public school teachers. The Graduate School gives no assurance that a program for a graduate degree and a program for a certificate will coincide. Students interested in certificates should, at the outset of their work, confer with the Dean of the College of Education.

DEGREES

Courses are offered leading to the Master of Arts, Master of Science, and Doctor of Philosophy degrees.

In addition, courses are offered leading to the professional degrees of Master of Agriculture, Master of Agricultural Education, Master of Architecture, Master of City and Regional Planning, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Industrial Education, Master of Nutritional Sciences, and Master of Recreation and Park Administration. The Master of Business Administration degree is offered jointly by Furman University and Clemson University.

REQUIREMENTS FOR THE MASTER'S DEGREE

Residence Requirements. To receive the Master of Science or Master of Arts degree, the student must complete at least nine (9) semester hours of graduate credit on the Clemson University campus during one academic semester or two consecutive summer sessions of the program. However, all full time University employees admitted to an advanced degree program may satisfy residence requirements by completing 15 semester hours of graduate credit on the campus during a continuous 12 months period. There are no residence requirements for the professional degrees.

Time Limit. All course work which is to be credited toward any of the master's degrees must have been completed not more than six (6) calendar years prior to the date on which the degree is to be awarded; except that when approved by the student's department head and the Dean of Graduate Studies and University Research, as many as six (6) semester hours of course work completed outside the six-year limit may be validated by written examination. Such examinations will be under the direction of the department regularly offering the course or courses for which the student seeks validation. Course work completed outside the six-year time limit at an institution other than Clemson University may not be transferred to Clemson or validated for graduate credit.

Course Work Required. In addition to such supplementary or supporting courses as may be required, the degree program will consist of a minimum of 30 semester hours of graduate credit subject to the following conditions:

a. The Master of Science or Master of Arts degree program will include six (6) semester hours of research if a thesis is required. Of the remaining required semester hours, at least half must be selected from courses numbered 800 or above. Research credits (891 or 991) cannot be part of the 30 hours if the non-thesis option is exercised.

b. For the professional degrees at least half of the required hours must be selected from courses numbered 700 or above. Except for programs in the College of Architecture which require a thesis, research credits (891 or 991) cannot be used to fulfill the minimum requirements for the professional degrees. Additional requirements for these degrees are listed in sections describing specific colleges which offer the degree.

Each master's degree program shall contain a minimum of twelve (12) semester hours, exclusive of research, in the student's major field. A minor, if selected, shall consist of at least six (6) semester hour credits in that area.

Language Requirement. A reading knowledge of one approved foreign language is a departmental requirement for all Master of Arts degrees and certain Master of Science degrees. The required

reading knowledge is equivalent to that provided by two years of study of the language at the college level. The procedures for satisfying this language requirement are identical to those for the Ph.D. degree as listed on page 39.

Study in Absentia. Although thesis research is normally performed at Clemson University, it is recognized that Clemson University may not have on its campus certain specialized equipment or facilities which would be desirable for advanced training at the master's level. Thus, for those cases in which theses or other advanced study is required and the facilities to pursue such study are not available on the Clemson University campus, permission may be granted for study in absentia. The requirements to be satisfied in such cases are identical to those listed under: "REQUIREMENTS FOR THE DOCTOR OF PHILOSOPHY DEGREE, Residence Requirements," with the exception that the off-campus research supervisor need not hold the Ph.D. degree so long as he or she is qualified and certified for the supervisory position by the department and college involved and by the Graduate Dean.

Final Examination. Each candidate for the master's degree, after the completion of the thesis, if required, and at least three weeks before the degree is to be awarded, must pass an examination as may be required by the student's advisory committee. The examination, which may be oral and/or written will ascertain the general knowledge of the candidate with particular reference to the major and minor subjects and the thesis or departmental research report. The Graduate School will be notified of the time and place of the examination at least 10 days prior to the time scheduled. Included with those members of the faculty and staff invited to attend the examination will be members of the Graduate Council and the Graduate Dean. Within three days after the examination, the examining committee, through the appropriate form (GS Form 7), will notify the Graduate Dean of the results of the examination. A student who fails a final examination may be allowed a second opportunity in a subsequent semester only with the recommendation of the advisory committee and department head and the written consent of the Graduate Dean. Failure of the second examination will result in dismissal from the Graduate School.

35

REQUIREMENTS FOR
DOCTOR OF PHILOSOPHY DEGREES

Work leading to the Doctor of Philosophy degree is planned in such a way as to give the student a comprehensive knowledge of his fields of specialization and a mastery of the methods of research. The degree is not awarded solely on the basis of course work completed, residence or other routine requirements. The final basis for granting the degree will be the student's grasp of the subject matter of a broad field of study, his competency to plan and conduct research, and his ability to express himself adequately and professionally in oral and written language.

The advisory committee will aid the student in developing a plan of study which will include the selection of specific courses and their sequence. Within the entire program of required course work, at least half must consist of courses numbered 800 or above. Work in the minor field or fields, if required, normally should consist of from 12 to 24 hours in courses carrying graduate credit. A minimum of 18 hours of doctoral research is required. Should the direction of study or research interest change, the student may request the appointment of a new advisor.

Residency Requirements. Residency is a necessary concept in graduate education, particularly in the preparation of the dissertation. The purpose of residency then is to require the student to spend a specified minimum amount of time as follows:

a. In direct personal association with members of the faculty of the University.

b. Under direct tutelage and advisement of a research advisor and advisory committee in the department or program of the major.

c. Participating in other normal activities pertinent to graduate education such as seminars and close association with other student researchers.

To receive the Doctor of Philosophy degree, the student must complete at least 12 semester hours of graduate credit in two con-

secutive academic semesters or one semester and two summer sessions, taken consecutively, on the Clemson University campus.

For students employed substantially more than half-time, a statement specifying the manner in which the residence requirement is to be satisfied shall be formulated by the advisory committee and be included in the plan of study. Also, upon completion of the final examination the student's committee will forward a statement approved by the department head and college dean certifying that residence requirements have been met.

Off-Campus Research. Under special circumstances, it may appear desirable that doctoral research be conducted external to the Clemson University campus. If such research is to be performed under the immediate direction of a Clemson University faculty member acting as dissertation advisor and supervisor, then in order to accommodate the student as well as to exercise proper and necessary control over this most important phase of doctoral study, the following additional requirements will be made:

a. The student must have the written consent of his university dissertation advisor, full advisory committee, department head, college dean, and the Dean of Graduate Studies and University Research. Prior to his departure from the campus, the student must submit in writing to his committee for their approval a plan for his research effort. Such plan should include a discussion of his problem and the intended scope of his investigation and should be structured in terms of a specific time frame.

b. The advisory committee may require a statement from an appropriate officer of the organization at which the student will be located agreeing to one or all of the following: 1) the student's plan to complete dissertation research using the organization's equipment and facilities, 2) the apportioning of at least 25 percent or other appropriate amount of the student's employment hours to his dissertation research, and 3) the release of patent rights or copyrights by the organization, arising from discoveries or concepts which evolve during the course of the student's doctoral research.

c. The student may be required to travel to Clemson University, not at the expense of Clemson University, to meet with his dissertation advisor and advisory committee as often as is deemed necessary by the committee. Further, the student may, at the discretion of his dissertation advisor and advisory committee, be required to return to the Clemson University campus subsequent to the performance of the mechanics of his research for the purpose of comprehensive review and analysis of his research.

d. The student must maintain continuous enrollment at Clemson University each semester while the research is in progress. It will be his responsibility to make suitable arrangements with his department to maintain this continuous registration. Normally the student will not be required to register for summer sessions; however, he must be registered for the term which involves the review of his completed dissertation and/or his final examination.

If doctoral research is to be conducted external to the Clemson University campus, but under the immediate direction of a dissertation supervisor who is an employee of an organization other than Clemson University; then in order to accommodate the student, as well as to exercise proper and necessary control over this most important phase of doctoral study, the following requirement (additional to those above) will be made:

a. An employee, having an earned Ph.D. and engaged in the general subject area of the student's research, must be designated by an officer of the organization to supervise the student's research work and recommended for appointment as an adjunct professor of Clemson University. A resume of the research supervisor must be submitted to the student's full advisory committee for their review and recommendation to the Graduate Dean.

b. The research supervisor will be required to submit a final statement regarding the dissertation research, as well as interim reports, if the committee deems such as being necessary. It is to be emphasized that the off-campus research supervisor cannot serve as the student's dissertation advisor.

Time Limit. All work for a Doctor of Philosophy degree must be completed within a period of seven years. If a student begins

his doctoral program after receiving the master's degree, all work above the master's level must be completed within a six-year period.

Language Requirement. Certain doctoral programs include a language requirement. Languages accepted by all departments are French and German; under certain conditions Spanish, Russian, or the classical languages may be accepted. A combination of two Romance languages is not normally acceptable. Upon the recommendation of the Head of the Department of Languages, use of other languages may be approved provided (a) adequate justification can be presented, (b) the language is not native to the student, and (c) a proper testing procedure can be established. Any expense incurred in obtaining assistance in testing must be paid by the student.

The language requirement may be a basic reading knowledge equivalent to that provided by two years of study at the college level of one or two languages or a command in depth of one language equivalent to that provided by three years of study at the college level.

Basic reading knowledge of each language is determined as follows:

Option 1. The student may complete the basic reading knowledge requirement by attaining the 30th percentile on the Graduate School Foreign Language Test (GSFLT).

Option 2. Upon the recommendation of the Head of the Department of Languages, students who have completed, within the last five years, the equivalent of 12 semester hours of study of a language at an accredited institution with average grades of B will be exempted from examination in that language.

Option 3. The student may elect to enroll on a pass-fail basis in French 151 or 152, or German 151 or 152. This sequence is designed to prepare graduate students to read technical material in their particular academic discipline. To receive a grade of pass, the student must present a satisfactory score as determined by the

Language Department from either the College Entrance Examinations Board test (CEEB), the GSFLT (see option 1), or a locally prepared translation exam similar to the GSFLT, otherwise, a grade of incomplete (I) will be reported. A passing score achieved at the end of 152 will automatically eradicate an incomplete in 151, but university procedures, appropriate for undergraduate courses, must be followed in order to change the incomplete (I) to Pass (P).

A student may repeat each course only once but may audit an unlimited number of times. An auditor does not qualify to take the CEEB. He may, however, take either the GSFLT or the translation exam.

A grade of pass (P) in 151 or 152 merely indicates that a student has attained a proficiency equivalent to the basic reading knowledge requirement; it does not indicate that he has fulfilled his Graduate School requirement. The Graduate School, based on information provided by the Department of Languages, will notify the student when he has completed his requirement.

Command in depth of a single approved language is evidenced by a score above the 60 percentile on the GSFLT.

Students who have completed a sequence of the equivalent of 18 semester hours of study in a language with average grades of B, at least half of it within the previous five years, may be exempted from this examination upon the recommendation of the Head of the Department of Languages. Command in depth may also be evidenced by superior performance in the 151-152 sequence offered by the Language Department. The locally prepared translation exam, however, may not be used for this purpose.

The Graduate School Foreign Language Tests of the Educational Testing Service are administered at Clemson by the University Testing Center according to the national schedules set by ETS.

All language requirements must have been satisfied prior to the student's preliminary or qualifying examination and prior to his admission to candidacy for the degree.

Qualifying Examinations Before Admission to Candidacy. The student must undertake such preliminary or qualifying examinations as may be prescribed by his department before he applies for admission to candidacy for his degree. These examinations may be written, oral, or a combination of both. The function of the examinations is to obtain objective evidence of an adequate intellectual mastery of the areas of major and minor specialization.

Immediately after the examination, the examining committee will notify the Graduate School of its findings. The student's performance on these examinations will determine whether the committee recommends acceptance of his application for admission to candidacy.

Should the student fail to pass his preliminary examinations, he may be given the opportunity to undergo the examinations a second time. A second failure shall result in the student being declared ineligible for the Doctor of Philosophy degree at Clemson University.

Some departments have both qualifying and comprehensive examinations. Information about these examinations may be obtained from the individual departments.

Final Doctoral Oral Examination. The candidate for the Doctor of Philosophy degree must pass a final oral examination at least three weeks prior to the time of the convocation at which he plans to obtain the degree. The examination will be conducted by the student's advisory committee, and all faculty members are invited to participate. The Graduate School will be notified of the time and place of the examination at least ten days prior to the time scheduled.

This final examination demands a broad and penetrating interpretation by the student of his research project and conclusions. It may include examination of the student in his major and minor fields of specialization.

FINANCIAL AID FOR GRADUATE STUDY

All graduate students, with the exception of full-time employees must enroll as full-time equivalent students in order to qualify for any financial aid from the University. The University reserves the right to withdraw financial aid at any time due to failure to meet this requirement.

Research and Teaching Assistantships are available to outstanding graduate students. Teaching assistantships are normally awarded for the academic year* while research assistantships may be granted for longer periods. Stipends range from $3,000 to $5,400 and tuition is reduced. Application forms are obtainable from the Graduate School or from department heads and should be completed and filed early in the academic year before the student expects to enroll. Recipients of assistantships are selected by the respective academic departments and will be notified by the department.

Graduate Fellowships and Grants-in-aid are also available. All fellowship awards are made by the heads of departments concerned. Information about grants-in-aid is obtainable from the Graduate School.

Other Funds. Limited assistance may also be available from the Clemson Foundation, Clemson Student Loan Funds, and National Defense Student Loan Programs. Contact the Student Aid Office prior to June 1 for further information.

---

* Teaching assistants are usually awarded stipends during the summer months for performance of departmental duties provided they continue to work towards their degree.

College of Agricultural Sciences

L. P. Anderson, Dean

In addition to the Master of Science and Ph.D. degrees, the College of Agricultural Sciences offers post-baccalaureate degree programs that are designed primarily to meet the continuing education needs of individuals whose interests lie outside of a research-oriented profession. Individuals who are interested in such professional training and development include extension service personnel; school food service, public health, and clinical nutritionists; vocational agriculture teachers; technical education center teachers; and management, executive, sales, and service personnel of agri-business firms.

These programs are designed to fulfill the following objectives: (a) provide university graduate level professional training of a non-research-oriented nature, and (b) provide a program of continuing education adapted to the needs of agriculture.

Professional degrees are awarded with majors in the following areas of study:

Agricultural Economics	Dairy Science
Agricultural Education*	Entomology
Agricultural Engineering**	Horticulture
Agricultural Mechanization	Nutritional Sciences
Agronomy — Crops and Soils	Plant Pathology
Animal Science	Poultry Science

A minimum of 30 semester hours is required. At least one-half of the credit hours in the student's program must come from courses numbered 700 or above. The student's program of study must be approved by his advisory committee.

Both a major field of study of at least 12 semester hours and minor field of at least six (6) semester hours are required.

*Jointly administered by the College of Agricultural Sciences and the College of Education.

**Jointly administered by the College of Agricultural Sciences and the College of Engineering.

All candidates for the degree of Master of Agriculture, Master of Agricultural Education, or Master of Nutritional Sciences will be required to take a course in applied statistics, if such a course has not been a part of the student's undergraduate degree program. In addition, a knowledge of research methods will be required and may be acquired through a research methods or a special problems type course.

AGRICULTURAL ECONOMICS

J. E. Faris, Head, Department of Agricultural Economics and Rural Sociology

Courses are offered leading to the Master of Agriculture, Master of Science, and Doctor of Philosophy degrees.

Graduate work in agricultural economics is of increasing importance since it enables the student to attain a higher degree of specialized professional competence and to secure a greater mastery of techniques for applying quantitative economic analysis to agricultural firm and industry problems. Industry, government, and universities offer challenging opportunities in research, development, education, management and other related areas for persons with advanced training in agricultural economics.

In addition to applicants from undergraduate programs in agricultural economics and other related agricultural programs, the department encourages applications from other students with bachelor's degrees in fields that provide a well rounded background in general economics. In many cases, such students may be admitted to full graduate status without prerequisites other than those required of all graduate students. Special emphasis in the program of graduate study is placed on the economics of agricultural production and marketing, economic development, analysis of programs and policies affecting agriculture, and statistical techniques used in solving economic problems of the agricultural industry.

Ag Ec 602—ECONOMICS OF AGRICULTURAL PRODUCTION— 3 cr. (3 and 0) F

Ag Ec 603—LAND ECONOMICS—3 cr. (3 and 0) S

Ag Ec 651—AGRICULTURAL COOPERATION—2 cr. (2 and 0) S

Ag Ec 652—AGRICULTURAL POLICY—3 cr. (3 and 0) F, S

Ag Ec 656—PRICES—3 cr. (3 and 0) F, S

Ag Ec 660—AGRICULTURAL FINANCE—2 cr. (2 and 0) F, S

44

Ag Ec 701—AGRIBUSINESS MANAGEMENT PRINCIPLES—
    3 cr. (3 and 0) F

A survey of concepts and principles of management of agribusiness firms. Included are such topics as decision theory, information systems, systems analysis and organization theory with special applications of these concepts to the organization, administration, and management of agriculturally-related businesses.

Ag Ec 802—PRODUCTION ECONOMICS—3 cr. (3 and 0)

An advanced study of production economics theory in a quantitative framework. Major emphasis is placed on technical and economic factor-product, factor-factor, and product-product relationships in single and multi-product firms under conditions of perfect and imperfect competition in both factor and product markets. **Prerequisite:** Ag Ec 808 or permission of instructor.

Ag Ec 804—WATER RESOURCE POLICIES—3 cr. (3 and 0) F

A study of the economic, social and legal aspects of the control, use, development and management of water resources, with special emphasis upon public policies relating thereto.

Ag Ec 805—SEMINAR IN MARINE RESOURCES MANAGEMENT AND
    POLICY—3 cr. (3 and 0)

A seminar devoted to the study of the economic, institutional and legal aspects of the control and management of common-property marine resources. Special attention is given to the study of management systems for the resources of the coastal zone and continental shelf.

Ag Ec 806—ECONOMIC DEVELOPMENT IN AGRICULTURAL AREAS
    —3 cr. (3 and 0) S

A critical examination of the theories of economic growth and development and their application to areas or regions. Also, a survey of methods of regional economic analysis with emphasis on both the macro- and microeconomic aspects.

Ag Ec 807—MARKET STRUCTURE IN AGRICULTURAL INDUSTRIES—
    —3 cr. (3 and 0) S

A study of market structure and other approaches as they relate to agricultural marketing. Students will undertake individual assignments in the field of their interest. **Prerequisite:** Permission of instructor.

Ag Ec 808—APPLIED QUANTIFICATIONS IN AGRICULTURAL
    ECONOMICS—3 cr. (3 and 0) F

A survey of mathematical tools requisite for concise description of the principles in the economics of agriculture. Microeconomic theory under the assumptions of perfect competition is emphasized. The relations among demand, supply, cost, revenue, and productivity are examined in a framework for agriculture. **Prerequisite:** Permission of instructor.

Ag Ec 809—PROBLEMS IN THE ECONOMICS OF WASTE DISPOSAL AND MANAGEMENT—3 cr. (3 and 0)

Supervised study of the economic problems of management and disposal of liquid, gaseous, and solid waste of firms and communities in non-urban areas. The student is expected to read extensively in the literature of the field and to prepare written and oral reports.

Ag Ec 814—CONTEMPORARY PUBLIC POLICY—3 cr. (3 and 0) F

A critical examination of contemporary public policy, including both price and resource policy, as it affects rural areas. Special emphasis will be given to public policy, or the lack thereof, as it relates to programs designed to implement public policy.

Ag Ec 851—SEMINAR IN RESEARCH METHODOLOGY—1 cr. (1 and 0)

A survey of logic and the scientific method; the formulation, initiation and carrying out of research problems in economics and business; methods and problems of obtaining and analyzing economic data; the role of electronic computers and data processing systems, and group discussions of the proposed thesis problems of individual students. (Required of all graduate students who have not already had a comparable course.)

Ag Ec 881—INTERNSHIP IN COMMUNITY AND RESOURCE DEVELOPMENT—1-6 cr.

Professional employment under competent supervision in an approved agency dealing with socio-economic aspects, community development and/or natural resource management. During the internship the student will submit monthly reports covering his experience. **Prerequisite:** 18 semester hours graduate credit.

Ag Ec 891—RESEARCH—Credit to be arranged.

Ag Ec 904—SEMINAR IN RESOURCE ECONOMICS—3 cr. (3 and 0)

Study of special problems and recent periodical literature relating to the control, management, development and use of land and water resources in the United States and in other parts of the world. **Prerequisite:** Ag Ec 603 or 804.

Ag Ec 906—SEMINAR IN AREA ECONOMIC DEVELOPMENT— 3 cr. (3 and 0)

A study of recent research developments in the field of economic development, including a review of research publications, journal articles, and other literature, with special emphasis given to a critical examination of objectives, analytical techniques and procedures used in area or regional development efforts. **Prerequisite:** Ag Ec 806.

Ag Ec 907—AGRICULTURAL MARKETING PROBLEMS—3 cr. (3 and 0)

An advanced study in the theory of, and the research related to consumer behavior; economic consequences of individuals' and firms' decisions upon supply and demand; general interdependency among economic variables. **Prerequisite:** Ag Ec 807.

Ag Ec 991—DOCTORAL RESEARCH—Credit to be arranged.
(See also courses listed under Economics.)

CRD 611—INVESTMENT IN HUMAN AND NATURAL RESOURCES—
3 cr. (3 and 0) F

CRD 612—REGIONAL ECONOMIC DEVELOPMENT POLICY—3 cr.
(3 and 0) S

AGRICULTURAL MECHANIZATION

A. W. Snell, Head, Department of Agricultural Engineering

Courses are offered leading to the Master of Agriculture degree.

The Master of Agriculture degree with a major in Agricultural Mechanization is designed to prepare, at an advanced level, individuals with agricultural and related backgrounds for positions of leadership in technical services, mechanized production and other businesses serving modern agriculture. Students with undergraduate backgrounds in agricultural mechanization, other agricultural curriculums or related curriculums from non-agricultural colleges and universities are eligible to enroll in this program.

The individual program of the student will be arranged to include courses both in the agricultural mechanization specialty and in supporting courses throughout the University. Emphasis is placed on the development of a coherent program to satisfy student objectives.

Ag M 605—ADVANCED INTEGRATED SHOP——3 cr. (2 and 3)

Ag M 652—FARM POWER—3 cr. (2 and 3)

Ag M 660—FARM AND HOME UTILITIES—3 cr. (2 and 3)

Ag M 712—FARM MACHINERY MANAGEMENT—3 cr. (2 and 3)
A course dealing primarily with the selection, functional analysis, and maximum utilization of existing and developing farm machinery. Computer application to the programming of field operations is stressed. Factors such as available capital and labor, machine size, critical field operations, growing degree days, and weather are considered. Maintenance equipment, procedures, and scheduling are emphasized.

Ag M 733—ANALYSIS OF AGRISTRUCTURES—3 cr. (3 and 0)
The study of materials and their function in farm buildings, aesthetic values and rational selection of individual components are stressed. Additional topics include farmstead planning, space and environmental considerations, crop processing, materials handling, and waste disposal.

Ag M 771—SELECTED TOPICS IN AGRICULTURAL MECHANIZATION
—1-3 cr. (1-3 and 0)

Under the guidance of an instructor the student will perform an in-depth study of an area of Agricultural Mechanization that is not covered in other course offerings. Student performance may be measured by oral or written reports or by examinations. Course may be repeated for credit for a maximum of 6 credits.

Ag M 781—SPECIAL PROBLEMS—1-3 cr. (1-3 and 0)

A course for independent study in which the student analyzes a problem in depth either through literature review, laboratory, or field research. A well-prepared written report, documenting the study is required. Course may be repeated for a maximum of 6 credits.

Ag M 851—SIMULATION OF AGRICULTURAL SYSTEMS—3 cr.
(3 and 0)

Synthesis and analysis of agricultural systems via computer simulation. Both continuous and discrete systems will be covered. Philosophy of system simulation and optimization will be taught. Models of interest to the class will be used as examples to teach the working techniques. Each student will build a model of a system of his choice. No computer background required. **Prerequisite:** Math 106 or permission of instructor.

AGRONOMY

G. R. Craddock, Head, Department of Agronomy and Soils

Courses are offered leading to the Master of Agriculture, Master of Science, and Doctor of Philosophy degrees.

Opportunities exist for B.S. or B.A. degree graduates with majors in chemistry, biology, plant science, physics, geology, general science or soils. Graduate programs include courses in soil chemistry, soil physics, soil genesis, soil fertility, cytogenetics, plant breeding and genetics as well as fundamental research problems relating to these subjects. Facilities include X-ray diffraction, differential thermal analysis equipment, a cytogenetics laboratory, a soil microbiology laboratory, controlled environmental chambers, and graduate student laboratories in an air-conditioned building.

Agron 601—FERTILIZERS—3 cr. (3 and 0) F

Agron 602—LAND POLLUTION CONTROL—3 cr. (3 and 0) S,
odd numbered years.

Agron 603—SOIL GENESIS AND CLASSIFICATION—2 cr. (1 and 3) F

Agron 604—SOILS AND LAND USE—2 cr. (1 and 3) F

Agron 605—PLANT BREEDING—3 cr. (2 and 2) S

Agron 607—PRINCIPLES OF WEED CONTROL—3 cr. (2 and 2) F

Agron 608—SOIL AND PLANT ANALYSIS—3 cr. (1 and 6) S

Agron 610—COTTON AND OTHER FIBER CROPS—2 cr. (2 and 0) S, odd numbered years.

Agron 611—GRAIN CROPS—2 cr. (2 and 0) F, even numbered years.

Agron 612—TOBACCO AND SPECIAL USE CROPS—2 cr. (2 and 0) S, even numbered years.

Agron 620—FORAGE AND PASTURE CROPS—3 cr. (3 and 0) S

Agron 622—FORAGE CROPS LABORATORY—1 cr. (0 and 2) S

Agron 652—SOIL FERTILITY AND MANAGEMENT—2 cr. (2 and 0) S

Agron 655—SEMINAR—1 cr. (1 and 0) F

Agron 656—SEMINAR—1 cr. (1 and 0) S

Agron 801—CROP PHYSIOLOGY AND NUTRITION—3 cr. (3 and 0) F, odd numbered years.

The application of basic concepts and physiologic aspects of growth and culture to crop management practices.

Agron 802—PEDOLOGY AND SOIL CLASSIFICATION—3 cr. (2 and 3) S, odd numbered years.

Deals with the factors of soil genesis, soil morphology, and soil classification. A study is made of such factors of soil formation as parent material, topography, climate and organisms. Particular attention is given to the classification of Southeastern soils.

Agron 804—THEORY AND METHODS OF PLANT BREEDING—3 cr. (3 and 0) F, even numbered years.

Concepts and principles of plant breeding and genetics as applied to the development and maintenance of improved crop varieties. Theoretical considerations of the various breeding methods are emphasized.

Agron 805—SOIL FERTILITY—3 cr. (3 and 0) S, even numbered years.

A study of the essential nutrients in the soil-plant system with emphasis on mechanisms of retention and transport; supplies and availability; reactions and interactions; deficiency diagnosis and remedies. Concepts and techniques for evaluating soil fertility problems will be studied.

Agron 806—SPECIAL PROBLEMS—1-3 cr. (0 and 3-9)

Original investigations of problems in Agronomy not related to a thesis are stressed to provide experience and training in research.

Agron 807—SOIL PHYSICS—3 cr. (2 and 3) S, even numbered years.

A study of fundamental principles of soil physics, methods of physical analysis of soils, and applications of soil physics in Agriculture.

Agron 808—SOIL CHEMISTRY—3 cr. (2 and 3) F, odd numbered years.

Principles and theories concerning the structure and chemical properties of soil colloids, ionic exchange and membrane phenomena, chemical equilibria, soil acidity, oxidation-reduction relations, soil chemistry of plant nutrients.

Agron 812—CROP ECOLOGY AND LAND USE—3 cr. (3 and 0) F, even numbered years.

Basic concepts of, and factors affecting, the adaptation and distribution of crop plants. Study of the microclimate and crop response to environmental factors, with modifications of microclimate by agricultural operations. Interactions among crop plants and between weeds and crop plants under field conditions.

Agron 820—PESTICIDE RESIDUES IN THE ENVIRONMENT—3 cr. (3 and 0) S, odd numbered years.

A study of the accumulation, decomposition and/or attenuation of pesticides in man's environment. Includes pesticide structures and properties; sorption-desorption by soil; diffusion and transport in water; volatility, and diffusion in air; and chemical-, bio- and photodegradation. **Prerequisites:** Introductory courses in organic and physical chemistry or permission of instructor.

Agron 825—SEMINAR—1 cr. (1 and 0) F, S

Presentation and discussion of special topics and original research in the field of agronomy. (Credit may be earned for more than one semester by doctoral candidates.)

Agron 891—RESEARCH—Credit to be arranged. F, S

Agron 991—DOCTORAL RESEARCH—Credit to be arranged. F, S

ANIMAL PHYSIOLOGY

B. D. Barnett, Head, Department of Poultry Science
J. F. Dickey, Program Coordinator

Courses are offered leading to the Doctor of Philosophy degree.

The graduate program in Animal Physiology utilizes the facilities of the departments of Animal Science, Dairy Science, Entomology and Economic Zoology, Poultry Science, and Zoology, and includes faculty from these departments plus Food Science, Electrical and Computer Engineering, Bioengineering, and Psychology. Physiological processes of both

vertebrates and invertebrates are considered. Areas of greatest research emphasis are reproduction, endocrinology and environment.

Students enrolling in Animal Physiology should have a strong background in the biological sciences, and at least one course in organic chemistry.

The student will organize his program of study from the courses listed below and from supporting fields as deemed proper by the advisory committee.

An Ph 801—ELECTRON MICROSCOPY OF ANIMAL AND PLANT TIS-
SUES—3 cr. (1 and 6) S, F

Theory of and practice in: preparing animal, plant and microbial specimens for electron microscope observations; thin-sectioning; section staining; operating the electron microscope; photographing, developing and printing micrographs; interpreting electron micrographs. Emphasis will be placed on a special problem in which the student selects a tissue of interest, studies it with the electron microscope, prepares and interprets electron micrographs.

An Ph 802—DIGESTIVE AND EXCRETORY PHYSIOLOGY—3 cr.
(2 and 3) F, even numbered years.

A study of the physiology of food intake, gastrointestinal secretions, digestion, absorption and excretion in ruminant and monogastric animals. Basal metabolism and temperature regulation will be discussed.

An Ph 803—CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY—
4 cr. (3 and 3) F, odd numbered years.

The study of the physiology of blood cell formation, clotting mechanism, immune response, hemostasis, cardio-vascular relationships, acid-base balance, lymphatic and interstitial fluid dynamics, fluid excretion, and respiration and gaseous exchange in mammals and birds. The effects of environmental stresses on respiration and circulation will be discussed.

An Ph 804—MUSCLE AND NERVE PHYSIOLOGY—4 cr. (3 and 3) S,
even numbered years.

A study of the physiology of muscles (striated, smooth and cardiac), nerve responses (transmitting, processing and receiving signals), hearing, seeing, tasting, smelling and feeling. Also, the functions of skin and bones will be discussed.

An Ph 805—PHARMACOLOGY—3 cr. (2 and 3) S, even numbered years.

The action of drugs upon the various biological systems of the mammal will be described. Drugs will be discussed by classes and discussions will include methods of action, uses, general dosage levels, and toxicity. The laboratory exercises will demonstrate the actions of drugs upon the mammalian systems. Both classroom and student experimentation will be employed.

An Ph 806—EXPERIMENTAL ANIMAL PHYSIOLOGY—3 cr. (1 and 6)
F, odd numbered years.

Demonstration and practice of research methodology in animal physiology. Emphasis is on the scientific approach for using animals or specific organs of intact animals as experimental units. The selection and use of animal techniques and practices, including surgical procedures for altering physiological and endocrinological activities with large and small animals. **Prerequisite:** Zool 660 or equivalent.

An Ph 807—SPECIAL PROBLEMS IN ANIMAL PHYSIOLOGY—1-3 cr.,
F, S, SS

Original investigation of special problems in animal physiology not related to a thesis and designed to provide experience and training in research. This may include a comprehensive review of literature which relates to a research project.

An Ph 808—MAMMALIAN AND AVIAN ENDOCRINOLOGY—3 cr.
(3 and 0) S, odd numbered years.

A study of the interrelationships of the nervous and endocrine systems as they influence growth and development, body metabolism, body regulatory mechanisms, behavior, and reproduction in mammals and birds, and lactation in mammals. Emphasis will be on the integrating actions of hormones as they affect production. The theoretical and practical aspects of exogenous administration of hormones (natural and synthetic) on body functions will be discussed.

An Ph 851—ANIMAL PHYSIOLOGY SEMINAR I—1 cr. (1 and 0) F

Major topics will be current research and developments in animal physiology. Student and faculty research will be discussed as well as the literature on animal physiology.

An Ph 852—ANIMAL PHYSIOLOGY SEMINAR II—1 cr. (1 and 0) S

This course is a continuation of An Ph 851 and will include further discussion of current research and literature on topics selected by instructor and students.

An Ph 991—DOCTORAL RESEARCH—Credit to be arranged.

Bioch 606—PHYSIOLOGICAL CHEMISTRY—3 cr. (3 and 0)

Bioch 608—PHYSIOLOGICAL CHEMISTRY LABORATORY—1 cr.
(0 and 3)

Bioch 817—CHEMISTRY AND METABOLISM OF HORMONES—
2 cr. (2 and 0)

Bioch 819—INTERMEDIARY METABOLISM—3 cr. (3 and 0)

Dy Sc 653—ANIMAL REPRODUCTION—3 cr. (3 and 0)

Dy Sc 655—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3)

Dy Sc 803—PHYSIOLOGY OF REPRODUCTION AND MILK SECRE-
TION—3 cr. (3 and 0)

Ent 670—INSECT PHYSIOLOGY—3 cr. (2 and 3)

Ent 870—ADVANCED INSECT PHYSIOLOGY—3 cr. (2 and 3)

Micro 811—BACTERIAL CYTOLOGY AND PHYSIOLOGY—4 cr.
(4 and 0)

Micro 813—BACTERIAL CYTOLOGY AND PHYSIOLOGY LABORA-
TORY—2 cr. (0 and 6)

Zool 658—CELL PHYSIOLOGY—3 cr. (2 and 3)

Zool 660—GENERAL PHYSIOLOGY—4 cr. (3 and 3)

Zool 661—ANATOMY—3 cr. (3 and 0)

Zool 675—GENERAL ENDOCRINOLOGY—3 cr. (2 and 3)

Zool 801—ANIMAL HISTOLOGY—3 cr. (2 and 3)

Zool 808—RADIOBIOLOGY—3 cr. (2 and 3)

Zool 830—HISTOCHEMISTRY—CYTOCHEMISTRY—3 cr. (2 and 3)

ANIMAL SCIENCE

R. F. Wheeler, Head, Department of Animal Science

**Courses are offered leading to the Master of Agriculture and Master of
Science degrees.**

The Department participates in interdepartmental Ph.D. programs in
Animal Physiology and Nutrition.

An Sc 601—BEEF PRODUCTION—3 cr. (3 and 0)

An Sc 603—BEEF PRODUCTION LABORATORY—1 cr. (0 and 3)

An Sc 608—PORK PRODUCTION—3 cr. (3 and 0)

An Sc 610—PORK PRODUCTION LABORATORY—1 cr. (0 and 3)

An Sc 652—ANIMAL BREEDING—3 cr. (3 and 0)

An Sc 802—TOPICAL PROBLEMS—1-3 cr. (1-3 and 0)

A critical study of animal science experiments and interpretation of
their results.

An Sc 803—MEAT TECHNOLOGY—3 cr. (3 and 0)

Biochemistry, histology and microbiology of fresh, frozen, cured, smoked and processed meats. Quality of meats, and meat products, processing methods, nutritive value, and research techniques will be given emphasis. **Prerequisites:** An Sc 353 and 355.

An Sc 804—METHODS IN ANIMAL BREEDING—3 cr. (3 and 0)

Gene and zygotic frequency; systems of mating; heritabilities; genetic consequences of selection; and criteria for evaluating improvement in beef cattle, swine, and sheep. **Prerequisite:** An Sc 452/652.

An Sc 805—NUTRITION OF MEAT ANIMALS—3 cr. (3 and 0)

Deals with the metabolism of carbohydrates, lipids, proteins, inorganic elements, and vitamins in the nutrition of beef cattle, swine and sheep. The nutritional requirements of meat animals are studied, with special emphasis on the properties and functions of nutrients in relation to practical production situations. Common nutritional aberrations will be discussed. **Prerequisite:** Nutr 401 or equivalent.

An Sc 891—RESEARCH—Credit to be arranged.

DAIRY SCIENCE

W. A. King, Head, Department of Dairy Science

Courses are offered leading to the Master of Agriculture and Master of Science degrees. The Doctor of Philosophy degree is offered in Animal Physiology and in Nutrition on an interdepartmental basis.

Dy Sc 602—DAIRY MANUFACTURES—4 cr. (3 and 3)

Dy Sc 604—PLANT MANAGEMENT—3 cr. (2 and 3)

Dy Sc 606—THE CHEMICAL AND PHYSICAL NATURE OF MILK— 3 cr. (2 and 3)

Dy Sc 607—MARKET MILK—3 cr. (2 and 3)

Dy Sc 652—DAIRY CATTLE FEEDING AND MANAGEMENT—3 cr. (2 and 3)

Dy Sc 653—ANIMAL REPRODUCTION—3 cr. (3 and 0)

Dy Sc 655—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3)

Dy Sc 801—TOPICAL PROBLEMS—1-3 cr. (1-3 and 0)

Topics of interest to the graduate student. The course is designed to give experience with problems in dairying not covered by thesis research. Credit varies with the problems selected.

Dy Sc 802—GENETICS OF DAIRY CATTLE IMPROVEMENT—3 cr.
(3 and 0)

Topics include a study of inheritance in dairy cattle; improvement of economic characters through selection; results of experiments on mating systems; methods of evaluating the transmitting ability of bulls and cows; evaluating the genetic potential of young animals; and evaluation of breed association and governmental programs for the improvement of dairy cattle.

Dy Sc 803—PHYSIOLOGY OF REPRODUCTION AND MILK SECRETION
—3 cr. (3 and 0)

The effects of hormones on gametogenesis, fertilization, embryological development, pregnancy and lactation. Comparative anatomy of mammary glands and physiology of lactation in various species will be considered. Emphasis will be placed on critically evaluating the most recent scientific literature in these areas for content, experimental methods, and authors' conclusions; and on selecting a problem, reviewing related literature and writing a research proposal for solving the problem.

Dy Sc 805—NEWER KNOWLEDGE OF DAIRY NUTRITION—3 cr.
(3 and 0)

The application of the latest information on digestion, metabolism and the nutritional requirements of dairy cattle.

Dy Sc 807—FERMENTED DAIRY PRODUCTS—3 cr. (2 and 3)

The biological and chemical changes involved in the processing and aging of cheese and fermented dairy products.

Dy Sc 808—INDUSTRIAL DAIRY SCIENCE—3 cr. (3 and 0)

Provides advanced managerial training for operating dairy and food plants. Managerial policy and decision making are emphasized.

Dy Sc 891—RESEARCH—Credit to be arranged.

ENTOMOLOGY

S. B. Hays, Head, Department of Entomology and Economic Zoology

Courses are offered leading to the Master of Agriculture, Master of Science, and Doctor of Philosophy degrees.

Graduate students in Entomology may choose the M.Ag., M.S., or Ph.D. level for professional training. Students can direct their programs towards several areas of specialization. Traditional fields of taxonomy and morphology are available or other programs which include economic entomology, insect pathology, medical and veterinary entomology, insect physiology, forest entomology, insect ecology, or pest management are available.

Ent 601—INSECT PESTS OF ORNAMENTAL PLANTS AND SHADE TREES—3 cr. (2 and 3)

Ent 602—FRUIT, NUT, AND VEGETABLE INSECTS—3 cr. (2 and 3)

Ent 603—FIELD CROP INSECTS—3 cr. (2 and 3)

Ent 604—STRUCTURAL, INDUSTRIAL AND HOUSEHOLD INSECTS—3 cr. (2 and 3)

Ent 605—INSECT MORPHOLOGY—4 cr. (3 and 3)

Ent 610—INSECT TAXONOMY—3 cr. (1 and 6)

Ent 655—MEDICAL AND VETERINARY ENTOMOLOGY—3 cr. (2 and 3)

Ent 668—INTRODUCTION TO RESEARCH—2 cr. (1 and 3)

Ent 669—AQUATIC INSECTS—3 cr. (2 and 3)

Ent 670—INSECT PHYSIOLOGY—3 cr. (2 and 3)

Ent 680—INSECT PATHOLOGY—3 cr. (2 and 3)

Ent 808—TAXONOMY OF IMMATURE INSECTS—3 cr. (1 and 6)

Identification of immature insects with particular emphasis on the Holometabola. Each student will make and submit an identified collection of immature insects.

Ent 809—RECENT ADVANCES IN ENTOMOLOGY I—1 cr. (1 and 0)

A review of the current literature in the fields of entomology. Needs and changes in future research in entomology will be discussed.

Ent 810—RECENT ADVANCES IN ENTOMOLOGY II—1 cr. (1 and 0)

A continuation of Ent 809.

Ent 840—INSECT ECOLOGY—3 cr. (2 and 3)

Principles of insect ecology including population dynamics and natural regulating mechanisms of insect populations. Effect of environment on distribution and abundance of insects.

Ent 856—MEDICAL ENTOMOLOGY—3 cr. (2 and 3)

Disease vectors of animals with emphasis on insects and related Arthropod disease carriers. **Prerequisite:** Ent 301 or permission of instructor.

Ent 860—INSECT PEST MANAGEMENT—3 cr. (3 and 0)

Application of ecological principles to the management or control of insect populations. Emphasis will be placed on major factors influencing insect population fluctuations and integrated systems including biological, cultural, physical, chemical and other techniques into a unified multifaceted approach based on applied ecology.

Ent 861—INSECT TOXICOLOGY—3 cr. (2 and 3)

History, development, application, chemical nature and mode of action of insecticides. **Prerequisite:** Organic Chemistry.

Ent 863—SPECIAL PROBLEMS IN ENTOMOLOGY—3-6 cr. (3-6 and 0)

Original investigation of special problems in entomology not related to a thesis but designed to provide experience and training in research. Emphasis will be placed on insect toxicology, insect physiology, medical entomology and biological control of insects.

Ent 870—ADVANCED INSECT PHYSIOLOGY—3 cr. (2 and 3)

An in-depth study of metabolism, excretion, regulatory mechanisms, the endocrine system, pheromones, and the nervous system. Specialized topics such as insect immunity, defensive secretions, and chemicals controlling insect behavior will be discussed.

Ent 891—RESEARCH—Credit to be arranged.

Ent 991—DOCTORAL RESEARCH—Credit to be arranged.

ENVIRONMENTAL SCIENCE

R. F. Borgman, Program Coordinator

Degrees are not awarded in Environmental Science. Courses listed below are used as part of the major or minor work to support health oriented programs for students pursuing degrees in curricula such as Agronomy and Soils, Agricultural Engineering, Chemical Engineering, Environmental Systems Engineering, Entomology, Zoology, Nutrition, Physiology, and Water Resources Engineering.

En Sc 631—PUBLIC HEALTH ADMINISTRATION—3 cr. (3 and 0)

En Sc 671—MAN AND HIS ENVIRONMENT—2 cr. (2 and 0)

En Sc 672—ENVIRONMENTAL PLANNING AND CONTROL—2 cr. (2 and 0)

En Sc 893—ENVIRONMENTAL HEALTH SEMINAR I—1 cr. (1 and 0)

A discussion of current advances and research developments in the area of environmental science. Both the students and the staff will participate. **Prerequisite:** Graduate standing.

EXPERIMENTAL STATISTICS

W. P. Byrd, Chairman, Experimental Statistics and Statistical Services

Courses in Experimental Statistics are offered as support for students majoring in other areas. A minor is offered at the master's and doctoral

levels. Courses to be used to satisfy the minor should be approved at the beginning of the student's program.

Students who elect a minor at the doctoral level will be expected to demonstrate competence in the theoretical basis as well as the application of statistics.

Ex St 662—STATISTICS APPLIED TO ECONOMICS—3 cr. (3 and 0) S

Ex St 801—STATISTICAL METHODS—4 cr. (3 and 3) F, S, SS
Role and application of statistics in research including estimation, test of significance, analysis of variance, multiple comparison techniques, basic designs, mean square expectations, variance components analysis, simple and multiple linear regression and correlation, and non-parametric procedures. **Prerequisite:** Permission of instructor.

Ex St 803—REGRESSION AND LEAST SQUARES ANALYSIS—3 cr.
(3 and 0) F
Regression analysis; simple and multiple linear, curvilinear and multiple curvilinear; curve fitting; least squares and computer techniques for fitting of constants and analysis of planned experiments. **Prerequisite:** Ex St 801.

Ex St 804—SAMPLING—3 cr. (3 and 0) F
The principles of scientific sampling; finite population sampling; simple random, stratified, multistage, and systematic sampling; optimum allocation: and methods of obtaining, processing and reporting survey information. Sampling as related to the environment, natural resources, and social and economic problems will be considered. **Prerequisite:** Ex St 801.

Ex St 805—DESIGN AND ANALYSIS OF EXPERIMENTS—3 cr.
(3 and 0) S
Review of the basic designs and analysis; data transformations; single degree of freedom, orthogonality, and responses in ANOVA; covariance; response surfaces; incomplete blocks; and introduction to least squares analysis of experiments. Uses of standard computer programs for selected analyses will be considered. **Prerequisite:** Ex St 801.

FOOD SCIENCE

W. P. Williams, Head, Department of Food Science

Advanced degrees are not awarded in Food Science. Courses may be taken as a minor or to supplement a major in other fields.

Fd Sc 601—FOOD CHEMISTRY I—4 cr. (3 and 3)

Fd Sc 602—FOOD CHEMISTRY II—4 cr. (3 and 3)

Fd Sc 620—SPECIAL TOPICS IN FOOD SCIENCE—1-3 cr. (1-3 and 0)

Fd Sc 622—QUALITY ASSURANCE AND SENSORY EVALUATION—
2 cr. (2 and 0)

Fd Sc 624—QUALITY ASSURANCE AND SENSORY EVALUATION
LABORATORY—1 cr. (0 and 3)

GENETICS

G. R. Craddock, Head, Department of Agronomy and Soils

Advanced degrees are not awarded in genetics. Courses are offered as a minor for students majoring in other areas.

Gen 602—GENETICS—4 cr. (3 and 3) F, S, SS

Gen 651—GENETICS—3 cr. (3 and 0) F

Gen 661—BIOMETRICAL GENETICS—3 cr. (3 and 0)

Gen 801—CYTOGENETICS—3 cr. (2 and 3) S, even numbered years.

A study of the classical and contemporary problems of chromosome structure, behavior and transmission. Topics will include recombination, interspecific hybridization, euchromatin and heterochromatin, polyploidy, mutable genetic systems, and structural and numerical aberrations of chromosomes and the effects upon breeding systems of plants and animals. **Prerequisite:** Gen 302 or equivalent.

Gen 806—SPECIAL PROBLEMS IN GENETICS—1-3 cr. (0 and 3-9)

Investigation of special problems in genetics not related to a thesis but designed to provide experience and training in research.

HORTICULTURE

T. L. Senn, Head, Department of Horticulture

Courses are offered leading to the Master of Agriculture and Master of Science degrees. The Doctor of Philosophy degree is offered in the area of Plant Physiology on an interdepartmental basis.

Graduate study in horticulture is designed to acquaint the student with the important biological principles underlying the production and post-harvest physiology and handling of horticultural crops. This includes not only the study of the economic product prior to harvest, but also through its harvesting, storage, marketing and processing. Scientific knowledge obtained in horticultural research as well as that available in the related fields of botany, plant physiology, biochemistry and genetics serve to give the student a broad base for future work in his chosen field.

Graduate study is carried on in pomology, vegetable crops, floriculture and ornamental horticulture, hortitherapy, and postharvest physiology and handling, as well as plant physiology at the doctoral level. Prior to admission for graduate work, acceptable courses on the undergraduate level are recommended. While students need not major in horticulture as undergraduates, deficiencies in this respect must be made up by taking courses as directed by the departmental advisers and the graduate committee of the Department of Horticulture.

Hort 605—NUT TREE CULTURE—2 cr. (2 and 0) F, even numbered years.

Hort 606—NURSERY TECHNOLOGY—3 cr. (2 and 3) S

Hort 607—LANDSCAPE DESIGN—3 cr. (2 and 3) F

Hort 608—FLORAL DESIGN AND RETAIL MARKETING—2 cr. (1 and 3)

Hort 610—FLORICULTURE—3 cr. (2 and 3) S

Hort 612—TURF MANAGEMENT—3 cr. (2 and 3) F

Hort 613—ADVANCED TURFGRASS CULTURE—3 cr. (3 and 0), S

Hort 651—SMALL FRUIT CULTURE—3 cr. (2 and 3) S

Hort 652—COMMERCIAL POMOLOGY—3 cr. (2 and 3) F

Hort 656—VEGETABLE CROPS— 3 cr. (3 and 0) S, odd numbered years.

Hort 661—PROBLEMS IN LANDSCAPE DESIGN—3 cr. (2 and 3), F

Hort 662—LANDSCAPE DESIGN IMPLEMENTATION—3 cr. (2 and 3), S

Hort 664—POSTHARVEST HORTICULTURE—3 cr. (2 and 2) F

Hort 668—INTRODUCTION TO RESEARCH—2 cr. (1 and 3) S

Hort 670—HORTICULTURAL THERAPY—3 cr. (3 and 0)

Hort 801—PROBLEMS IN SMALL FRUIT PRODUCTION—3 cr. (3 and 0) F, odd numbered years.

A study of selected problems encountered in the production of blueberries, strawberries, brambles and grapes.

Hort 802—RESEARCH SYSTEMS IN HORTICULTURE—3 cr. (2 and 3) F

A study of current trends, developments, and techniques in horticultural research. **Prerequisites:** Ch 223, 227 or Ch 201 and Phys 207, or Bioch 210.

Hort 803—EXPERIMENTAL OLERICULTURE—3 cr. (3 and 0) F, even numbered years.

A systematic study of sources of information on research developments in vegetable crops.

Hort 804—SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICUL-
TURE—3 cr. (3 and 0) S, odd numbered years.

Discussions on topics from scientific periodicals and on other research and current developments in ornamental horticulture.

Hort 805—PHYSIOCHEMICAL PROCEDURES FOR DETERMINING
QUALITY IN HORTICULTURAL CROPS—3 cr. (2 and 3) F,
even numbered years.

Subject matter will include the study of special titrations, organoleptic evaluations, refractory, colorimetry, and quality evaluations with succulometers and texturometers. The effect of acids, sugars, salts, and other chemical constitutents on quality of horticultural crops will be evaluated.

Hort 806—POSTHARVEST PHYSIOLOGY AND HANDLING OF HORTI-
CULTURAL CROPS—3 cr. (3 and 0) S, even numbered years.

Principles, developments, and application of research findings dealing with the physiology of maturation and storage of horticultural crops are emphasized. A concept of quality is formed through a study of the factors affecting physical and biological changes occurring in horticultural crops. **Prerequisite:** Bot 421.

Hort 807—POMOLOGY—3 cr. (3 and 0) S, odd numbered years.

A study of the growth and development of deciduous fruits with emphasis on the peach and apple. **Prerequisite:** Hort 352.

Hort 808—SPECIAL INVESTIGATIONS IN HORTICULTURE— 2 cr.
(2 and 0) S, SS

Special research investigations in horticulture not related to a thesis, but designed to provide opportunities for research experience and training. **Prerequisite:** Hort 802 or 805.

Hort 809—SEMINAR I—1 cr. (1 and 0) F

A review of current topics in horticulture with special emphasis on the preparation, organization, and presentation of material by the students.

Hort 810—SEMINAR II—1 cr. (1 and 0) S

A continuation of Hort 809.

Hort 811—QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT—
2 cr. (1 and 3) S, even numbered years.

Principles and application of quantitative morphology and crop production analysis. Techniques for visually detecting minute daily changes in plant development are studied and formulated. Graphic and statistical evaluation is made of the influence of specific environmntal factors and their interactions on plant development. Practical and theoretical applications of the derived systems of observation and analysis are considered.

Hort 891—RESEARCH—Credit to be arranged. F, S, SS

Hort 991—DOCTORAL RESEARCH—Credit to be arranged. F, S, SS

NUTRITION

W. A. King, Head, Department of Dairy Science

D. E. Turk, Program Coordinator

Courses are offered leading to the Master of Nutritional Science, Master of Science, and Doctor of Philosophy degrees.

Nutrition is an interdisciplinary program encompassing four departments: Animal Science, Dairy Science, Food Science and Poultry Science. Nutritionists from those departments form the faculty that teach the nutrition courses listed below. Students enrolling in the program will be expected to have had sound undergraduate training in the biological and physical sciences. Students with deficiencies may be admitted, however, if they correct their deficiencies by completing the appropriate courses. A student's program of study will include a core of basic courses in nutrition, biochemistry, and physiology. Additional course work can be taken in areas of special interest. For the M.S. and Ph.D. degrees, a student will complete an original research project and submit a theisis or dissertation respectively. The subject may deal with human, labatory or domestic animal nutrition.

Students enrolling for a degree in nutrition will choose from courses listed below and from others deemed appropriate by the Advisory Committee.

An Ph 802—DIGESTIVE AND EXCRETORY PHYSIOLOGY—3 cr. (2 and 3)

An Ph 803—CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY— 4 cr. (3 and 3)

An Ph 804—MUSCLE AND NERVE PHYSIOLOGY—4 cr. (3 and 3)

An Sc 805—NUTRITION OF MEAT ANIMALS—3 cr. (3 and 0)

Bioch 606—PHYSIOLOGICAL CHEMISTRY—3 cr. (3 and 0) S

Bioch 608—PHYSIOLOGICAL CHEMISTRY LABORATORY—1 cr. (3 and 0)

Bioch 815—LIPIDS AND BIOMEMBRANES—3 cr. (3 and 0)

Bioch 817—CHEMISTRY AND METABOLISM OF HORMONES—3 cr. (3 and 0)

Bioch 822—ENZYMES—3 cr. (3 and 0)

Bioch 823—CARBOHYDRATES—2 cr. (2 and 0)

Dy Sc 805—NEWER KNOWLEDGE OF DAIRY NUTRITION—3 cr.
(3 and 0)

PS 651—POULTRY NUTRITION—2 cr. (2 and 0)

Nutr 601—FUNDAMENTALS OF NUTRITION—3 cr. (3 and 0)

Nutr 625—NUTRITION AND DIETETICS—3 cr. (3 and 0)

Nutr 651—HUMAN NUTRITION—3 cr. (3 and 0)

Nutr 652—CLINICAL NUTRITION—3 cr. (3 and 0)

Nutr 701—THERAPEUTIC NUTRITION—3 cr. (3 and 0)

The study of the interrelationship of the pathological, physiological, and metabolic alterations produced by various disease states and body nutrient status. Included is the application of current practices in nutritional therapy and dietary management in the treatment of the diseases discussed.

Nutr 702—PUBLIC HEALTH NUTRITION—3 cr. (3 and 0)

The improvement of the dietary practices of the general population. Particularly, the application of nutritional principles to the problems of disease and infection.

Nutr 703—NUTRITION EDUCATION—3 cr. (3 and 0)

Methods of instruction appropriate for varied age and educational levels, including preparation and use of visual aids. Cultural patterns in food use as related to nutrition improvement programs for various population groups are discussed.

Nutr 704—FOOD SERVICE SYSTEMS—3 cr. (3 and 0)

A study of volume feeding systems and their relationship to food quality, food acceptance, sanitation and materials selection. An introduction to physical plant layout, management structure, food flow dynamics and computer-assisted diet formulation and accounting in various feeding systems.

Nutr 705—FIELD TRAINING IN NUTRITION—6 cr. (6 and 0)

Supervised training to provide experience in outlining important aspects of practical nutrition situations, and preparing plans to bring about desired improvements or changes.

Nutr 801—TOPICAL PROBLEMS IN NUTRITION—1-3 cr. (1-3 and 0)

Topics of interest to graduate students in various fields of nutrition. This course is designed to give experience in nutrition not covered by other courses or by thesis research. Credit varies with problems selected.

Nutr 808—MONOGASTRIC NUTRITION—3 cr. (3 and 0)

Basic concepts and current research related to nutrient requirement and metabolism of poultry, swine, and other monogastric species.

Nutr 809—POLYGASTRIC NUTRITION—3 cr. (3 and 0)

Microbiological, biochemical and physiological processes of digestion with special attention to synthesis of amino acids and proteins, B-vitamins, and the relation of such processes to digestion of proteins, lipids and fibrous and non-fibrous feed ingredients. Properties and functions of nutrients for dairy and beef cattle, sheep, and horses. Nonprotein nitrogen compounds and growth-promoting substances are emphasized.

Nutr 812—METABOLISM OF NUTRIENTS—3 cr. (3 and 0)

The metabolism of nutrients as applicable to mammals and birds is discussed. The role of nutrients in metabolic pathways and the effects of deficiences upon these pathways are included. The role of nutrition in metabolic diseases is emphasized. **Prerequisite:** General biochemistry and nutrition.

Nutr 813—NUTRITION TECHNIQUES WITH LARGE ANIMALS—2 cr.
    (1 and 3)

In vivo and in vitro methods for evaluating nutrient utilization in beef and dairy cattle, sheep, swine, and horses.

Nutr 814—NUTRITION TECHNIQUES WITH LABORATORY ANIMALS
    —2 cr. (1 and 3)

Nutritional techniques employing small laboratory animals. Metabolism and nutrient deficiencies are studied. To be taken concurrently with Nutr 812 or later.

Nutr 816—AMINO ACIDS AND PROTEIN NUTRITION—2 cr. (2 and 0)

Nutrition of the amino acids, nonprotein nitrogen, and proteins as related to humans and domestic animals. Essentiality, interrelationships, and metabolism of amino acids are emphasized.

Nutr 818—VITAMINS AND MINERALS—4 cr. (3 and 3)

Dietary vitamins and mineral requirements of humans and domestic animals. Laboratory materials include development of nutritional imbalances and chemical and biological assays of nutrients. **Prerequisite:** General biochemistry and nutrition.

Nutr 851—NUTRITION SEMINAR I—1 cr. (1 and 0) F

Major topics will be current research and developments in nutrition. Both student research and nutrition literature will be discussed. Topics are selected by the instructor and students.

Nutr 852—NUTRITION SEMINAR II—1 cr. (1 and 0) S
    A continuation of Nutr 851.

Nutr 891—RESEARCH—Credit to be arranged. F, S, SS

(May be taken more than one semester).

Nutr 991—DOCTORAL RESEARCH—Credit to be arranged. F, S, SS
    (May be taken more than one semester).

PLANT PATHOLOGY

W. M. Epps, Head, Department of Plant Pathology and Physiology

Courses are offered leading to the Master of Agriculture, Master of Science, and Doctor of Philosophy degrees.

Students who desire to pursue graduate work in plant pathology should have sound undergraduate training in the biological and physical sciences, especially botany and chemistry. This training may be obtained in an undergraduate curriculum in botany, microbiology, biology, chemistry, or one of the agricultural plant sciences such as agronomy, forestry, or horticulture. Undergraduate courses in plant pathology are desirable but not essential.

Pl Pa 601—PLANT PATHOLOGY—3 cr. (2 and 3) F, S

Pl Pa 605—FOREST PATHOLOGY—3 cr. (2 and 3) F

Pl Pa 651—BACTERIAL PLANT PATHOGENS—3 cr. (2 and 3) S, odd numbered years.

Pl Pa 656—PLANT VIROLOGY—3 cr. (3 and 0) S, even numbered years.

Pl Pa 658—PLANT PARASITIC NEMATODES—3 cr. (2 and 3) F, odd numbered years.

Pl Pa 800—ADVANCED PLANT PATHOLOGY I—3 cr. (3 and 0) F, odd numbered years.

The economic and social importance and history of plant pathology. The reproduction, genetics and variability of the major groups of plant pathogens. The infection process, the response of the host to infection, and the effects of the environment on disease development. **Prerequisite:** Pl Pa 601 or 605.

Pl Pa 801—ADVANCED PLANT PATHOLOGY II—3 cr. (3 and 0) S, even numbered years.

The epidemiology and control of plant diseases, including a practical and theoretical coverage of chemical, physical, and biological means of plant disease control. **Prerequisites:** Pl Pa 601 or 605; organic chemistry.

Pl Pa 804—PHYSIOLOGICAL PLANT PATHOLOGY—3 cr. (3 and 0) F, even numbered years.

This course is designed to acquaint the student with the interaction of pathogen and host in the development of plant diseases. Emphasis will be given to the factors that influence infection and the development of the pathogen within the host. **Prerequisites:** Bot 621; Pl Pa 601 or 605; organic chemistry.

Pl Pa 805—SPECIAL PROBLEMS IN PLANT PATHOLOGY—Credit to
be arranged. F, S, SS

Original investigation of special problems in plant pathology which are
not related to a thesis but designed to provide experience and training in
research. **Prerequisite:** Permission of instructor.

Pl Pa 807—SEMINAR—1 cr. (1 and 0) F

A study of areas of plant pathology and plant physiology not covered
by formal courses, with special emphasis on the review of literature, and
organization and presentation of material by students.

Pl Pa 808—TECHNIQUES AND METHODS IN PLANT PATHOLOGY I—
1 cr. (0 and 3) F, even numbered years.

An introduction to the techniques and methods used in research in plant
pathology. **Prerequisites:** Pl Pa 601 or 605 or concurrent registration in
Pl Pa 601 or 605.

Pl Pa 809—TECHNIQUES AND METHODS IN PLANT PATHOLOGY II—
1 cr. (0 and 3) S, odd numbered years.

A continuation of Pl Pa 808 with emphasis on more advanced methods
and techniques. **Prerequisites:** Organic chemistry; Pl Pa 601 or 605;
Pl Pa 808 or permission of instructor.

Pl Pa 811—PLANT DISEASE DIAGNOSIS I— 1 cr. (0 and 3) SS, odd num-
bered years.

A comprehensive study of procedures used in the diagnosis of plant
diseases, followed by practice in the diagnosis of all types of diseases of
cultivated and wild plants. Emphasis on diseases of spring and early sum-
mer. **Prerequisite:** Pl Pa 601 or 605 or permission of instructor.

Pl Pa 812—PLANT DISEASE DIAGNOSIS II—1 cr. (0 and 3) SS, even
numbered years.

A comprehensive study of procedures used in the diagnosis of plant
diseases followed by practice in the diagnosis of all types of diseases of
cultivated and wild plants. Emphasis on diseases of mid-summer. **Pre-
requisites:** Pl Pa 601 or 605 or permission of instructor.

Pl Pa 891—RESEARCH—Credit to be arranged.

Pl Pa 991—DOCTORAL RESEARCH—Credit to be arranged.

PLANT PHYSIOLOGY

W. M. Epps, Head, Department of Plant Pathology and Physiology

Courses are offered leading to the Doctor of Philosophy degree.

Graduate work in Plant Physiology encompasses the Departments of
Agronomy and Soils, Horticulture, and Plant Pathology and Physiology

in the College of Agricultural Sciences and the Departments of Botany and Microbiology in the College of Sciences. A student may select courses and his major area of study in any one of the above departments.

Agron 608—SOIL AND PLANT ANALYSIS—3 cr. (1 and 6)

Agron 652—SOIL FERTILITY AND MANAGEMENT—2 cr. (2 and 0)

Agron 801—CROP PHYSIOLOGY AND NUTRITION—3 cr. (3 and 0)

Agron 805—SOIL FERTILITY—3 cr. (3 and 0)

Agron 807—SOIL PHYSICS—3 cr. (2 and 3)

Agron 808—SOIL CHEMISTRY—3 cr. (2 and 3)

Agron 812—CROP ECOLOGY AND LAND USE—3 cr. (3 and 0)

Agron 820—PESTICIDE RESIDUES IN THE ENVIRONMENT—3 cr. (3 and 0)

Agron 991—DOCTORAL RESEARCH—Credit to be arranged.

Bot 621—PLANT PHYSIOLOGY—4 cr. (3 and 3)

Bot 821—INORGANIC PLANT METABOLISM—4 cr. (3 and 3)

Bot 822—ORGANIC PLANT METABOLISM—3 (3 and 0)

Bot 823—PLANT GROWTH & DEVELOPMENT—3 cr. (3 and 0)

Bot 824—MODE OF ACTION OF GROWTH SUBSTANCES—4 cr. (3 and 3)

Bot 826—PHYSIOLOGY OF THE FUNGI—3 cr. (3 and 0)

Bot 991—DOCTORAL RESEARCH—Credit to be arranged.

Hort 801—PROBLEMS IN SMALL FRUIT PRODUCTION—3 cr. (3 and 0)

Hort 803—EXPERIMENTAL OLERICULTURE—3 cr. (3 and 0)

Hort 804—SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICUL-TURE—3 cr. (3 and 0)

Hort 805—PHYSIOCHEMICAL PROCEDURES FOR DETERMINING QUALITY IN HORTICULTURAL CROPS—3 cr. (2 and 3)

Hort 806—POSTHARVEST PHYSIOLOGY AND HANDLING OF HORTICULTURAL CROPS—3 cr. (3 and 0)

Hort 807—POMOLOGY—3 cr. (3 and 0)

Hort 811—QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT —2 cr. (1 and 3)

Hort 991—DOCTORAL RESEARCH—Credit to be arranged.

Micro 612—BACTERIAL PHYSIOLOGY—4 cr. (3 and 3)

Micro 614—BASIC IMMUNOLOGY—3 cr. (2 and 3)

Micro 811—BACTERIAL CYTOLOGY AND PHYSIOLOGY—4 cr. (4 and 0)

Micro 812—BACTERIAL METABOLISM—3 cr. (3 and 0)

Micro 813—BACTERIAL CYTOLOGY AND PHYSIOLOGY LABORATORY—2 cr. (0 and 6)

Micro 814—BACTERIAL METABOLISM LABORATORY—2 cr. (0 and 6)

Micro 991—DOCTORAL RESEARCH—Credit to be arranged.

Pl Pa 804—PHYSIOLOGICAL PLANT PATHOLOGY—3 cr. (3 and 0)

Pl Pa 991—DOCTORAL RESEARCH—Credit to be arranged.

POULTRY SCIENCE

B. D. Barnett, Head, Department of Poultry Science

Courses are offered leading to the Master of Agriculture and Master of Science degrees.

The Doctor of Philosophy degree is offered in animal physiology and in nutrition on an interdepartmental basis.

The Master of Science degree is offered with emphasis in nutrition physiology, pathology, products technology or management. The student should have a sound background in biology. Agricultural training is helpful but not essential.

Strong research programs in the areas mentioned above provide students with a wide selection of thesis problems.

Students choosing to emphasize products technology will work in a cooperative program with the Department of Food Science.

Courses are selected from the following and from animal physiology, nutrition, and other supporting areas deemed proper by the advisory committee.

PS 601—ANIMAL ENVIRONMENTAL TECHNOLOGY—2 cr. (2 and 0) F, even numbered years.

PS 603—ANIMAL ENVIRONMENTAL TECHNOLOGY LABORATORY— 1 cr. (0 and 3) F, even numbered years.

PS 605—TOPICAL PROBLEMS—1-3 cr. (0 and 3-9)

PS 651—POULTRY NUTRITION—2 cr. (2 and 0) S, even numbered years.

PS 652—BREEDER FLOCK AND HATCHERY MANAGEMENT—3 cr. (3 and 0) F, even numbered years.

PS 653—BREEDER FLOCK AND HATCHERY MANAGEMENT LABORATORY—1 cr. (0 and 3) F, even numbered years.

PS 655—POULTRY PRODUCTS GRADING AND TECHNOLOGY—3 cr. (2 and 3) F, odd numbered years.

PS 658—AVIAN MICROBIOLOGY AND PARASITOLOGY—4 cr. (3 and 3) F, even numbered years.

PS 659—MANAGEMENT OF EGG, BROILER, AND TURKEY ENTER-PRISES—3 cr. (2 and 3) F, even numbered years.

PS 660—SEMINAR—2 cr. (2 and 0) S, odd numbered years.

PS 804—POULTRY PATHOLOGY—3 cr. (1 and 6) S, odd numbered years.

A study of the etiological agents, prophylaxis and treatment of poultry diseases. The laboratory material will include experiments in bacteriology, virology, protozoology, and immunology procedures with emphasis on the isolation and identification of disease producing agents. **Prerequisite:** PS 458/658 or permission of instructor.

PS 805—SEMINAR—1 cr. (1 and 0) F

Report on special topics or original research by students, staff and visiting speakers.

PS 891—RESEARCH—Credit to be arranged.

WILDLIFE BIOLOGY

S. B. Hays, Head, Department of Entomology and Economic Zoology

Courses are offered leading to the Master of Science degree.

Students desiring to pursue graduate work in wildlife biology should have sound undergraduate training in the biological or related sciences. Programs of study are designed to emphasize the relationship between wild animals and their changing environments. Additional course work for a major in wildlife biology is usually taken in experimental statistics, botany, zoology or other related areas. The following options are offered: upland game, warm water fisheries and marine biology.

WB 612—WILDLIFE MANAGEMENT—3 cr. (2 and 3)

WB 616—FISH CULTURE—3 cr. (2 and 3)

WB 660—BIOLOGY OF MARINE ORGANISMS—3 cr. 2 and 3)

WB 662—AQUATIC PRODUCTIVITY—3 cr. (3 and 0)

WB 809—WILDLIFE BIOLOGY I—1 cr. (1 and 0)

A review of the current literature regarding the problems encountered in applied wildlife biology.

WB 810—WILDLIFE BIOLOGY SEMINAR II—1 cr. (1 and 0)

Continuation of WB 809.

WB 815—PRINCIPLES OF WILDLIFE BIOLOGY—3 cr. (2 and 3) SS, and alternate years.

Theories and principles applicable to wildlife biology. Emphasis will be placed on upland game species.

WB 816—APPLIED WILDLIFE BIOLOGY—3 cr. (2 and 3)

Techniques and practices involved in the management of wildlife species with special reference to upland game.

WB 840—IMPOUNDMENT AND STREAM MANAGEMENT—3 cr. (2 and 3)

Principles and techniques of managing ponds and streams for sport fishing and/or commercial fishing. Emphasis is placed on trout streams, farm ponds, and reservoirs. Laboratory work includes demonstration and application of management techniques and field trips to observe other management practices. **Prerequisite:** Zool 410 and Zool 463 or permission of instructor.

WB 850—MARINE AQUACULTURE—3 cr. (3 and 0)

Basic aquacultural techniques as applied to marine organisms and problems peculiar to marine aquaculture. Past and present culture of marine organisms around the world. Survey of marine aquaculture facilities of the Southeastern U. S. **Prerequisite:** WB 416.

WB 852—PARASITES AND DISEASES OF MARINE ANIMALS—3 cr. (2 and 3)

The major groups of symbionts will be considered as causative agents of disease in marine organisms. Systematics, life cycles, and physiology will be studied as they contribute to the intimate host — symbiont relationship. A special problem will be assigned and completed during the course. **Prerequisite:** Zool 456.

WB 856—DIRECTED STUDIES AND FIELD WORK IN MARINE BIOLOGY—4 cr. (2 and 6)

Selected topics for study and investigation in marine biology will be offered while in residence at the coast (South Carolina Marine Resource Research Institute at Charleston, S. C.) in the summer. This course will

include an intensive survey of systemics and morphology of marine organisms appropriate to the students background and experimental investigations depending on the interests and intentions of the staff and the students. **Prerequisite:** Permission of the instructor(s).

WB 863—SPECIAL PROBLEMS IN WILDLIFE BIOLOGY—1-4 cr.
          (1-4 and 0)

Original investigation of special problems in wildlife biology which are not related to theisis research but designed to provide experience and training in research or specialized areas of wildlife biology. Credit varies with the problems selected. **Prerequisite:** Permission of instructor.

WB 891—RESEARCH—Credit to be arranged.

College of Architecture

H. E. McClure, Dean

The Clemson University College of Architecture provides coordinated preprofessional and professional degree programs at undergraduate and graduate levels in preparation for careers in Architecture, City and Regional Planning, and Visual Studies. These curriculums are not offered elsewhere in the state. Graduate programs leading to the degrees Master of Architecture, Master of City and Regional Planning, and Master of Fine Arts in Visual Studies are available.

The College enjoys contracts for creative research in several areas, and receives an annual support budget from the Clemson Architectural Foundation to enrich its program. It is a member of the Association of Collegiate Schools of Architecture, the Associated Schools of Construction, collaborates with the South Carolina Chapter of the American Institute of Planners, and is accredited by the National Architectural Accrediting Board, and the Association of Collegiate Schools of Planning.

The Clemson Architectural Foundation, a nonprofit corporation was established in January 1956 under the Laws of the State of South Carolina and under the sponsorship of the South Carolina Chapter of the American Institute of Architects to facilitate the continuous improvement of architectural education and of the art and technology of building in South Carolina by providing financial and other assistance to the College of Architecture at Clemson University. By this means students in the College of Architecture at Clemson have been able to enjoy instruction, facilities, and conditions of superior quality.

To further enrich its graduate offerings, the College of Architecture maintains an overseas program in Genoa, Italy, and each graduate student may spend the period of a semester and summer in that facility

ARCHITECTURE

G. B. Witherspoon, Head, Department of Architectural Studies

Courses are offered leading to the Master of Architecture degree.

The graduate program in Architecture is founded upon professional studies in depth, and research is the vehicle for environmental problem solving. Each student is offered the choice and opportunity to develop specific interests and capabilities. Optional areas of concentration include general design, building systems, health care facilities planning, urban design, housing, and building science. The professional program provides an opportunity to work with government officials, experts in other fields, and the general public, while using the region as a laboratory for research and public service. Students seek out available resources and collaborate with other professionals as particular problems may require.

Admission Requirements:

The graduate program comprises the fifth and sixth years of study in the six-year architectural curricula of the College of Architecture. Admission to the program at the fifth-year level is available to students who have completed an undergraduate course of studies in pre-architecture and are working toward the Master of Architecture as the first professional degree. Admission at the sixth-year level is available to students who have attained an undergraduate professional degree in architecture and are working toward the Master of Architecture as the second professional degree.

The following requirements for admission to the graduate program in architecture pertain only to students working toward the Master of Architecture as the first professional degree.

1. Attainment of a pre-professional degree with a major in architecture.

2. Attainment of a satisfactory academic record in the last 60 major* credit (semester) hours.

---

* Major credit hours — those which relate directly to the student's major (i.e., for Architecture majors: architectural design, art and architectural history, building science, city and regional planning, visual studies, etc.).

3. Completion of a counseling review with the Dean of the College of Architecture and the Head of the Department of Architectural Studies, including a portfolio of previous creative efforts.

4. Letters of recommendation from three of the following: the dean of the undergraduate school, an undergraduate teacher, an employer, or a personal acquaintance.

5. Completion of the Graduate Record Examination.

Requirements for Degree Candidacy:

1. Thirty (30) semester hours in the student's prescribed professional curriculum in the graduate program.

2. Work experience of a minimum of 1,000 hours in an architectural office.

Requirements for Awarding of a Degree:

1. Forty-five (45) semester hours in the student's prescribed professional curriculum, excluding a thesis or a terminal project with an overall grade point ratio of 3.0 or above.

2. Satisfactory completion of a thesis or terminal project, each of 15 credit hours, while in residence as a full-time student.

Arch 603—SEMINAR IN THE ANALYSIS AND CRITICISM OF ARCHITECTURAL AND TOWN BUILDING WORKS—3 cr. (3 and 0)

Arch 675—MECHANICAL PLANT—3 cr. (3 and 0)

Arch 676—MECHANICAL PLANT—3 cr. (3 and 0)

Arch 681—ARCHITECTURAL OFFICE PRACTICE—3 cr. (3 and 0)

Arch 682—ARCHITECTURAL OFFICE PRACTICE—3 cr. (3 and 0)

Arch 685—HEALTH CARE DELIVERY SYSTEMS AND HEALTH CARE FACILITIES SEMINAR—3 cr. (3 and 0)

Arch 688—HEALTH CARE FACILITIES PROGRAMMING TECHNIQUES—3 cr. (2 and 3)

Arch 853—ARCHITECTURAL STUDIES—6-9 cr. (0 and 18-27)

City Planning design and the development of complex building structures.

Arch 854—ARCHITECTURAL STUDIES—6-9 cr. (0 and 18-27)

Architectural and planning research and the design of complex buildings and urban groupings. **Prerequisite:** Arch 853.

Arch 857—ARCHITECTURAL STUDIES—9 cr. (0 and 27)

Urban design problems, a portion of which will be undertaken as group effort and in individual problems. **Prerequisite:** Arch 854.

Arch 859—TERMINAL PROJECT—3-15 cr. (0 and 9-45)

A special project which may be undertaken with approval of department faculty in lieu of thesis. **Prerequisite:** Arch 857.

Arch 861—CONSTRUCTION ECONOMIC SEMINAR—3 cr. (3 and 0)

Studies in urban and building economics.

Arch 881—ARCHITECTURAL STRUCTURAL SEMINAR—3 cr. (3 and 0)

The application of structural theory to the development of building systems.

Arch 882—ARCHITECTURAL STRUCTURAL SEMINAR—3 cr. (3 and 0)

Analysis of architectural structures with special emphasis on shells and space frames. **Prerequisite:** Arch 881.

Arch 883—ARCHITECTURAL STRUCTURAL SEMINAR—3 cr. (3 and 0)

The analysis of advanced structural problems as related to concurrent graduate design problems. **Prerequisite:** Arch 882.

Arch 886—HEALTH CARE FACILITIES COMPONENTS AND FUNCTIONS—3 cr. (2 and 3)

An in-depth study of the components and service functions of physical and mental health care delivery systems and facilities.

Arch 890—DIRECTED STUDIES—1-5 cr.

Comprehensive studies and research of special topics not covered in other courses. Emphasis will be placed on field studies, research activities, and current developments in architecture and planning. **Prerequisite:** Permission of faculty advisor.

Arch 891—ARCHITECTURAL THESIS—3-15 cr.

Each student will select an individual thesis problem of appropriate scope, conducting his own comprehensive research. Under approved circumstances, the thesis may be a team effort. The solution will be presented in oral, written and visual form. **Prerequisite:** Arch 854. (May be repeated for no more than 15 credits.)

Bl Sc 632—CONSTRUCTION EQUIPMENT AND FORMWORK—3 cr.
(3 and 0)

Bl Sc 675—BUILDING EQUIPMENT AND SYSTEMS—3 cr. (3 and 0)

Bl Sc 676—BUILDING EQUIPMENT AND SYSTEMS—3 cr. (3 and 0)

CITY AND REGIONAL PLANNING

G. E. Varenhorst, Head, Department of City and Regional Planning

Courses are offered leading to the Master of City and Regional Planning degree.

Admission Requirements:

1. Attainment of a Bachelor's degree from an accredited college or university.

2. Attainment of a satisfactory academic record in the last 60 major* credit hours of undergraduate work.

3. Completion of a counseling review with the Dean of the College of Architecture and the Head of the Department of Planning Studies. This review is for acceptance as well as counseling in the case of applicants from outside the College of Architecture.

4. Letters of recommendation from any three of the following: the dean of the undergraduate school, an undergraduate teacher, an employer, or a personal acquaintance.

5. Completion of the Graduate Record Examination.

Requirements for Degree Candidacy:

1. Thirty (30) hours of study in the student's prescribed professional curriculum in the graduate studies program.

2. A minimum of three months internship in an approved public or private planning agency.

---

* Major credit hours — those which relate directly to the student's major (i.e., for architecture majors: architectural design, art and architectural history, building science, city and regional planning, visual studies, etc.).

Requirements for Awarding of a Degree:

1. A minimum of 51 hours of study in the student's prescribed professional curriculum, excluding a thesis or a terminal project.

2. Satisfactory completion of a 9 credit planning thesis or terminal project while in residence as a full-time student.

CRP 611—INTRODUCTION TO CITY AND REGIONAL PLANNING—
3 cr. (3 and 0)

CRP 612—CITY AND REGIONAL PLANNING THEORY—3 cr. (3 and 0)

CRP 621—URBAN SOCIAL STRUCTURE—1-3 cr. (1-3 and 0)

CRP 641—HISTORY OF PLANNING—3 cr. (3 and 0)

CRP 672—IMPLEMENTATION OF THE LOCAL PLANNING PROCESS
—3 cr. (3 and 0)

CRP 673—GOVERNMENT AND PLANNING LAW—3 cr. (3 and 0)

CRP 683—SEMINAR ON PLANNING COMMUNICATION—2 cr. (2 and 0)

CRP 821—INTERGOVERNMENTAL RELATIONS IN THE PLANNING
PROCESS—1-3 cr. (1-3 and 0)

This course is designed to provide an understanding of the operations, structure, and review procedures between local, state, and multi-state agencies and the federal government, as well as the techniques of regional delineation and areal problems in governmental planning operations. **Prerequisite: CRP 611.**

CRP 822—URBAN SYSTEMS—3 cr. (3 and 0)

An analysis of the past and present urban, social, economic, and political systems and their future applications.

CRP 831—ECONOMICS OF LAND USE PLANNING—3 cr. (3 and 0)

A study of cost factors relating to the development and redevelopment of land.

CRP 853—INTRODUCTION TO PLANNING STUDIO—3 cr. (0 and 9)

An introductory laboratory experience in the process of problem solving utilized in comprehensive planning. Involves steps of study design, analysis, policy advising, and preparation of alternatives for general planning problem solving. Emphasis is placed on plans for physical development.

CRP 854—PLANNING STUDIO II—3 cr. (0 and 9)

Refinement and elaboration of the planning problem solving process with emphasis on concepts, policies, and applications of programming and

implementation techniques within a governmental framework. This studio advances to more complex problems than Studio I.

CRP 863—PLANNING STUDIO III—3-6 cr. (0 and 9-18)

Planning studies involving small or medium-sized cities and regions. These include evaluation of community goals and objectives, appropriate surveys and projects, and development of comprehensive planning alternatives or suitable planning projects. Work with available data, planning professionals, and preparation of a comprehensive plan, reflective and responsive to community needs.

CRP 865—PLANNING STUDIO IV—3-9 cr. (0 and 9-27)

This studio is a continuation of CRP 863.

CRP 881—SEMINAR IN QUANTITATIVE METHODS I—3 cr. (3 and 0)

An examination of the potentials and limitations of data, statistical methods, operations research, electronic data processing and other methods used in City and Regional Planning. Techniques and methods of interpretation will be introduced through lectures, visiting speakers, student reports and field trips.

CRP 882—SEMINAR IN QUANTITATIVE METHODS II—3 cr. (3 and 0)

A continuation of CRP 881.

CRP 884—PUBLIC FACILITY PLANNING—3 cr. (3 and 0)

An examination of the problems inherent in the planning and design of public facilities such as community water and sanitation systems.

CRP 885—CAPITAL IMPROVEMENTS PROGRAMMING—3 cr. (3 and 0)

This course is a continuation of CRP 884 and deals with the budget process, budgeting for capital improvements and studying sources of revenue. In addition, a detailed study of the local tax base, general obligation and revenue bonds, revenue certificates, interest, sinking funds and amortization schedules, and other relevant subjects are covered. Federal, state, local, and private funding will be studied as these sources relate to long-term financing of capital improvements.

CRP 890—DIRECTED STUDIES IN CITY AND REGIONAL PLANNING —1-5 cr.

Special studies in which a student may pursue individual professional interests under the guidance of the graduate faculty of the City and Regional Planning Program.

CRP 891—PLANNING THESIS—3-9 cr.

The student, working individually, will carefully program a planning problem of appropriate scope and conduct his own comprehensive research. He will make a complete oral, written, and, where appropriate, a visual presentation of his thesis. **Prerequisite:** Permission of faculty.

CRP 893—CITY AND REGIONAL PLANNING INTERNSHIP—3 cr.

One and one-half months professional employment under competent supervision in an approved planning office or agency. During the internship the student will submit monthly reports covering his experience. **Prerequisite:** Two semesters of city and regional planning courses or its equivalent and CRP 893.

CRP 894—CITY AND REGIONAL PLANNING INTERNSHIP—3 cr.

One and one-half months professional employment under competent supervision in an approved planning office or agency. During the internship the student will submit monthly reports covering his experience. **Prerequisite:** Two semesters of city and regional planning courses or its equivalent and CRP 893.

VISUAL STUDIES

T. E. McPeak, Head, Department of History and Visual Studies

Courses are offered leading to the Master of Fine Arts degree.

Admission Requirements:

The graduate program in visual studies leading to the Master of Fine Arts degree admits a limited number of talented and creative professional candidates on a competitive basis.

1. Attainment of a bachelor's degree from an accredited college or university with a major in a visual arts area (B.F.A.), or a liberal arts or science degree, or an undergraduate major in architecture or fine arts. Especially well-qualified persons may be accepted from other degree backgrounds.

2. Attainment of a satisfactory academic record in the last 60 major* credit hours of undergraduate work.

3. Completion of a counseling review with the Head of the Department of History and Visual Studies and an admissions committee. The review of creative work accomplished by the candidate should be in one or more of the following: ceramics, cinematography, painting, sculpture, printmaking, graphic design, drawing, photography, multimedia.

---

* Major credit hours — those which relate directly to the student's major (i.e., for architecture majors: architectural design, art and architectural history, building science, city and regional planning, visual studies, etc.).

79

4. Letters of recommendation are preferred from three of the following: dean of undergraduate school, a former major professor, a producing artist, or a personal acquaintance. Other letters of recommendation will be accepted.

Requirements for Degree Candidacy:

1. The prospective candidate must have a review of his or her work at the end of each semester. It will be determined at this time if the student should continue or whether additional study is required at either the undergraduate or graduate level.

2. Completion of 30 semester hours and a full-time residency during the second year of study.

Requirements for Awarding of a Degree:

1. A minimum of 60 credit hours of study in the student's professional curriculum including thesis. Forty-eight (48) hours are required in studio art and 12 hours are required in the History of Art and Architectural History.

2. Satisfactory completion of a written documentary of the "thesis show" and an oral examination by the Graduate Committee.

3. Completion of a 15 credit hour thesis.

AAH 611—DIRECTED RESEARCH IN ART HISTORY—3 cr. (3 and 0)

AAH 612—DIRECTED RESEARCH IN ART HISTORY—3 cr. (3 and 0)

AAH 613—20th CENTURY VISUAL ARTS—3 cr. (3 and 0)

AAH 815—HISTORY SEMINAR I— 3 cr. (3 and 0)
Detailed studies of some particular aspect or period. **Prerequisite:** Permission of the instructor.

AAH 816—HISTORY SEMINAR II—3 cr. (3 and 0)
Continuation of AAH 815.

Vis 605—DRAWING—3 cr. (0 and 9)

Vis 606—DRAWING—3 cr. (0 and 9)

Vis 607—PAINTING—3 cr. (0 and 9)

Vis 608—PAINTING—3 cr. (0 and 9)

Vis 609—SCULPTURE—3 cr. (0 and 9)

Vis 610—SCULPTURE—3 cr. (0 and 9)

Vis 611—PRINTMAKING—3 cr. (0 and 9)

Vis 612—PRINTMAKING—3 cr. (0 and 9)

Vis 613—PHOTOGRAPHY—3 cr. (0 and 9)

Vis 614—PHOTOGRAPHY—3 cr. (0 and 9)

Vis 615—GRAPHIC DESIGN—3 cr. (0 and 9)

Vis 616—GRAPHIC DESIGN—3 cr. (0 and 9)

Vis 617—ADVANCED CERAMIC ARTS—3 cr. (0 and 9)

Vis 618—ADVANCED CERAMIC ARTS—3 cr. (0 and 9)

Vis 619—GRAPHIC DESIGN—3 cr. (0 and 9)

Vis 620—GRAPHIC DESIGN—3 cr. (0 and 9)

Vis 621—GRAPHIC DESIGN-STUDIO SEMINAR—3 cr. (0 and 9)

Vis 690—DIRECTED STUDIES—1-5 cr.

Vis 850—VISUAL ARTS STUDIO—3 cr. (0 and 9)
Concentrated and advanced work in ceramics, drawing, painting, print-making, sculpture, photography, graphic design or multimedia. **Prerequisite:** MFA majors only.

Vis 851—VISUAL ARTS STUDIO—3-6 cr.
Continuation of Vis 850. May be repeated for credit when total does not exceed the maximum. **Prerequisite:** Vis 850. MFA majors only.

Vis 870—VISUAL ARTS STUDIO—6 cr. (1 and 15)
Advanced theory, directed research in art criticism, applied work in ceramic arts, drawing, painting, sculpture, photography, graphic design, or multimedia. **Prerequisite:** Vis 851. MFA majors only.

Vis 871—VISUAL ARTS STUDIO—3-6 cr.
Continuation of Vis 870. May be repeated for credit when total does not exceed the maximum. **Prerequisite:** Vis 870. MFA majors only.

Vis 880—VISUAL ARTS STUDIO—3-15 cr.
Continuation of Vis 871. May be repeated for credit when total does not exceed the maximum. **Prerequisite:** Vis 871. MFA majors only.

Vis 891—VISUAL ARTS THESIS—3-15 cr.
May be repeated for credit when total does not exceed the maximum. **Prerequisite:** Vis 880.

College of Education

H. F. Landrith, Dean

The College of Education offers a professional program leading to the degrees Master of Education, Master of Agricultural Education, Master of Industrial Education, and the Specialist in Education certificate.

The graduate program is designed to provide a combination of professional and major field content to prepare students to intellectually and efficiently perform the duties required in the areas of concentration, encourage students to continue to develop in their professional fields, and enable them to meet the standards recommended by agencies in specific programs.

Individuals involved in elementary and secondary education (including industrial and agricultural education), educational media, higher education, agricultural extension, and other agricultural business and industry are being served.

PROGRAM OF STUDY

A minimum of 30 semester hours, at least 15 of which are numbered 700 or above, are required for all programs. In addition to such supplementary or supporting courses as may be required, by individual departments, course work and other requirements for degrees in the College of Education are as follows:

Master of Agricultural Education. Candidates are required to complete:

1. Twenty-one (21) semester hours in the student's major field including a course in statistics and a course in research methods.

2. A minimum of nine (9) semester hours in an area of concentration outside the major field.

Master of Education. A major in **Secondary Education** is offered to high school or prospective junior college teachers in the subject

areas of English, history and government, mathematics, and natural sciences. Candidates are required to complete:

1. At least six (6) and not more than 12 hours in education.

2. A minimum of 18 hours in the area of specialization.

A major in **Personnel Services** is offered to teachers who have a valid teacher's certificate on the level in which the specialization is sought. Those interested in the junior college or post-high school technical institute where a certificate is not usually required must have appropriate experience and/or training. The areas of specialization include Guidance Counselor (Elementary School or Secondary School), Vocational Counselor, or Junior College Counselor. Candidates are required to complete:

1. A minimum of 21 hours in the area of specialization.

2. Three (3) to six (6) hours in field training at the level of specialization.

3. Three (3) to six (6) hours in statistics, research techniques or in a field related to the area of specialization.

A major in **Reading** is offered for reading specialists, consultants and/or supervisors. The 30 semester hours are prescribed by the Department of Elementary and Secondary Education.

A major in educational **Administration and Supervision** is offered to experienced teachers who wish to prepare as elementary school administrators, elementary school supervisors, secondary school administrators, or secondary school supervisors. Courses may be selected from four areas as prescribed by the Department of Elementary and Secondary Education.

A major in **Elementary Education** is offered to teachers who hold professional elementary certificates. Courses may be selected from six areas as prescribed by the Department of Elementary and Secondary Education.

Special Education. Students interested in teaching in the area of special education (emotionally handicapped, learning disabili-

ties, or mental retardation) should enroll in the Elementary Education curriculum.

Master of Industrial Education. Candidates are required to complete:

1. Eighteen (18) hours in subjects which contribute to the student's technical, administrative and/or supervisory competence.

2. Six (6) hours in research methods including a research problem.

3. Six (6) hours must be taken outside the major department.

The **Specialist in Education Certificate** is offered in school administration. The program consists of 30 semester hours beyond the master's degree which must be selected from five areas as prescribed by the Department of Elementary and Secondary Education. Admission requirements include a master's degree and an administrator's certificate.

AGRICULTURAL EDUCATION

E. T. Carpenter, Head, Department of Agricultural Education

Courses are offered leading to the Master of Agricultural Education degree.

The Master of Agricultural Education is designed for persons desiring to increase their competence in providing professional educational services in agriculture and vocational education. The program is quite flexible permitting specialization in areas of particular interest. Recipients of the degree often return to their former positions as agriculture teachers in high schools, vocational schools, technical education centers and community colleges. They are also in demand for administrative, supervisory and specialized positions in these institutions. Agricultural extension workers and many others who have educational responsibilities in the agribusiness complex will also find this program to be a valuable step in their professional development.

Ag Ed 601—METHODS IN AGRICULTURAL EDUCATION—3 cr. (2 and 3)

Ag Ed 623—CURRICULUM—2 cr. (2 and 0)

Ag Ed 625—TEACHING AGRICULTURAL MECHANICS—2 cr. (1 and 3)

Ag Ed 631—METHODS IN ENVIRONMENTAL EDUCATION—
3 cr. (3 and 0)

Ag Ed 663—ADVANCED CONSERVATION EDUCATION—3 cr. (3 and 0)

Ag Ed 665—PROGRAM AND CURRICULUM DEVELOPMENT—3 cr.
(3 and 0)

Ag Ed 667—ADULT EDUCATION IN AGRICULTURE—3 cr. (2 and 3)

Ag Ed 726—AGRICULTURAL MECHANIZATION FOR INSERVICE
TEACHERS—3 cr. (3 and 0)
Development of teaching materials, course construction and curriculum
design in Agricultural Mechanics. Procedures and processes for imple-
menting a new course in Agricultural Mechanics at the high school level.

Ag Ed 727—AGRICULTURAL EDUCATION SHOP MANAGEMENT—
3 cr. (1 and 6)
Basic processes and tools used in repair, maintenance and construction
of farm equipment. Emphasis will be on shop management and the
methods of teaching technical skills. Application of shop principles to
the design and construction of projects in Agricultural Mechanics.

Ag Ed 736—INTERNSHIP: TEACHING—3 cr. (1 and 6)
Professional competency and program development through classroom
and participatory experiences in planning, conducting, and evaluating
educational programs.

Ag Ed 737—INTERNSHIP IN AGRIBUSINESS FIRMS—3 cr. (1 and 6)
Classroom and participatory experiences in selected agricultural busi-
nesses and industries, identifying and practicing entry-level competencies
required in selected agribusiness and natural resource management en-
terprises.

Ag Ed 803—EVALUATION IN AGRICULTURAL EDUCATION—
3 cr. (2 and 3)
Application of principles in evaluation to agricultural education. Major
emphasis on development and use of instruments for appraising educa-
tional outcomes. **Prerequisite:** Experience in agricultural education.

Ag Ed 804—SPECIAL PROBLEMS—3 cr. (2 and 3)
Planning, conducting and reporting a special problem in agricultural
education appropriate to the need of the student.

Ag Ed 805—ADMINISTRATION AND SUPERVISION IN AGRICULTUR-
AL EDUCATION—3 cr. (3 and 0)
Emphasis given to developing a philosophy of education including the
application of concepts of administration in supervising programs of agri-
cultral education. **Prerequisite:** Experience in agricultural education.

Ag Ed 815—TEACHING AGRICULTURAL AND POWER MECHANICS—
3 cr. (2 and 3)

Methods of determining course content, organizing teaching modules
in a logical sequence, equipping the shop, teaching agricultural and
power mechanics to farm and agribusiness clientele. Providing individu-
alized instruction and developing off-farm experience programs will also
be stressed.

Ag Ed 820—TEACHING YOUNG FARMERS—3 cr. (3 and 0)

Principles and practices appropriate to the solution of problems in de-
veloping and conducting instructional programs for young farmers.

Ag Ed 825—SUPERVISION OF STUDENT TEACHING—3 cr. (3 and 0)

Major emphasis is placed upon the following: (1) developing a philoso-
phy of teacher education; (2) analyzing the present teacher training pro-
gram in South Carolina, to discover problem situations to be used as a
basis for teacher-education programs; (3) determining the relative em-
phasis for each teacher to place upon the solution of the problems in the
teacher-education program; (4) projecting plans for an apprentice training
program; and (5) supervising apprentice training. **Prerequisite:** Experi-
ence in agricultural education and permission of instructor.

Ag Ed 869—SEMINAR—1-3 cr. (1-3 and 0)

Ag Ed 889—INTRODUCTION TO RESEARCH IN EDUCATION—3 cr.
(3 and 0)

Major emphasis is placed on problem selection, types of educational re-
search and the techniques employed. Use of the ERIC system is stressed
together with interpretation of research findings.

ELEMENTARY AND SECONDARY EDUCATION

M. A. King, Head, Department of Elementary and Secondary Education

J. H. Mandel, English Advisor

W. F. Steirer, History and Government Advisor

J. D. Fulton, Mathematics Advisor

F. J. Keller, Natural Science Advisor

The Department of Elementary and Secondary Education offers the
Master of Education degree with subject specialties in personnel services,
elementary education, reading, school administration and supervision,
English, history and government, mathematics and the natural sciences.

Students seeking admission to the M.Ed. programs should have: (a) A
valid teacher's certificate; or (b) at least twelve hours in professional
education.

Ed 601—THE COMMUNITY COLLEGE—3 cr. (3 and 0)

Ed 605—PRINCIPLES OF GUIDANCE—3 cr. (3 and 0)

Ed 606—HISTORY AND PHILOSOPHY OF EDUCATION—3 cr. (3 and 0)

Ed 628—THE SYSTEMS APPROACH TO EDUCATION—3 cr. (2 and 3)

Ed 629—TEACHER AS MANAGER—3 cr. (3 and 0)

Ed 631—SPECIAL INSTITUTE COURSE: EARLY CHILDHOOD EDUCA-
TION—3 cr. (3 and 0)

Ed 632—SPECIAL INSTITUTE COURSE: ELEMENTAY SCHOOL—
3 cr. (3 and 0)

Ed 633—SPECIAL INSTITUTE COURSE: SECONDARY SCHOOL—
3 cr. (3 and 0)

Ed 634—SPECIAL INSTITUTE COURSE: CURRENT PROBLEMS IN
EDUCATION—3 cr. (3 and 0)

Ed 635—SPECIAL INSTITUTE COURSE: CURRICULUM—3 cr. (3 and 0)

Ed 636—SPECIAL INSTITUTE COURSE: SUPERVISION AND ADMIN-
ISTRATION—3 cr. (3 and 0)

Ed 659—FUNDAMENTALS OF BASIC READING—3 cr. (3 and 0)

Ed 660—CURRICULUM DEVELOPMENT IN THE ELEMENTARY
SCHOOL—3 cr. (3 and 0)

Ed 661—TEACHING READING IN THE ELEMENTARY SCHOOL—
3 cr. (1 and 4)

Ed 662—READING DIAGNOSIS AND REMEDIATION—3 cr. (2 and 3)

Ed 665—SECONDARY SCHOOL CURRICULUM—3 cr. (3 and 0)

Ed 669—CHARACTERISTICS OF CHILDREN WITH EMOTIONAL
HANDICAPS—3 cr. (3 and 0)

Ed 670—CHARACTERISTICS OF CHILDREN WITH LEARNING
DISABILITIES—3 cr. (3 and 0)

Ed 671—THE EXCEPTIONAL CHILD—3 cr. (3 and 0)

Ed 672—PSYCHOLOGY OF MENTAL RETARDATION—3 cr. (3 and 0)

Ed 673—TEACHING THE MENTALLY RETARDED—3 cr. (3 and 0)

Ed 674—EDUCATIONAL PROCEDURES FOR CHILDREN WITH
EMOTIONAL HANDICAPS—3 cr. (3 and 0)

Ed 675—EDUCATIONAL PROCEDURES FOR CHILDREN WITH
LEARNING DISABILITIES—3 cr. (3 and 0)

Ed 676—PRACTICUM IN INSTRUCTION FOR EXCEPTIONAL
CHILDREN—3 cr. (1 and 4)

Ed 694—SCHOOL AND COMMUNITY RELATIONSHIPS—3 cr. (3 and 0)

Ed 697—AUDIO VISUAL AIDS IN EDUCATION—3 cr. (3 and 0)

Ed 698—TEACHING SECONDARY SCHOOL READING—3 cr. (1 and 4)

Ed 707—READING IN EDUCATION—3 cr. (3 and 0)

An individualized course in education designed to enable the student to study in an area in which appropriate courses are not being offered during a particular semester. Reading, research, and independent study are under the supervision of a faculty member. **Prerequisite:** Consent of instructor.

Ed 720—SCHOOL PERSONNEL ADMINISTRATION—3 cr. (3 and 0)

A study of school personnel selection, practices, and problems. **Prerequisites:** One administration course and three other graduate courses in education.

Ed 721—LEGAL PHASES OF SCHOOL ADMINISTRATION—
3 cr. (3 and 0)

Legal principles involved in school administration and in court actions. **Prerequisites:** One administration course and three other graduate courses in education.

Ed 722—FIELD EXPERIENCES IN SCHOOL ADMINISTRATION AND
SUPERVISION—3 cr. (2 and 3)

Provisions will be made for the student to have a practicum with an experienced administrator or supervisor. **Prerequisites:** One administration course and three graduate courses in education.

Ed 741—INTRODUCTION TO PUPIL PERSONNEL SERVICES IN
HIGHER EDUCATION—3 cr. (3 and 0)

Survey and introduction to pupil personnel services offered by institutions of higher education.

Ed 742—PSYCHOLOGY OF POST SECONDARY SCHOOL YOUTH—
3 cr. (3 and 0)

Developmental aspects of the young adult age group and its relationship to post secondary schools and training programs.

Ed 776—COLLEGE TEACHING—3 cr. (3 and 0)

Study of instructional practices, and curriculum; techniques of organizing and planning learning experiences; analysis of teaching strategies and systems.

Ed 801—SEMINAR IN HUMAN GROWTH AND DEVELOPMENT—
3 cr. (3 and 0)

Critical analysis of theory and research in human development. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

Ed 802—HUMAN DEVELOPMENT: PSYCHOLOGY OF LEARNING—
3 cr. (3 and 0)

Analysis of the major theories of the learning processes applied to human education. Each student must conduct an experiment in learning theory. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

Ed 803—ADVANCED METHODS OF TEACHING IN THE SECONDARY
SCHOOL—3 cr. (3 and 0)

The principles and practices involved in promoting effective learning in secondary schools.

Ed 804—ADVANCED METHODS OF TEACHING IN THE ELEMENTARY
SCHOOL—3 cr. (3 and 0)

Principles and practices involved in promoting effective learning in the elementary school; analysis and evaluation of educational media.

Ed 808—EDUCATIONAL TESTS AND MEASUREMENT—
3 cr. (3 and 0) S

Construction, use, and interpretation of tests, subjective and standardized. Familiarizing with measurement applications.

Ed 809—ANALYSIS OF THE INDIVIDUAL—3 cr. (3 and 0)

Experience in gathering, interpreting and utilizing data as it relates to the individual. Especially significant to counselors. **Prerequisite:** Ed 808.

Ed 810—TECHNIQUES OF COUNSELING—3 cr. (3 and 0)

A study and use of counseling techniques (such as interviewing, testing, use of cumulative files, etc.). **Prerequisite:** Ed 605.

Ed 811—SCHOOL FINANCE—3 cr. (3 and 0)

A study of school finance relative to programs, revenues, and experience.

Ed 813—EDUCATIONAL AND VOCATIONAL INFORMATIONAL SERVICE AND PLACEMENT—3 cr. (3 and 0)

Gathering, interpretating and utilizing educational, social, and occupational information. Techniques used in placement, survey, and follow-up.

Ed 814—FIELD EXPERIENCES IN ELEMENTARY SCHOOL GUIDANCE
—3 cr. (2 and 3)

Practicum designed to give experience in developing, evaluating, and reporting on a project appropriate to the particular field of interest. Open only to those seeking certification on the elementary school level. Permission of the instructor is required. **Prerequisite:** Ed 810.

Ed 815—FIELD EXPERIENCES IN SECONDARY SCHOOL GUIDANCE
—3 cr. (2 and 3)

Practicum designed to give experience in developing, evaluating, and reporting on a project appropriate to the particular field of interest. Open only to those seeking certification on the secondary school level. Permission of instructor is required. **Prerequisite:** Ed 810.

Ed 816—FIELD EXPERIENCES IN PERSONNEL SERVICES IN HIGHER EDUCATION—3 cr. (2 and 3)

Practicum designed to give experience in developing, evaluating, and reporting on a project appropriate to the particular field of interest. Open only to those entering the field of Higher Education. Permission of instructor is required. **Prerequisite:** Ed 810.

Ed 817—CLINICAL STUDIES IN COUNSELING AND GUIDANCE—
3 cr. (3 and 0)

Intensive case studies of those with psychological and educational difficulties.

Ed 818—FIELD PROBLEMS IN SCHOOL ADMINISTRATION AND SUPERVISION OF INSTRUCTION—3 cr. (2 and 3)

Application of research techniques and practices in the solution of field problems in school administration and supervision.

Ed 819—PSYCHOEDUCATIONAL EVALUATION INTERNSHIP—
3 cr. (0 and 6)

Internship designed to provide psychoeducational evaluation and counseling experiences with students in primary and elementary grades. Also includes consulting experiences with parents and teachers under the supervision of school psychologists of the Department of Elementary and Secondary Education. Open only to those seeking certification as elementary counselors or evaluators. Permission of the instructor is required.

Ed 830—TECHNIQUES OF SUPERVISION—THE PUBLIC SCHOOLS—
3 cr. (3 and 0)

Designed for teachers, supervisors, and administrators who are interested in improving, coordinating and evaluating instruction. Modern trends of supervisory practices are emphasized.

Ed 831—EVALUATION OF SECONDARY SCHOOL INSTRUCTION—
3 cr. (3 and 0)

A study of the techniques of determining the effectiveness of classroom instruction, with emphasis on curriculum.

Ed 832—EVALUATION OF INSTRUCTION IN THE ELEMENTARY SCHOOL—3 cr. (3 and 0)

A study of the devices for determining the effectiveness of instructional techniques and programs in terms of predetermined objectives.

Ed 840—RESEARCH UTILIZATION—3 cr. (3 and 0)

A course designed to acquaint users of research — administrators and practitioners in education — with the developing systems of research information, e.g., the ERIC system. Techniques for bringing research information to bear on educational problems will be emphasized.

Ed 851—ORGANIZATION AND ADMINISTRATION OF THE ELEMENTARY SCHOOL—3 cr. (3 and 0)

Leadership roles, self-images, and administrative behavior; organizational principles, patterns and trends in the elementary schools; planning, developing, and assessing the elementary programs; building and grounds management; office and business management; student activities; staff selection and development.

Ed 852—ORGANIZATION AND ADMINISTRATION OF THE SECONDARY SCHOOL—3 cr. (3 and 0)

Leadership roles, self-images, and administrative behavior; organizational principles, patterns and trends in the secondary schools; planning, developing and assessing the secondary school program; building and ground management; office management; student activities; scheduling staff selection and development.

Ed 853—ADMINISTRATION AND SUPERVISION OF SPECIAL EDUCATION—3 cr. (3 and 0)

This course is designed to acquaint principals, supervisors, directors of instruction with administrative and supervisory practices in initiating, maintaining and expanding special education programs. **Prerequisite:** 471/671, or permission of instructor.

Ed 861—ORGANIZATION AND SUPERVISION OF READING PROGRAMS—3 cr. (3 and 0)

Detailed study of supervisory problems concerned with the planning of reading programs, analysis of methods and materials of teaching, and evaluation of reading programs. **Prerequisite:** Ed 662.

Ed 862—CLINICAL RESEARCH IN READING—3 cr. (3 and 0)

Intensive analysis of reading research and literature; original investigation in such problems as development of reading skills and attitudes, clinical procedures and techniques. **Prerequisite:** Ed 662.

Ed 863—PRACTICUM IN READING—3 cr. (2 and 2)

Supervised practicum emphasizing diagnostic and remedial work with readers in the public schools. Permission of instructor is required. **Prerequisite:** Ed 662.

Ed 871—INTERPERSONAL AND GROUP RELATIONSHIPS—3 cr.
          (3 and 0)
Study of human relations, staff interaction, informal and small group processes, supervisor-teacher counseling, conducting group meetings, staff participation in decision-making, creating a climate conducive to change and success, human motivation.

Ed 881—INDIVIDUAL TESTING I—3 cr. (3 and 0)
Interpretation of the Wechsler scales with supervised practice in their administration. **Prerequisites:** Ed 801, 802, 808, 809 and permission of the instructor.

Ed 882—INDIVIDUAL TESTING II—3 cr. (3 and 0)
Interpretation of the Stanford-Binet scales with supervised practice in their administration. **Prerequisites:** Ed 801, 802, 808, 809 and permission of instructor.

Ed 890—INTRODUCTION TO RESEARCH IN EDUCATION—3 cr.
          (3 and 0)
A study of historical, descriptive, and experimental research methodology; tools of research; use of reference materials; interpretation and analysis of data; techniques of writing research reports; evaluation of source materials.

The following courses are applicable only to the Master of Education degree with emphasis in the specific subject areas. For a complete description of these courses, refer to the sections in the appropriate departments.

English

Engl 740—BLACK AMERICAN LITERATURE FOR TEACHERS—3 cr.
          (3 and 0)

Engl 751—CHILDREN'S LITERATURE FOR TEACHERS—3 cr. (3 and 0)

Engl 761—ENGLISH LITERATURE FOR TEACHERS I—3 cr. (3 and 0)

Engl 762—ENGLISH LITERATURE FOR TEACHERS II—3 cr. (3 and 0)

History and Government

Hist 715—HISTORY OF THE BLACK AMERICAN—3 cr. (3 and 0)

Hist 719—UNITED STATES HISTORY SINCE 1900—3 cr. (3 and 0)

Hist 732—MODERNIZATION OF EAST ASIA—3 cr. (3 and 0)

Hist 741—COMPARATIVE HISTORY OF THE AMERICAS—3 cr.
(3 and 0)

Soc 781—RACE RELATIONS—3 cr. (3 and 0)

Mathematics

Math 701—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS—NUMBER SYSTEMS I—3 cr. (3 and 0)

Math 702—MODERN MATHEMATICS FOR ELEMENTARY TEACHERS —NUMBER SYSTEMS II—3 cr. (3 and 0)

Math 703—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS—GEOMETRY—3 cr. (3 and 0)

Math 705—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS—ALEGBRA, PROBABILITY, AND STATISTICS —3 cr. (3 and 0)

Math 711—MODERN ALGEBRAIC CONCEPTS I—3 cr. (3 and 0)

Math 712—MODERN ALGEBRAIC CONCEPTS II—3 cr. (3 and 0)

Math 721—MATRIX ALGEBRA I—3 cr. (3 and 0)

Math 722—MATRIX ALGEBRA II—3 cr. (3 and 0)

Math 725—COMBINATORIAL MATHEMATICS FOR TEACHERS—3 cr. (3 and 0)

Math 730—MODERN GEOMETRY FOR TEACHERS—3 cr. (3 and 0)

Math 731—NON-EUCLIDEAN GEOMETRY—3 cr. (3 and 0)

Math 732—PROJECTIVE GEOMETRY—3 cr. (3 and 0)

Math 741—INTRODUCTION TO LINEAR PROGRAMMING WITH APPLICATIONS—3 cr. (3 and 0)

Math 751—FUNDAMENTAL CONCEPTS OF CALCULUS I—3 cr. (3 and 0)

Math 752—FUNDAMENTAL CONCEPTS OF CALCULUS II—3 cr. (3 and 0)

Math 761—PROBABILITY AND STATISTICS—3 cr. (3 and 0)

Math 771—NUMERICAL METHODS IN SECONDARY MATHEMATICS— 3 cr. (3 and 0)

Math 772—NUMERICAL METHODS IN SECONDARY MATHEMATICS II—3 cr. (3 and 0)

Math 781—HISTORY OF MATHEMATICS—3 cr. (3 and 0)

Math 783—THEORY OF NUMBERS—3 cr. (3 and 0)

Math 791—MATHEMATICAL PROBLEMS IN THE CURRICULUM—3 cr. (3 and 0)

Natural Sciences

Astr 704—ASTRONOMY FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Bot 701—EVOLUTIONARY BOTANY FOR TEACHERS—3 cr. (2 and 3)

Bot 702—MODERN BOTANICAL CONCEPTS FOR TEACHERS—3 cr. (3 and 0)

Ch 700—PHYSICAL SCIENCE IN ELEMENTARY SCHOOL— CHEMISTRY—3 cr. (2 and 3)

Ch 701—REVIEW OF GENERAL CHEMISTRY I—3 cr. (3 and 0)

Ch 702—CHEMISTRY FOR HIGH SCHOOL TEACHERS—3 cr. (2 and 3)

Geol 700—EARTH SCIENCE I—3 cr. (2 and 3)

Geol 750—EARTH SCIENCE II—3 cr. (2 and 3)

Phys 700—PHYSICAL SCIENCE IN ELEMENTARY SCHOOL PHYSICS —3 cr. (3 and 0)

Phys 701—PHYSICS FOR HIGH SCHOOL TEACHERS I—4 cr. (3 and 3)

Phys 702—PHYSICS FOR HIGH SCHOOL TEACHERS II—4 cr. (3 and 3)

Phys 703—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Phys 715—EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS I—4 cr. (2 and 4)

Phys 716—EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS II—4 cr. (2 and 4)

Zool 700—MODERN DEVELOPMENTS IN ZOOLOGY FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Zool 701—MAN'S IMPACT ON ECOLOGY—3 cr. (3 and 0)

Zool 702—FIELD METHODS IN ZOOLOGY FOR HIGH SCHOOL TEACHERS—3 cr. (2 and 3)

INDUSTRIAL EDUCATION

A. F. Newton, Head, Department of Industrial Education

The Department of Industrial Education offers the master of Industrial Education degree with specialization in industrial arts education, vocational-technical education, and education for industry.

In Ed 605—COURSE ORGANIZATION AND EVALUATION—3 cr.
    (3 and 0)

In Ed 608—TRAINING PROGRAMS IN INDUSTRY—3 cr. (3 and 0)

In Ed 610—SPECIAL INSTITUTE COURSE: TOPICS IN INDUSTRIAL
    EDUCATION—3 cr. (3 and 0)

In Ed 614—ELECTRONICS FOR TEACHERS—3 cr. (1 and 6)

In Ed 615—CONSTRUCTION PRACTICES—3 cr. (2 and 3)

In Ed 618—TECHNOLOGICAL CONCEPTS IN MANUFACTURING—3 cr.
    (2 and 3)

In Ed 622—HISTORY AND PHILOSOPHY OF INDUSTRIAL AND
    VOCATIONAL EDUCATION—3 cr. (3 and 0)

In Ed 625—TEACHING INDUSTRIAL SUBJECTS—3 cr. (3 and 0)

In Ed 632—ADVANCED WOODWORKING—2 cr. (1 and 3)

In Ed 635—ADVANCED INDUSTRIAL METALWORKING PRACTICES—
    3 cr. (2 and 3)

In Ed 636—ADVANCED MATERIAL FORMING—3 cr. (1 and 3)

In Ed 638—ADVANCED MACHINING—3 cr. (1 and 6)

In Ed 640—ADVANCED TECHNIQUES OF THE GRAPHIC ARTS—4 cr.
    (2 and 4)

In Ed 644—GRAPHIC ARTS PRODUCTION CONTROL—3 cr. (2 and 3)

In Ed 652—ADVANCED PROJECTS—1-6 cr.

In Ed 660—INTRODUCTION TO CAREER EDUCATION—3 cr. (3 and 0)

In Ed 696—PUBLIC RELATIONS—3 cr. (3 and 0)

In Ed 815—SEMINAR IN INDUSTRIAL EDUCATION—1 cr. (1 and 0)

A joint study and discussion by graduate students and members of the faculty of new technological and professional advances.

In Ed 820—RECENT PROCESS DEVELOPMENTS—3 cr. (3 and 0)

Consideration of new developments in production processes including ultrasonic and electrical discharge machining, high energy rate forming, precision casting methods, and recent joining techniques.

In Ed 840—SCHOOL SHOP DESIGN—3 cr. (3 and 0)

This course is designed to cover all aspects of unit shops, general shops, and comprehensive shops for schools giving vocational industrial subjects and industrial arts courses.

In Ed 845—CURRICULUM PLANNING AND DEVELOPMENT IN INDUSTRIAL EDUCATION—3 cr. (3 and 0)

Major consideration is given to curriculum construction, departmental co-ordination of subject matter with other school subjects, curriculum modification, and staff organization in curriculum development. Emphasis is given to selection and organization of course materials.

In Ed 860—CURRICULUM MATERIALS DEVELOPMENT IN INDUS-TRIAL EDUCATION—3 cr. (3 and 0)

Major consideration is given to developing instructional materials and laboratory activities appropriate to learning and reinforcing concepts taught in industrial education. This course is designed for both industrial arts and vocational-technical education majors.

In Ed 861—ADMINISTRATION AND SUPERVISION OF VOCATIONAL EDUCATION—3 cr. (3 and 0)

A study of the principles and practices of administering and supervising various types of schools and classes under the Federal vocational acts and state regulations.

In Ed 865—AMERICAN INDUSTRIES—3 cr. (3 and 0)

Major emphasis given to developing an understanding of the concepts and principles of American industry and technology. Fifteen plant visitations will supplement study of industrial organization, economics, management, production, and products. The study of American industry provides a basis for identifying Industrial Arts subject content.

In Ed 891—RESEARCH—Credit to be arranged.

In Ed 895—SPECIAL PROBLEMS I—3 cr. (3 and 0)

Directed study of special problems in the field of Industrial Education. Subject matter will vary with interests, experiences, and needs of the students.

In Ed 896—SPECIAL PROBLEMS II—3 cr. (3 and 0)

Continuation of In Ed 895.

College of Engineering

L. C. Wilcox, Dean

The College of Engineering awards advanced degrees in Agricultural Engineering, Bioengineering, Ceramic Engineering, Chemical Engineering, Civil Engineering, Electrical and Computer Engineering, Engineering Mechanics, Environmental Systems Engineering, Materials Engineering, Mechanical Engineering, Systems Engineering, and Water Resources Engineering.

In addition to the traditional M.S. and Ph.D. degrees, the professional degree, Master of Engineering, is awarded in Agricultural, Ceramic, Chemical, Civil, Electrical, Environmental Systems, Mechanical, and Water Resources Engineering. Admission to this program is open to those applicants who, by virtue of their academic and professional records, have demonstrated the motivation for additional professional study and the ability to successfully complete such studies. The applicant must have at least a Bachelor of Science degree and must be accepted by the head of the department or chairman of the program in which he plans to do his major work.

The requirement for graduation with the Master of Engineering degree is the satisfactory completion of a minimum of thirty (30) semester hours of approved courses, one-half of which must be selected from the student's major area of study. For those programs considered to be interdisciplinary, the approved courses will be identified by the chairman of the program. In addition, at least one-half of the approved courses must be numbered 700 or above.

The College offers cooperative graduate programs with industry. These normally take the form of alternate semesters between study programs on campus and work assignments in industry.

AGRICULTURAL ENGINEERING

A. W. Snell, Head, Department of Agricultural Engineering

Courses are offered leading to the Master of Engineering, Master of Science, and Doctor of Philosophy degrees.

The graduate programs in agricultural engineering are designed to prepare the individual for leadership, creative accomplishment and continued learning in his profession, and to qualify the student to conduct independent scientific research.

Utilization and conservation of energy and natural resources are increasingly important elements in the conception, design, and implemen-

tation of production systems which must provide food and fiber for an expanding world market. Development and management of these living systems requires that the agricultural engineer have, in addition to a thorough preparation in the physical sciences, a basic understanding of the biological sciences.

The M.E., M.S., and Ph.D. degree programs of study are planned individually for each student to augment his previous engineering and science background with adequate breadth in engineering and specialization in a specific area of agricultural engineering. Course work, in addition to agricultural engineering, consists of mathematics, physics, chemistry, statistics, biological science, and selected engineering sciences.

Ag E 616—AGRICULTURAL MACHINERY DESIGN—3 cr. (2 and 3) S

Ag E 622—SOIL AND WATER RESOURCES ENGINEERING II—3 cr. (2 and 3) S

Ag E 631—AGRICULTURAL STRUCTURES DESIGN—3 cr. (2 and 3) F

Ag E 633—DESIGN CRITERIA FOR PLANT AND ANIMAL ENVIRON-MENT—2 cr. (2 and 0) S

Ag E 642—AGRICULTURAL PROCESS ENGINEERING—3 cr. (2 and 3) S

Ag E 665—ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS —2 cr. (1 and 3) S

Ag E 781—SPECIAL PROBLEMS—1-3 cr.
A course designed for candidates for the Master of Engineering degree. Each student will select a subject according to his particular interest in agricultural engineering. Library, laboratory and/or field research will be conducted. A technical report documenting the study is required. May be repeated for a maximum of 6 credits.

Ag E 806—INSTRUMENTATION IN AGRICULTURAL AND BIOLOGI-CAL RESEARCH—3 cr. (2 and 3)
A course designed to acquaint the graduate student in agriculture and the biological sciences with fundamental mathematical and physical principles involved in measuring and recording physical phenomena studied in agricultural research. Methods and instruments used in measuring temperature, humidity, fluid pressure and flow, force, velocity, acceleration, mechanical strain and displacement, color and chemical composition are studied. Transducers and sensing elements, amplifiers, and recording instruments are related to each other through the appropriate electrical circuitry. Not open to engineering students. **Prerequisite**: general physics.

Ag E 811—TILLAGE AND SOIL DYNAMICS—3 cr. (3 and 0)

Soil physical and dynamic properties are related to the actions of tillage tools, tractive vehicles and plant growth and development. Some major topics dealt with are soil strength parameters, seedling environment and emergence, mechanics of tillage implements, soil compaction causes and effects, tractive efforts of wheel and track-type vehicles and off-the-road locomotion. **Prerequisite:** Ag E 616 or equivalent.

Ag E 822—WATER MOVEMENT IN SOILS—3 cr. (3 and 0) F

A study of theory and principles of water movement in soils. Principal topics include theory and application of flow of water through soil in unsaturated and saturated states, flow nets and seepage forces, and the fundamentals of engineering design with respect to ground water problems and soil moisture relationships. **Prerequisite:** Math 208 or equivalent.

Ag E 865—HEAT AND MOISTURE TRANSFER IN BIOLOGICAL MATERIALS—3 cr. (3 and 0) S

A study of heat and moisture diffusion in biological materials. Criteria for selecting the proper operational mathematics to solve certain boundary value problems are presented. The integral transforms of Laplace, Fourier, and Hankel are applied to various geometric configurations. The influence of heat of respiration and moisture of transpiration production are considered. **Prerequisites:** Math 653 or 657, or permission of instructor.

Ag E 871—SELECTED TOPICS IN AGRICULTURAL ENGINEERING— 1-3 cr.

Under the guidance of an instructor the student will perform an in-depth study of an area of agricultural engineering that is not covered in other course offerings. Student performance may be measured by oral and written reports and/or by examination. Course may be repeated for a maximum of 6 credits.

Ag E 882—SYSTEMS—3 cr. (2 and 3) F

Systems analysis methods applied to the engineering of agricultural operations. Topics include: activity network analysis, the Critical Path Method, PERT, linear programming, modeling, simulation, and linear systems analysis. Application of digital computation in the analysis of complex systems is stressed.

Ag E 891—RESEARCH—Credit to be arranged.

Ag E 901—SPECIAL PROBLEMS IN AGRICULTURAL ENGINEERING— 3 cr. (3 and 0)

Each student will select a subject pertaining to his particular interest or major field of study in agricultural engineering. Library and/or laboratory research will be conducted and a technical report will be written. The subject may be selected from one of the following: (a) power and

machinery, (b) soil and water resources, (c) farm structures, (d) electric power and processing, (e) food engineering, (f) forest engineering, or (g) waste management.

Ag E 991—DOCTORAL RESEARCH—Credit to be arranged.

AUTOMATIC CONTROL

The courses listed are offered by the faculties of the Departments of Chemical Engineering, Electrical and Computer Engineering, and Mechanical Engineering for students majoring in those departments who desire an area of concentration in automatic controls. This integrated sequence provides the opportunity for in-depth penetration of this study area as well as breadth of application in areas ranging from textile machinery to aerospace systems.

AC 610—INTRODUCTION TO DIGITAL CONTROL—3 cr. (3 and 0)

AC 810—MODELING AND CONTROL OF ENGINEERING SYSTEMS—
3 cr. (3 and 0)

Mathematical modeling of engineering systems using the state-space approach. Fluid, thermal, mechanical, and electrical systems are represented by matrix differential equations that are analyzed to determine eigenvalues, eigenvectors, and time solutions. Both lumped parameter and distributed parameter systems are treated. Multivariable control techniques are applied to determine suitable control laws for systems with more than one input and output.

AC 811—MODERN CONTROL THEORY—3 cr. (3 and 0)

A detailed treatment of state space analysis and design methods. Included is a review of matrix theory; the development of state space models from transfer functions; the solution of matrix differential equations; and the analysis of state space models for controllability, observability, stability, and trajectory characteristics.

AC 815—NONLINEAR CONTROLS—3 cr. (3 and 0)

A study of control systems in which nonlinear elements occur. In some cases these are used deliberately to achieve results not obtainable by other methods. Both graphical and analytical procedures are used; these include the describing function technique, the method of harmonic balance, and the phase plane method. Stability is analyzed by Liapunov's second method.

AC 820—DIGITAL CONTROL I—3 cr. (3 and 0)

A study of components and techniques needed to design digital control systems. Logic and switching circuit components and subsystems, control

logic circuits, input and output device functions, A/D and D/A conversion techniques, data transmission techniques, and computer interface concepts will be studied.

AC 821—DIGITAL CONTROL II—3 cr. (3 and 0)

A study of the use of computers, digital instrumentation, and data conversion equipment in controls to include digital and analog computers, transducers, telemetering, sampling and filtering signal conditioning, data logging and sequence control. Static optimization is also included.

AC 910—ADAPTIVE AND OPTIMAL CONTROL—3 cr. (3 and 0)

The consideration of adaptive and optimal control; includes performance criteria, system identification and the use of the computer for optimum design. Also covered are topics in calculus of variations, maximum principle and dynamic programming.

BIOENGINEERING

F. W. Cooke, Head, Division of Interdisciplinary Studies

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

The bioengineering program is devoted to the application of engineering science to the problems of medical research spanning the range from the mechanics of health care delivery to investigations of fundamental physiological processes using engineering methodology. The principal thrust of this program is in the area of biomaterials and includes the development and evaluation of prosthetic materials, the physical and mechanical behavior of tissues considered as engineering materials, corrosion and the physiological response of the host to foreign materials. Closely coupled with this effort is a strong emphasis on artifical organ development and evaluation. Other active programs include fluid dynamics applied to the cardiovascular system, bioinstrumentation, mathematical modeling and computer simulation and biomechanics.

The full-time faculty is augumented by 6 adjunct medical faculty and most research programs are conducted in collaboration with leading institutions for clinical or research medicine. All students have some direct experience with an appropriate aspect of this medical involvement.

Normally, students enrolling in this program will have a strong background in one of the traditional engineering disciplines such as materials, engineering mechanics, mechanical engineering, electrical engineering or chemical engineering. Some background in general biology and physiology is recommended but is not a prerequisite. Students with degrees in science may also be considered for admission if they can demonstrate proficiency in certain prescribed engineering courses.

Candidates for a degree in this field are allowed wide flexibility in planning their program but are encouraged to seek maximum advice and direction from the faculty because of the rapid evolution of this emerging discipline.

The following courses offered by various departments represent a typical core curriculum for the student in bioengineering.

An Ph 801—ELECTRON MICROSCOPY OF ANIMAL AND PLANT TISSUES—3 cr. (1 and 6)

An Ph 803—CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY—4 cr. (3 and 3)

An Ph 805—PHARMACOLOGY—3 cr. (2 and 3)

Bioch 606—PHYSIOLOGICAL CHEMISTRY—3 cr. (3 and 0)

Bioch 608—PHYSIOLOGICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)

Bioch 623—PRINCIPLES OF BIOCHEMISTRY—3 cr. (3 and 0)

Bioch 624—PRINCIPLES OF BIOCHEMISTRY—3 cr. (3 and 0)

Bio E 601—COMPUTERS FOR BIOSCIENTISTS—1 cr. (1 and 0)

Bio E 602—MEDICAL APPLICATIONS OF ENGINEERING SCIENCE—3 cr. (3 and 0)

Bio E 650—SPECIAL TOPICS IN BIOMEDICAL ENGINEERING—1-4 cr.

Ch E 810—BIOCHEMICAL ENGINEERING—3 cr. (3 and 0)

E&CE 815—RANDOM DATA MEASUREMENTS AND ANALYSIS—3 cr. (3 and 0)

E&CE 827—INSTRUMENTATION AND MEASUREMENTS—3 cr. (3 and 0)

E&CE 870—BIOSYSTEMS ANALYSIS—3 cr. (3 and 0)

FM 951—BIO-FLUID MECHANICS—3 cr. (3 and 0)

Mat E 605—PHYSICAL METALLURGY I—3 cr. (3 and 0)

Mat E 606—PHYSICAL METALLURGY II—3 cr. (3 and 0)

Mat E 621—MECHANICAL METALLURGY—3 cr. (3 and 0)

Mat E 651—CORROSION OF MATERIALS—3 cr. (2 and 3)

Mat E 807—PHYSICAL PROPERTIES OF POLYMERS—3 cr. (3 and 0)

Mat E 808—MECHANICAL PROPERTIES OF POLYMERS—3 cr. (3 and 0)

Mat E 814—SURFACE CHEMISTRY OF MATERIALS—3 cr. (3 and 0)

ME 601—DESIGN OF MACHINE ELEMENTS—3 cr. (3 and 0)

SE 801—ANALYSIS OF LINEAR SYSTEMS—3 cr. (3 and 0)

SE 860—DYNAMIC PROGRAMMING—3 cr. (3 and 0)

Zool 604—ANIMAL PATHOLOGY—3 cr. (2 and 3)

Zool 658—CELL PHYSIOLOGY—3 cr. (2 and 3)

Zool 660—GENERAL PHYSIOLOGY—3 cr. (2 and 3)

Zool 661—ANATOMY—3 cr. (3 and 0)

Zool 801—ANIMAL HISTOLOGY—3 cr. (2 and 3)

In addition to the three 600 level courses listed above, the following courses are offered by the Division of Interdisciplinary Studies:

Bio E 800—SEMINAR IN BIOMEDICAL ENGINEERING RESEARCH— 1 cr. (1 and 0)

Presentation and discussion of special topics and original research in biomedical engineering. (Credit may be earned for more than one semester).

Bio E 801—BIOMATERIALS—3 cr. (3 and 0)

A study of primary and secondary factors determining the performance of artificial organs in terms of materials used and design properties for each specific site of implantation. Topics, such as the following, are treated: metallurgy of stainless steel, cobalt-chromium alloys, dental amalgams, chemistry of medical polymers, physical properties of reinforced structures, ceramic-metallic bonding and corrosion in biological media.

Bio E 802—RESEARCH TECHNIQUES IN BIOMATERIALS EVALUA- TION—3 cr. (1 and 6)

A study of autoradiographic, microradiographic, electron beam microprobe, electron microscopy, optical microscopy, ultraviolet fluorescent, immunoelectrophoresis, blood chemistry analysis, and urine chemistry, analysis techniques employed in determining the compatibility of biomaterials with the physiological environment. A study of research techniques associated with determining thrombogenic characteristics of biomaterials. Corrosion and wear testing of biomaterials. **Prerequisite:** Bio E 801.

Bio E 803—POLYMERS AS BIOMATERIALS—3 cr. (3 and 0)

A summary of problems and accomplishments in bioengineering pertaining to the utilization of polymeric materials. Contact of such compositions with the living system often give rise to important interactions,

which deserve careful study. The state of the art of this branch of bio-materials will be reviewed, and an outlook to an active research area will be provided.

Bio E 812—BIOELECTROCHEMISTRY—3 cr. (3 and 0)

The theory and application of electrochemistry to biological problems. Development of the fundamental laws of electrode kinetics and its relation with corrosion of prosthetic materials. Electrochemical effects in tissue. Application of electrochemistry to bioengineering. **Prerequisite:** Undergraduate physical chemistry.

Bio E 820—STRUCTURAL BIOMECHANICS—3 cr. (3 and 0)

An analysis of the mechanical functions of the human body treated as an engineering structure and of the devices used to assist and supplement these functions. Topics to be covered include: movement of the musculo-skeletal system; locomotion, gait, prehension, lifting, function of artificial limbs, and of orthopedic prostheses and braces, effect of vibration and impact on the body, mathematical and other models of the body. **Prerequisite:** Permission of instructor.

Bio E 846—ELEMENTS OF BIOENGINEERING I—3 cr. (3 and 0)

Instrumentation for biological systems; signal conditioning, telemetry, impedance measurements, noise. Biological materials and mechanics; physiology of cells and tissue, physical properties of tissue, mathematical models of muscular action. Nervous system; physiology of central nervous system, information coding, analogs of nerves, EEG, EKG, nerve conduction velocity.

Bio E 847—ELEMENTS OF BIOENGINEERING II—3 cr. (3 and 0)

Cardiovascular systems; physiology of blood, the heart, vascular bed, and organ blood flow. Hemodynamics, properties of blood as a fluid, fluid flow equations, turbulence, pulse propagation. Electrocardiography, pacemakers, blood pressure and flow instrumentation. Respiration; dynamics of breathing, gas exchange, and regulation. Digestive system and temperature regulation.

Bio E 850—SPECIAL TOPICS IN BIOMEDICAL ENGINEERING—1-4 cr. (0-4 and 12-0)

Directed study of advanced topics in bioengineering intended to develop indepth areas of particular student interest. (Credit may be earned for more than one semester). **Prerequisite:** Permission of instructor.

Bio E 870—BIOINSTRUMENTATION—3 cr. (2 and 2)

Concepts and techniques of instrumentation in the area of bioengineering with particular emphasis on the effects of instrumentation on the biological system under investigation. Transducers and couplers, data conversion, conditioning and transmission. Experimental problems involved in acute and chronic procedures, with static dynamic subjects.

Bio E 871—BIOELECTRIC PHENOMENA—3 cr. (2 and 2)

Presentation of fundamental properties of excitable tissue. Discussion of models of membrane and action potentials (sodium pump, Hodgkin-Huxley, non-linear, solid state). Properties of bioelectric phenomena as reflected in surface potentials such as the ECG, EEG, EMG, and ERG.

Bio E 880—APPLIED HEALTH ENGINEERING LABORATORY—1 cr. (0 and 3)

A course designed to expose the advanced bioengineering graduate student to the "real world" of the medical community. Trips will be taken to a number of medical facilities so that the student will be able to see firsthand the types of engineering problems that exist. Class projects will be designed to provide possible solutions to some of these problems. **Prerequisite:** BioE 847 and permission of instructor.

Bio E 891—RESEARCH—Credit to be arranged.

(May be taken more than one semester).

Bio E 980—INTERNSHIP—1-5 cr.

Observation and assignment in a medical college or dental college, hospital, veterinary clinic, dental clinic, health service, or industrial department. Credits to be arranged. (For Ph.D. students only.) **Prerequisite:** Four semesters of graduate work in bioengineering.

Bio E 991—DOCTORAL RESEARCH—Credit to be arranged.

CERAMIC ENGINEERING

G. C. Robinson, Head, Department of Ceramic Engineering

Courses are offered leading to the Master of Engineering and Master of Science degrees.

Cr Ar 601—ADVANCED POTTERY—3 cr. (2 and 3)

Cr E 602—SOLID STATE CERAMICS—3 cr. (3 and 0)

Cr E 603—GLASSES—3 cr. (3 and 0)

Cr E 604—CERAMIC COATINGS—3 cr. (3 and 0)

Cr E 610—ANALYTICAL PROCESSES—3 cr. (2 and 3)

Cr E 612—RAW MATERIAL PREPARATION—3 cr. (3 and 0)

Cr E 616—ELECTRONIC CERAMICS—3 cr. (3 and 0)

Cr E 618—PROCESS CONTROL—3 cr. (3 and 0)

Cr E 619—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)

Cr E 620—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)

Cr E 621—EXPERIMENTS IN MATERIAL SCIENCE FOR TEACHERS—
3 cr. (2 and 3)

Cr E 701—SPECIAL PROBLEMS—3 cr. (1-3 and 0)

Engineering analysis or design problems are selected from practical problems existent in the ceramic engineering field. The students are assigned individual problems. The topics will vary from year to year in keeping with developments in the field and with interests and experience of the student and instructor. Can be repeated for additional credit.

Cr E 807—SPECIALIZED CERAMICS—3 cr. (3 and 0)

An advanced study of one of the division of ceramics. The student may select either structural products, refractories, whitewares, abrasives, enamels, glass, cements, or raw materials processing.

Cr E 809—HIGH-TEMPERATURE MATERIALS—3 cr. (3 and 0)

A study of properties of oxides, carbides, nitrides, borides and silicides; the obtainment and measurement of high-temperatures; the measurement of properties at high temperatures.

Cr E 810—CERAMIC ENGINEERING THERMODYNAMICS—3 cr.
(3 and 0)

The application of thermodynamics with special reference to physical and chemical changes in ceramic systems.

Cr E 811—CERAMIC ENGINEERING KINETICS—3 cr. (3 and 0)

Theory and measurement of the rates and mechanisms of reactions in ceramic processes.

Cr E 812—CURRENT TOPICS IN CERAMIC ENGINEERING—1 cr.
(1 and 0)

A study of the current literature in selected areas of ceramic science and engineering.

Cr E 813—NUCLEAR CERAMICS—3 cr. (3 and 0)

A study of the properties, selection, and uses of ceramic materials in nuclear reactors.

Cr E 814—CERAMIC PHYSICAL PROCESSING—3 cr. (3 and 0)

A study of the role of physical processing in determining the structure and composition of products.

Cr E 815—COLLOIDAL AND SURFACE SCIENCE—3 cr. (3 and 0)

The theory and application of colloidal and surface chemistry to ceramic materials and processes.

Cr E 816—CONSTITUTION AND STRUCTURE OF GLASSES—3 cr.
(3 and 0)

A study of modern concepts of glass structure and properties.

Cr E 821—ANALYTICAL PROCEDURES AND EQUIPMENT I—3 cr.
(2 and 3)

Theory and application of powder x-ray diffractometry, emission spectroscopy, electron microscopy, and optical microscopy to ceramic problems.

Cr E 822—ANALYTICAL PROCEDURES AND EQUIPMENT II—3 cr.
(2 and 3)

A continuation of Cr E 821.

Cr E 823—THERMAL PROPERTIES OF CERAMIC MATERIALS—3 cr.
(3 and 0)

A study of heat capacity, thermal conductivity, thermal expansion, and thermal shock resistance from a microscopic and macroscopic standpoint.

Cr E 824—MECHANICAL PROPERTIES OF CERAMIC MATERIALS—
3 cr. (3 and 0)

Stress-strain-time relations in elasticity, plasticity, and rupture showing effects of high and low temperature and structures.

Cr E 825—MAGNETIC AND ELECTRICAL CERAMIC MATERIAL—3 cr.
(3 and 0)

Application of magnetic and electrical theory to ceramic insulators, semiconductors, and ferroelectric and ferromagnetic products.

Cr E 826—CERAMIC COATINGS—3 cr. (3 and 0)

A study of glassy and crystalline coatings emphasizing fundamentals of application, adhesion theories, and development of required properties.

Cr E 828—SOLID STATE CERAMIC SCIENCE—3 cr. (3 and 0)

A study of bonding and structure of crystalline materials as related to mechanical, thermal, and chemical properties of solids.

Cr E 891—RESEARCH—Credit to be arranged.

CHEMICAL ENGINEERING

W. B. Barlage, Jr., Acting Head, Department of Chemical Engineering

Courses are offered leading to the Master of Engineering, the Master of Science, and the Doctor of Philosophy degrees.

Graduate students will be accepted with backgrounds in chemistry, physics, or branches of engineering other than chemical engineering. Special programs will be laid out for non-chemical engineering graduates.

Minors for doctoral students may be taken in chemistry, physics, mathematics, life science, or other branches of engineering. Teaching in undergraduate courses is considered to be an integral part of doctoral study in chemical engineering and is required of all doctoral students.

Ch E 601—TRANSPORT PHENOMENA—3 cr. (3 and 0)

Ch E 607—UNIT OPERATIONS LABORATORY II—2 cr. (0 and 6)

Ch E 615—INTRODUCTION TO NUCLEAR ENGINEERING I—3 cr. (3 and 0)

Ch E 616—INTRODUCTION TO NUCLEAR ENGINEERING II—3 cr. (3 and 0)

Ch E 621—PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS I—3 cr. (2 and 3)

Ch E 622—PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS II—3 cr. (0 and 9)

Ch E 625—CHEMICAL PROCESS ENGINEERING—3 cr. (3 and 0)

Ch E 630—CHEMICAL ENGINEERING THERMODYNAMICS II—3 cr. (3 and 0)

Ch E 650—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)

Ch E 653—PROCESS DYNAMICS—3 cr. (3 and 0)

Ch E 660—INTRODUCTION TO OCCUPATIONAL SAFETY AND HEALTH—3 cr. (3 and 0)

Ch E 661—INDUSTRIAL HYGIENE ANALYSIS AND INSTRUMENTATION—3 cr. (2 and 3)

Ch E 662—AIR RESOURCES ENGINEERING—3 cr. (3 and 0)

Ch E 802—PROCESS DYNAMICS AND CONTROL—3 cr. (3 and 0)
The utilization of engineering principles in the dynamic analysis and design of chemical processes, processing equipment and plants. The greatest emphasis will be placed on systems dynamics with some consideration of closed loop control and optimization. **Prerequisites:** Ch E 453/653 and Math 208 or permission of instructor.

Ch E 803—HEAT, MASS, AND MOMENTUM TRANSFER—3 cr. (3 and 0)
An advanced treatment of the fundamental mechanisms of molecular and turbulent transport of heat, mass and momentum.

Ch E 804—CHEMICAL ENGINEERING THERMODYNAMICS—3 cr.
        (3 and 0)

Advanced topics in chemical engineering thermodynamics including equilibria of physical and chemical systems, generalized properties of hydrocarbons and the application of thermodynamic methods in the design of equipment.

Ch E 805—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)

An advanced treatment of the kinetics of chemical reactions, particularly in the design and operation of chemical reactors.

Ch E 806—PROCESS SYSTEMS ANALYSIS AND SIMULATION I—3 cr.
        (3 and 0)

Formulation and solution of mathematical models describing dynamic and steady state behavior of chemical and physical process systems. Methodology of systems analysis and techniques of analog and digital solutions are emphasized.

Ch E 807—PROCESS SYSTEMS ANALYSIS AND SIMULATION II—
        3 cr. (3 and 0)

A continuation of Ch E 806. Attention is given to the methodology and application of large scale systems analysis.

Ch E 808—CHEMICAL ENGINEERING DESIGN AND ANALYSIS—3 cr.
        (1 and 6)

Design and analysis of chemical process equipment through the solution of comprehensive problems involving unit operations, kinetics, thermodynamics, strength of materials, and chemistry.

Ch E 809—WASTE TREATMENT—3 cr. (3 and 0)

Basic biochemical principles underlying biooxidation and their applications in activated sludge and trickling filter processes; basic theory of oxygen transfer and its application to aeration equipment, and the design of typical industrial waste treatment processes.

Ch E 810—BIOCHEMICAL ENGINEERING—3 cr. (3 and 0)

Principles of biochemical reaction systems and their applications in the chemical process industries. Enzyme systems, their sources, essential characteristics and employment in commercial chemical production (fermentation). Certain related topics (i.e., biological waste disposal, protein technology, etc.) introduced for illustration.

Ch E 814—APPLIED NUMERICAL METHODS IN PROCESS SIMULA-
        TION—3 cr. (3 and 0)

An advanced treatment of numerical solution techniques as applied to chemical process systems. Finite difference techniques for partial differential equations are emphasized with stress on applied numerical methods

rather than theoretical numerical analysis. A review of standard methods for ordinary differential equations is normally included. **Prerequisite:** Permission of instructor.

Ch E 818—POLYMER PROCESSING—3 cr. (3 and 0)

The course will be an introduction into the processing of polymeric materials. Injection molding, calendering, extrusion and surface activation of plastic film are to be studied. Physical science principles such as crystallization, surface chemistry, heat transfer and rheology will be applied when studying the process operations. **Prerequisite:** FM 817.

Ch E 821—HEAT TRANSPORT—3 cr. (3 and 0)

Advanced topics in heat transport by conduction, convection and radiation.

Ch E 822—MASS TRANSFER AND DIFFERENTIAL CONTACT OPERATIONS—3 cr. (3 and 0)

Topics include diffusion theory in binary and muticomponent gas and liquid systems, the HTU concept, and design considerations in absorption and extraction.

Ch E 823—MASS TRANSFER AND STAGEWISE CONTACT OPERATIONS—3 cr. (3 and 0)

Stagewise contact operations with major emphasis on distillation. Topics include vapor-liquid equilibria, integral and differential distillation, binary and multicomponent rectification, analytical methods, batch rectification, and azeotropic and extractive distillation.

Ch E 830—CHEMICAL TECHNOLOGY—3 cr. (3 and 0)

A study of those unit processes and operations that are of direct interest to the organic, inorganic, or electrochemical industries. Special emphasis is placed on the manner in which chemical engineering principles are used in solving the problems of these industries.

Ch E 840—GRADUATE LABORATORY—Credit to be arranged.

Graduate level laboratory experiments in kinetics, unit operations and thermodynamics. Emphasis will be placed on independent work. The student will be required to plan the experiments to achieve a given objective, perform the experimental work and prepare a technical report on the work.

Ch E 845, 846, 847—SELECTED TOPICS IN CHEMICAL ENGINEERING— 3 cr. (3 and 0)

A comprehensive study of any topic in the field of chemical engineering, not covered in the other courses. Special emphasis will be placed on studies of the current literature and the results of recent and current research. The topics covered will be expected to vary from year to year to keep pace with developments in the field. May be repeated for credit.

Ch E 852—AIR POLLUTION CONTROL PROCESSES—3 cr. (3 and 0)

A course devoted to operational and design variables in equipment for removal of gas, liquid and solid phase pollutants from air. Basic theory of small particle dynamics. Performance and design are discussed.

Ch E 853—INDUSTRIAL AIR HYGIENE—3 cr. (3 and 0)

Deals with the control of air contaminants in confined industrial areas. Application of maximum allowable concentrations in the design of air handling and cleaning systems in enclosed work areas. A survey of heat, noise, and other industrial hazards.

Ch E 854—ENVIRONMENTAL INSTRUMENTATION AND MEASURE-MENTS—3 cr. (2 and 3)

The theory and practice of measurement of environmental control parameters are studied. The applications of survey instrumentation and micro analytical procedures in environmental and biochemical engineering are emphasized.

Ch E 891—RESEARCH—Credit to be arranged.

Ch E 902—PROCESS DYNAMICS AND CONTROL—3 cr. (3 and 0)

An extension of Ch E 802; includes a detailed analysis of the recent chemical engineering literature in the areas of process dynamics and control. The analysis of non-linear systems along with complex control schemes will be considered. **Prerequisite:** Ch E 802.

Ch E 903—TRANSPORT PHENOMENA—3 cr. (3 and 0)

A consideration of problems in transport phenomena from the current literature. **Prerequisite:** Ch E 803.

Ch E 904—CHEMICAL ENGINEERING THERMODYNAMICS—3 cr. (3 and 0)

A continuation of Ch E 804. Includes non-ideal behavior of mixtures, statistical thermodynamics and irreversible process. **Prerequisite:** Ch E 804.

Ch E 905—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)

A continuation of Ch E 805. **Prerequisite:** Ch E 805.

Ch E 945, 946, 947—SELECTED TOPICS IN CHEMICAL ENGINEERING—3 cr. (3 and 0)

Study of any advanced topic in chemical engineering. Intended primarily for more comprehensive study of topics first covered in Ch E 845-847.

Ch E 954—ENVIRONMENTAL SYSTEMS DESIGN—3 cr. (3 and 0)

The design and evaluation of life support systems are considered. A study of energy and chemical requirements, the application of regenerative processes, and current developments. **Prerequisites:** Ch E 854.

Ch E 991—DOCTORAL RESEARCH—Credit to be arranged.

The catalog descriptions for the following interdepartmental Automatic Control courses are given on pages 100 to 101.

AC 610—INTRODUCTION TO DIGITAL CONTROL—3 cr. (3 and 0)

AC 810—MODELING AND CONTROL OF ENGINEERING SYSTEMS— 3 cr. (3 and 0)

AC 811—MODERN CONTROL THEORY—3 cr. (3 and 0)

AC 815—NONLINEAR CONTROLS—3 cr. (3 and 0)

AC 820—DIGITAL CONTROL I—3 cr. (3 and 0)

AC 821—DIGITAL CONTROL II—3 cr. (3 and 0)

AC 910—ADAPTIVE AND OPTIMAL CONTROL—3 cr. (3 and 0)

The catalog descriptions for the following interdepartmental Fluid Mechanics courses are given on pages 130 to 132.

FM 801—FOUNDATION OF FLUID MECHANICS—3 cr. (3 and 0) F

FM 811—EXPERIMENTAL FLUID MECHANICS—3 cr. (2 and 3) F

FM 812—THEORY OF INCOMPRESSIBLE IDEAL FLOW—3 cr. (3 and 0) S

FM 814—TURBULENT BOUNDARY LAYER—3 cr. (3 and 0) S

FM 815—NUMERICAL METHODS IN FLUID MECHANICS—3 cr. (3 and 0) F

FM 816—FLOW IN OPEN CHANNELS—3 cr. (3 and 0) S

FM 817—NON-NEWTONIAN FLOW—3 cr. (3 and 0) S

FM 841—SEMINAR—1 cr. (1 and 0) F, S

FM 901—APPLIED HYDRODYNAMICS—3 cr. (3 and 0)

FM 921—TWO-PHASE FLOW—3 cr. (3 and 0)

FM 931—FREE SURFACE FLOW—3 cr. (3 and 0)

FM 951—BIO-FLUID MECHANICS—3 cr. (3 and 0)

CIVIL ENGINEERING

H. W. Busching, Head, Department of Civil Engineering

Courses are offered leading to the Master of Engineering, Master of Science, and Doctor of Philosophy degrees.

Graduate students in civil engineering can pursue programs in areas of specialization such as traffic and transportation, structures, ocean and coastal engineering, construction, planning, systems and public works engineering. Opportunities for study and research also exist in several interdisciplinary programs such as water resource engineering, environmental systems engineering and bioengineering. Each student's educational and research program can be arranged to best reflect his personal motives and professional goals.

CE 603—MODERN USES OF COMPUTERS IN STRUCTURAL ENGINEERING—3 cr. (2 and 2)

CE 610—TRAFFIC ENGINEERING OPERATIONS—3 cr. (3 and 0) S

CE 612—URBAN TRANSPORTATION PLANNING—3 cr. (3 and 0) F

CE 615—SEMINAR IN TRAFFIC ENGINEERING—1 cr. (0 and 2) F

CE 617—AIRPHOTO INTERPRETATION I—3 cr. (2 and 3) F

CE 619—GENERAL PHOTOGRAMMETRY—3 cr. (2 and 3) S

CE 620—MECHANICAL PROPERTIES OF MATERIALS—3 cr. (3 and 0)

CE 621—ADVANCED BUILDING MATERIALS SELECTION—3 cr. (3 and 0)

CE 631—APPLIED SOIL MECHANICS—3 cr. (2 and 2)

CE 634—CONSTRUCTION COSTS AND ESTIMATES—3 cr. (2 and 3)

CE 635—ENGINEERING PROJECT ANALYSIS—3 cr. (2 and 2)

CE 641—APPLIED HYDRAULICS—3 cr. (3 and 0)

CE 653—ADVANCED STRUCTURAL ANALYSIS—3 cr. (3 and 0)

CE 662—PORT AND HARBOR ENGINEERING—3 cr. (3 and 0)

CE 801—STRUCTURAL ENGINEERING I— 3 cr. (3 and 0)
Analysis and design of tall buildings subjected to wind stresses; analysis of space frames; analysis and design of continuous trusses; secondary stresses in trusses; introduction to matrix methods of analysis; introduction to the design of arches. **Prerequisite:** CE 453/653 or equivalent.

CE 802—PRESTRESSED CONCRETE ANALYSIS AND DESIGN—3 cr.
(3 and 0)

Design and analysis of prestressed concrete beams, columns and floor slabs. Composite design of steel and concrete. **Prerequisite:** CE 402.

CE 803—REINFORCED CONCRETE STRUCTURAL SYSTEMS—3 cr.
(3 and 0)

Relates behavior of reinforced concrete beams, columns, and frames to design practice. Discusses the effect of past and present research in the formulation of reinforced concrete design codes. **Prerequisite:** CE 402.

CE 804—THEORY AND DESIGN OF THIN PLATES—3 cr. (3 and 0)

Elastic analysis and design of circular, rectangular, and continuous plates by both classical and numerical methods. **Prerequisites:** A knowledge of Fourier series, and partial differential equations.

CE 805—PLASTIC DESIGN OF STEEL STRUCTURES—3 cr. (3 and 0)

The inelastic behavior of metal frameworks; concept of the plastic hinge and collapse configurations; requirements for stability; connections; minimum weight and cost design. **Prerequisites:** CE 302, CE 453/653.

CE 806—DESIGN OF STEEL MEMBERS—3 cr. (3 and 0)

Relates behavior of steel members to design practice. Review of experimental investigations of and design practice for primary buckling, twist buckling, local buckling, web buckling and interaction. **Prerequisite:** CE 302.

CE 807—NUMERICAL AND APPROXIMATE METHODS OF STRUCTURAL ANALYSIS—3 cr. (3 and 0)

Application of finite difference equations, iterative procedures and relaxation methods to the solution of structural problems. Introduction to the matrix formulation of structural problems. Application of matrix methods to the vibration of structures, and analysis and stability of statically loaded beams, frames, space frames and stiffened shell structures. **Prerequisite:** CE 453/653.

CE 808—FINITE ELEMENT METHODS IN STRUCTURAL ANALYSIS— 3 cr. (3 and 0)

The basic formulation of finite element structural analysis; types of elements, application to linear elastic analysis; elastic instability; dynamic response; and inelastic analysis. **Prerequisites:** CE 801 or permission of instructor.

CE 811—HIGHWAY GEOMETRIC DESIGN—3 cr. (2 and 3)

Geometric design of roadways, at-grade intersections, and interchanges in accordance with the conditions imposed by driver ability, vehicle performance, safety and economics: **Prerequisite:** CE 310/610.

CE 812—AIRPHOTO INTERPRETATION II—3 cr. (2 and 3)

Principles of airphoto interpretation as applied to transportation planning. Cultural, industrial and recreational land use features are identified and analyzed in order to predict the future needs of the transportation system. Transportation projects utilizing airphoto interpretation.

CE 813—HIGHWAY AND AIRPORT PAVEMENT DESIGN—3 cr. (3 and 0)

Structural design of rigid and flexible pavements; design of bases and subbases; theory of stresses and application of plate bearing, triaxial, and California Bearing Ratio design methods to flexible pavements; Westergaard analysis for rigid pavements; pavement evaluation methods. **Prerequisite: CE 330.**

CE 814—TRAFFIC FLOW THEORY—3 cr. (3 and 0)

Qualitative and quantitative description of traffic flow, study of the parameters used to characterize traffic flow, procedures for adjusting traffic flow parameters to optimize flow, solution of traffic flow problems by methods of analogy and queuing theory, and discussion of digital simulation of vehicular motion and traffic flow. **Prerequisite: CE 310/610.**

CE 815—HIGHWAY SAFETY ENGINEERING—3 cr. (3 and 0)

An examination of the methodology for conducting highway traffic accident studies; accident characteristics as related to the vehicle driver, roadway, and vehicle; statistical applications to accident data and studies; and consideration of current trends and problems in highway safety. **Prerequisite: CE 310/610.**

CE 816—HIGHWAY PLANNING—3 cr. (3 and 0)

Advanced treatment of various aspects of highway planning including planning surveys, needs studies, impact studies, sufficiency ratings, highway finance, highway administration and extensive treatment of economic evaluation of alternative highway projects by benefit-cost ratio, annual cost, rate of return and investment return procedures.

CE 817—MASS TRANSIT PLANNING—3 cr. (3 and 0)

A comprehensive coverage of mass transit planning, including characteristics of modern mass transit systems, case studies of mass transit in selected cities, transit studies, marketing and financing mass transit, recent innovation in mass transit, current issues in mass transit planning, and future developments in mass transit.

CE 818—AIRPORT PLANNING AND DESIGN—3 cr. (3 and 0)

A comprehensive coverage of important aspects of the planning and design of airports and other air transportation facilities, an introduction to the characteristics of air transport, and a study of the future role of air transport in the overall transportation program.

CE 819—TRANSPORTATION RESEARCH—2-4 cr.

Independent investigation of problems in transportation engineering.

CE 820—CEMENT AND CONCRETE—3 cr. (2 and 3) S

Chemistry and properties of cements; properties of plastic and hardened concrete; mix design methods. **Prerequisite: CE 320/620.**

CE 821—BITUMINOUS PAVING MATERIALS—3 cr. (2 and 3)

Manufacture of asphalt cements, road oils, asphalt emulsions, cutback asphalts and tars; theory, design and evaluation of asphalt-aggregate mixes. **Prerequisite: CE 320/620.**

CE 822—AGGREGATES AS CONSTRUCTION MATERIALS—3 cr.
    (2 and 3)

Identification and suitability of aggregates for embankment, drainage, and roadbed structures, concrete mixes, and bituminous mixtures. **Prerequisite: CE 320/620.**

CE 823—INELASTIC BEHAVIOR OF ENGINEERING MATERIALS—3 cr.
    (3 and 0)

Formulation of constitutive equations of mechanical behavior, strength theories, use of rheological models, static and dynamic viscoelasticity, introduction to fracture mechanics, applications in civil engineering. **Prerequisite: EM 304.**

CE 825—DISTRIBUTION AND PROPERTIES OF SOILS—3 cr. (3 and 0)

Distribution and engineering properties of soils and aggregates in North America on a physiographic basis, identification of the common problems associated with various natural construction materials and their solutions, and performance of structures as related to natural construction materials available in different areas. **Prerequisite: CE 330.**

CE 830—ADVANCED SOIL MECHANICS—3 cr. (3 and 0)

Stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, analysis of flexible retaining wall and bulkheads, solution of problem by elastic theory. **Prerequisite: CE 330.**

CE 831—FOUNDATION ENGINEERING—3 cr. (2 and 3)

Requirements for satisfactory foundations, theory and design of shallow foundations, pressure distribution beneath rigid and flexible shallow foundations, bearing capacity and settlement of deep foundations, foundation failures. Laboratory includes site investigation field tests, and determination of design parameters. **Prerequisite: CE 830.**

CE 833—PHYSICAL AND PHYSIO-CHEMICAL PROPERTIES OF SOILS
    —3 cr. (2 and 3)

Formation of soils, soil minerals, soil structure, permeability, swelling pressures, pore pressure theory as related to shear strength and consolida-

tion; soil stabilization, shear strength tests, properties of compacted soils. **Prerequisite:** CE 330.

CE 835—DESIGN OF EARTH STRUCTURES—3 cr. (3 and 0)

Design and construction of earth and rock fill dams, appurtenances and embankment details, highway embankments, methods of stabilization, compaction, and compaction control, drainage systems for seepage and pressure control. **Prerequisite:** CE 330.

CE 889 and 890—SPECIAL PROBLEMS I AND II—1-3 cr.

Research design problems may be assigned from the field of structures, construction, soil mechanics, transportation, ocean and coastal engineering, or materials engineering. Subject matter will vary with interest and experience of student and instructor.

CE 891—RESEARCH—Credit to be arranged.

CE 901—THEORY AND DESIGN OF SHELLS—3 cr. (3 and 0)

Elastic analysis and design of shell structures such as cylindrical shells, folded plates, domes, roof structures with double curvature. **Prerequisites:** A knowledge of Fourier series and partial differential equations.

CE 902—STRUCTURAL VIBRATION—3 cr. (3 and 0)

Analysis and design of structures subjected to dynamic loading. Response will be investigated for both lumped and distributed parameter systems of one or many degrees of freedom. Approximate design methods, earthquake analysis and design, and blast-resistant design. **Prerequisite:** Permission of the instructor.

CE 991—DOCTORAL RESEARCH—Credit to be arranged.

ELECTRICAL AND COMPUTER ENGINEERING

A. L. Duke, Head, Department of Electrical and Computer Engineering

Courses are offered leading to the Master of Engineering, Master of Science, and Doctor of Philosophy degrees.

Graduate students in electrical and computer engineering can direct their program towards several areas of specialization. The traditional fields of networks, controls, communications, electronics, power systems, and computers are available. Also, the student can elect to work in one of the multi-disciplinary fields such as bio-medical engineering, systems or operations research.

E&CE 603—ENERGY CONVERSION—3 cr. (3 and 0) F

E&CE 606—INTRODUCTION TO INTEGRATED CIRCUITS—3 cr.
(3 and 0) F

E&CE 610—SYSTEMS III—(3 and 0) F, S

E&CE 611—ELECTRICAL SYSTEMS WORKSHOP—2 cr. (0 an 4) F, S

E&CE 612—DIGITAL CONTROL SYSTEMS—3 cr. (3 and 0) S

E&CE 620—POWER SYSTEM ANALYSIS I—3 cr. (3 and 0) S

E&CE 621—ELECTRICAL MACHINERY—3 cr. (2 and 2) F

E&CE 622—ELECTRONICS III—2 cr. (2 and 0) F, S

E&CE 624—POWER SYSTEMS ANALYSIS II—3 cr. (3 and 0)

E&CE 626—DIGITAL COMPUTER DESIGN—3 cr. (3 and 0)

E&CE 627—OPERATIONAL AMPLIFIERS—2 cr. (2 and 0)

E&CE 628—COMMUNICATIONS THEORY I—3 cr. (3 and 0) F

E&CE 629—COMPUTER ORGANIZATION—3 cr. (3 and 0) F

E&CE 630—COMMUNICATIONS THEORY II—3 cr. (3 and 0) S

E&CE 631—DIGITAL ELECTRONICS—3 cr. (2 and 2)

E&CE 632—INSTRUMENTATION—3 cr. (3 and 0) S

E&CE 634—POWER ELECTRONICS—3 cr. (3 and 0) F

E&CE 635—COMMUNICATIONS CIRCUITS—3 cr. (3 and 0) S

E&CE 636—RADIATION AND WAVE PROPAGATION—3 cr. (3 and 0) F

E&CE 637—LASER TECHNOLOGY AND APPLICATIONS—3 cr.
    (3 and 0) S

E&CE 638—PROCESS INSTRUMENTATION AND CONTROL SYSTEMS
    —3 cr. (3 and 0)

E&CE 650—SYSTEMS IV—3 cr. (3 and 0) F, S

E&CE 651—SYSTEMS DESIGN WORKSHOP—2 cr. (0 and 4) F, S

E&CE 652—PROGRAMMING SYSTEMS—3 cr. (3 and 0)

E&CE 660—COMPUTER-AIDED ANALYSIS AND DESIGN—3 cr.
    (3 and 0) F

E&CE 661—ANALOG/HYBRID COMPUTATION AND SIMULATION—
    3 cr. (2 and 2) S

E&CE 701—SPECIAL PROBLEMS—1-3 cr.
    Engineering analysis or design problems are selected from practical problems in fields of interest to students in electrical and computer engineering. The course can be repeated for additional credits.

E&CE 801—ANALYSIS OF LINEAR SYSTEMS—3 cr. (3 and 0)

An introduction to the foundations of linear system analysis. The application of matrix algebra, linear graph theory, and operational mathematics to the formulation and solution of system equations in the time domain and in the frequency domain.

E&CE 802—ANALYSIS OF LINEAR SYSTEMS II—3 cr. (3 and 0) S

An extension of the topics of E&CE 801. The study of multiterminal representations and equivalance concepts for linear systems. Emphasis is placed on computer formulation and solution techniques applicable to large-scale physical systems such as electric power networks. **Prerequisite:** E&CE 801.

E&CE 803—SEMINAR—1 cr. (1 and 0) F, S

Student presentations and group discussions dealing with current research activities.

E&CE 804—NETWORK SYNTHESIS I—3 cr. (3 and 0) F

Synthesis of linear passive networks. Detailed study of driving-point immittances of one-port networks; positive-real properties and physical realizability. Realization of driving-point immittance functions. Properties of transfer functions for two-port networks. **Prerequisite:** E&CE 801.

E&CE 805—NETWORK SYNTHESIS II—3 cr. (3 and 0) S

Continuation of E&CE 804. Realization of two-port transfer functions with an emphasis on LC and RC networks. The approximation problem. Extension to active network synthesis. **Prerequisite:** E&CE 804.

E&CE 806—NONLINEAR NETWORKS AND SYSTEMS—3 cr. (3 and 0) S

Organized treatment of nonlinear problems arising in system analyses. Description and characterization of the properties of nonlinear components. Formulation and solution of system equations with emphasis on computer-oriented solution techniques. Stability in nonlinear systems.

E&CE 807—POWER SYSTEM TECHNIQUES—3 cr. (3 and 0) S

A study of electric power system operation. The models of transmission line components and networks are developed. Computer methods for solving linear and nonlinear systems of network equations are presented. Operating problems in load flow, scheduling and economic dispatch are included. **Prerequisite:** Permission of instructor.

E&CE 808—ELECTROMECHANICAL ENERGY CONVERSION—3 cr. (3 and 0) F

An in-depth analysis of DC and AC motors and generators. Includes principles of electromechanical energy conversion, steady state and dynamic operation of DC and AC machines and the machine as part of a control system. Laboratory experience is included. **Prerequisite:** Permission of instructor.

119

E&CE 812—SAMPLED DATA SYSTEMS—3 cr. (3 and 0) F

Analysis and design of control systems in which sampling elements occur. Sampling theory and data reconstruction are considered. The use of the classical Z-transform analysis techniques augment modern control theory methods. Stability, compensation, and performance are considered.

E&CE 815—RANDOM DATA MEASUREMENTS AND ANALYSIS— 3 cr. (3 and 0) S

Principles involved in the measurement and analysis of random data. Response characteristics of physical systems. Data sampling techniques. Analog and digital measurement techniques. Analysis of non-stationary data.

E&CE 816—LINEAR INTEGRATED CIRCUITS—3 cr. (3 and 0) F

Centering around the operational amplifier, this course discusses the characteristics, applications, and modeling techniques of linear integrated circuits. **Prerequisite:** E&CE 823.

E&CE 817—POWER SYSTEM TRANSIENT ANALYSIS—3 cr. (3 and 0) F

A study of dynamic operation of power systems. The models for dynamic operation of the synchronous machine and the transmission system are developed. Computer methods for solving transient problems are presented. Applications to power systems include the control problem, fault analysis and stability analysis. **Prerequisite:** Permission of instructor.

E&CE 819—DETECTION AND ESTIMATION THEORY—3 cr. (3 and 0) F

An introduction to the theory of statistical testing of hypotheses as applied to the detection and estimation of communication signal parameters. Detection of signals with random amplitude, phase and arrival time in noise. Detection of single and multiple observation. Estimates and their properties, signal resolution. **Prerequisites:** E&CE 815 and 820.

E&CE 820—THEORY OF COMMUNICATIONS I— 3 cr. (3 and 0) F

A study of modern communications systems with emphasis on modulation and methods of taking into account the effects of noise on various systems. **Prerequisite:** E&CE 428 or equivalent.

E&CE 821—THEORY OF COMMUNICATIONS II—3 cr. (3 and 0) S

Continuation of E&CE 820.

E&CE 822—INFORMATION THEORY—3 cr. (3 and 0) F

A study of the statistical problems encountered in information handling. Relates probability, information, and coding theory. Presents a unified treatment of set theory, sample space, random variables, information measure and capacity as applied to communication.

E&CE 823—INTEGRATED CIRCUIT TECHNOLOGY—3 cr. (3 and 0) F

Characteristics of semiconductor devices are discussed in the context of their use in integrated circuits. Monolithic and hybrid construction are described and related to electrical performance. Circuits are categorized by technology and design guidelines developed.

E&CE 824—APPLICATIONS OF INTEGRATED CIRCUITS—3 cr. (3 and 0) S

Continuation of E&CE 823 with emphasis on circuit layout and technological limitations to design. Complex function circuits and LSI structures are discussed. **Prerequisite:** E&CE 823.

E&CE 825—SOLID-STATE ELECTRONICS—3 cr. (3 and 0) S

The electron in solids is studied by the modern physics approach. This includes elementary quantum mechanics, statistics, plasmas, and band theory. These principles are then applied to modern amplfiers; e.g., the traveling-wave tube, tunnel diode, masers, and parametric amplifiers.

E&CE 826—LARGE-SCALE INTEGRATION—3 cr. (3 and 0) S

LSI concepts are increasingly influencing electronic system design. This course examines in depth the technological and economic factors affecting the use of these components. **Prerequisite:** E&CE 824.

E&CE 827—INSTRUMENTATION AND MEASUREMENTS—3 cr. (3 and 0) F

Instrumentation capable of measuring physical parameters, including spectrophotometry, spectroscopy, mass spectrometry, gas chromatography, NMR and ESR, will be considered. Electronic components such as detectors, pulse height analyzers, and data processing and telemetry equipment will also be covered.

E&CE 830—ELECTROMAGNETICS I—3 cr. (3 and 0) F

Vector analysis, electrostatics, electrostatic fields in material bodies, solution of boundary-value problems, stationary currents, static magnetic fields, magnetic field in material bodies, quasi-stationary magnetic fields. **Prerequisite:** Permission of instructor.

E&CE 831—ELECTROMAGNETICS II—3 cr. (3 and 0) S

Time dependent fields, plane waves, guided transmission systems, resonators, radiation, antennas, and interaction of charged particles with fields. **Prerequisite:** E&CE 830.

E&CE 832—ANTENNA THEORY—3 cr. (3 and 0) F

Point sources, the antenna as an aperture, thin linear antennas, loop antennas, helical antennas, the current distribution and impedance of the cylindrical antenna, coupled antennas, and the electromagnetic fields of antennas. **Prerequisite:** E&CE 831.

E&CE 834—MICROWAVE ELECTRONICS—3 cr. (3 and 0) S

Interaction of charged particles with electromagnetic fields, fundamental principles of microwave devices, including klystrons, magnetrons, traveling wave tubes and particle accelerators. Semiconductor devices as sources of microwave frequencies. **Prerequisite.** E&CE 831.

E&CE 836—OPTICAL ELECTROMAGNETICS AND QUANTUM ELECTRONICS—3 cr. (3 and 0) F

An advanced study of the theory and modern technology of physical optics including methods used to generate, guide, and detect coherent waves in the millimeter, infrared, and visual portions of the electromagnetic spectrum.

E&CE 844—DIGITAL SIGNAL PROCESSING—3 cr. (3 and 0) S

Introduction to the application of discrete mathematics, including difference equations and Z-transform applications. Study of the sampling process and analog-to-digital conversion. Design of digital filters in both the time and frequency domains. Quantization effects in digital filters, and real-time implementation methods. Analysis and application of the Fast Fourier Transform algorithm. Design of hardware array processors for very high-speed processing. **Prerequisite:** E&CE 801.

E&CE 850—COMPUTATION AND SIMULATION— 3 cr. (3 and 0) F

Covers the general area of computer modeling as related to engineering problems. Emphasis is placed on matching problems and computers to obtain the most effective solution.

E&CE 851—THEORY AND DESIGN OF DIGITAL-ANALOG MACHINES —3 cr. (3 and 0) S

Theory and design of general purpose, special purpose, hybrid and sequential machines. Particular emphasis is placed on practical applications.

E&CE 852—DIGITAL COMPUTERS AND INFORMATION PROCESSES —3 cr. (3 and 0) F

A survey of techniques and problems involved in computer and information processing technology. Algorithmic approach to problem solving, software concepts, and machine organization are considered. **Prerequisite:** Prior knowledge of computer programming.

E&CE 853—COMPUTER DATA DISPLAYS—3 cr. (3 and 0) S

This course discusses both the methods and hardware required for displaying visually computer output. Included are cathode ray, discrete readout, and large screen displays. **Prerequisite:** E&CE 429/629 or approval of instructor.

E&CE 854—ADVANCED SIMULATION STUDIES—3 cr. (3 and 0) F

Modeling and simulation techniques in the study of dynamic system behavior. Digital, analog, and hybrid approaches are considered. Em-

phasis is placed upon relationships between simulation, system analysis, and actual system performance.

E&CE 855—ARTIFICIAL INTELLIGENCE—3 cr. (3 and 0) F

A study of the problem of creating intelligent behavior in machines with emphasis on computer-oriented approaches. Topics covered include models of cognitive processes, goal-seeking behavior, self-organizing systems, learning algorithms, game-playing machines, pattern recognition, and heuristic programming. Practical applications such as machine aids to human problem-solving and computer control of external manipulators are considered. Current developments in the field are reviewed.

E&CE 856—PATTERN RECOGNITION—3 cr. (3 and 0) S

An investigation of several approaches to the general pattern recognition problem with practical computer-oriented applications. Topics treated include feature extraction, classification algorithms, discriminant functions, learning schemes, statistical methods, information theoretic approaches, and applications. Current developments in the field are reviewed.

E&CE 857—CODING THEORY—3 cr. (3 and 0) S

A study of the principles of algebraic coding and its application to the transmission of information over noisy communications channels. Topics covered include an introduction to abstract algebra, code performance bounds, code representations, linear codes of the Hamming and Bose-Chandnuri types and burst-error correcting codes. Also considered are problems of implementation and decoding. **Prerequisite:** E&CE 822.

E&CE 858—AUTOMATA THEORY—3 cr. (3 and 0) S

A study of the structure and capabilities of sequential machines. Topics covered include: machine identification, regular expressions, linear machines, and stochastic machines.

E&CE 870—BIOSYSTEMS ANALYSIS—3 cr. (3 and 0) F

A discussion of the classical and recent mathematical models of biological systems, particularly as they relate to modern systems theory. Biomedical instrumentation, data collection and data processing are covered. Emphasis is on applications to humans.

E&CE 890—SELECTED TOPICS IN ELECTRICAL ENGINEERING—
    3 cr. (3 and 0) F, S

A comprehensive study of any topic in the field of electrical engineering not covered in the other courses. Special emphasis will be placed on studies of the current literature and results of recent and current research. The topics covered will be expected to change from year to year in keeping with developments in the field. Can be repeated for additional credit.

E&CE 891—RESEARCH—Credit to be arranged.

E&CE 991—DOCTORAL RESEARCH—Credit to be arranged.

The catalog descriptions for the following interdepartmental Automatic Control courses are given on pages 100 to 101.

AC 610—INTRODUCTION TO DIGITAL CONTROL—3 cr. (3 and 0)

AC 810—MODELING AND CONTROL OF ENGINEERING SYSTEMS—
   3 cr. (3 and 0)

AC 811—MODERN CONTROL THEORY—3 cr. (3 and 0)

AC 815—NONLINEAR CONTROLS—3 cr. (3 and 0)

AC 820—DIGITAL CONTROL I—3 cr. (3 and 0)

AC 821—DIGITAL CONTROL II—3 cr. (3 and 0)

AC 910—ADAPTIVE AND OPTIMAL CONTROL—3 cr. (3 and 0)

ENGINEERING MECHANICS

H. W. Busching, Head, Department of Civil Engineering

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

Enrollment in these programs is open to students possessing baccalaureate or master's degrees in any branch of engineering and to those with degrees in physics or applied mathematics who have credit for certain prescribed courses in engineering.

The three general areas of concentration are mechanics of solids, dynamics, and fluid mechanics. Some limitations are imposed on the selections of courses to reflect the particular concentration. The normal minor area of study is mathematics. However, suitable complementary minor programs may also be arranged in physics, materials engineering, civil engineering, and mechanical engineering.

EM 621—HYDROLOGY AND HYDRAULICS—2 cr. (2 and 0)

EM 625—ADVANCED MECHANICS OF MATERIALS—3 cr. (3 and 0)

EM 650—MECHANICAL VIBRATIONS—3 cr. (3 and 0)

EM 670—EXPERIMENTAL STRESS ANALYSIS I—3 cr. (2 and 3)

EM 802—EXPERIMENTAL STRESS ANALYSIS II—3 cr. (2 and 3)

Experimental analysis of stress fields using photoelasticity as the principal method. Basic theory of photoelasticity and transmission polariscope and the reflective polariscope are discussed with applications utilizing two and three dimensional models and photoelastic coatings. Emphasis is on

the techniques of simulating stress fields with model and the proper interpretation of fringe patterns. **Prerequisites:** EM 304 and permission of instructor.

EM 821—CONTINUUM MECHANICS—3 cr. (3 and 0)

A comprehensive, unified treatment of the mathematical theories of elastic solids. Introduction to tensor analysis; stress and strain tensors; invariants; deformations and flow; conservation of mass; momentum theorems; constitutive equations; equations of elastic solids. **Prerequisites:** Math 208 and permission of instructor.

EM 823—DIMENSIONAL ANALYSIS AND DYNAMIC SIMILARITY— 3 cr. (3 and 0)

Systematic study of the algebraic theory of dimensional analysis and the theory of models. Applications include problems in the following areas: mechanics of materials, fluid mechanics, heat transfer and electromagnetic theory. Special attention is given the method of deriving model laws from the differential equations governing a particular phenomenon. **Prerequisite:** Permission of instructor.

EM 827—TOPICS IN ANALYTICAL MECHANICS—3 cr. (3 and 0)

An introduction to topics of fundamental importance in the formulation of the classical theories of solid mechanics, fluid mechanics, and dynamics. **Prerequisites:** Math 208 and permission of instructor.

EM 829—ENERGY METHODS AND VARIATIONAL PRINCIPLES—3 cr. (3 and 0)

Theory of variational energy principles including the principle of virtual work, first law of thermodynamics, principle of complementary energy, Castigliano and unit-dummy load methods, principle of stationary potential energy. Hamilton's principle and the equations of Hamilton and Lagrange. Application of these principles to dynamics of rigid bodies, analyses of linear and nonlinear elastic frames, general elasticity theory, theories of plates and shells, and the theories of buckling and vibrations. **Prerequisites:** EM 831 and permission of instructor.

EM 831—THEORY OF ELASTICITY I—3 cr. (3 and 0)

The theory of stress and the general theory of deformation for continuous media. The linear stress-strain relations for an elastic region including the particular case of a homogenous, isotropic material. Basic equations are developed in both scalar and tensor form. Specific topics are considered: e.g., the Airy stress function, torsion and bending of prismatic bars, and thermal stresses. **Prerequisites:** EM 304, Math 208.

EM 832—THEORY OF ELASTICITY II—3 cr. (3 and 0)

Continuation of EM 831. Three-dimensional problems associated with the infinite elastic medium, the elastic half-space, contact stresses and the

deformation of a symmetrically loaded elastic sphere and circular cylinder. **Prerequisite:** EM 831.

EM 834—THEORY OF ELASTIC STABILITY—3 cr. (3 and 0)

Theoretical bases for the analysis of the static and dynamic stability of conservative and non-conservative systems are developed. Emphasis is placed on the application of the classical stability criteria to various important structural elements such as columns, beam-columns, rings, arches, thin plates, and shells. Special attention is given to the methods of adjacent equilibrium, initial imperfection, and total potential energy. **Prerequisite:** EM 831 or permission of instructor.

EM 845—INTERMEDIATE DYNAMICS—3 cr. (3 and 0)

Kinematics and dynamics of particles and rigid bodies. Lagrange and Hamilton's formulation of mechanics. Two-body central force problem. Rendezvous of two bodies in a central force field. Rotation of rigid bodies about a fixed point in space. Vector analysis and matrix methods are introduced as aids in the mathematical analysis. **Prerequisite:** EM 202 or permission of instructor.

EM 881—SPECIAL PROBLEMS—3 cr.

Experience is provided in the development and solution of an assigned comprehensive problem in the student's major area of interest. A report of findings is required.

EM 889, 890—SEMINAR—1 cr. (1 and 0)

(May be taken more than one semester.)

EM 891—RESEARCH—Credit to be arranged.

EM 932—THEORY OF PLASTICITY—3 cr. (3 and 0)

Development of the fundamental equations of the theory of plasticity. Yield criteria, yield surfaces, plastic stress-strain relations, considerations of perfectly plastic and strain-hardening materials and methods and solutions for a number of specific problems. **Prerequisite:** EM 831.

EM 980, 981, 982, 983—SPECIAL TOPICS IN MECHANICS—3 cr. (3 and 0)

Directed study of advanced topics in both solid and fluid mechanics. Intended to develop in depth the candidate's area of particular interest.

EM 991—DOCTORAL RESEARCH—Credit to be arranged.

The catalog description for the following interdepartmental Fluid Mechanics courses are given on pages 130 to 132.

FM 801—FOUNDATION OF FLUID MECHANICS—3 cr. (3 and 0)

FM 811—EXPERIMENTAL FLUID MECHANICS—3 cr. (2 and 3)

FM 812—THEORY OF INCOMPRESSIBLE IDEAL FLOW—3 cr. (3 and 0)

FM 814—TURBULENT BOUNDARY LAYER—3 cr. (3 and 0)

FM 815—NUMERICAL METHODS IN FLUID MECHANICS—3 cr. (3 and 0)

FM 816—FLOW IN OPEN CHANNELS—3 cr. (3 and 0)

FM 817—NON-NEWTONIAN FLOW—3 cr. (3 and 0)

FM 841—SEMINAR—1 cr. (1 and 0)

FM 901—APPLIED HYDRODYNAMICS—3 cr. (3 and 0)

FM 921—TWO-PHASE FLOW—3 cr. (3 and 0)

FM 931—FREE SURFACE FLOW—3 cr. (3 and 0)

FM 951—BIO-FLUID MECHANICS—3 cr. (3 and 0)

ENVIRONMENTAL SYSTEMS ENGINEERING

J. H. Austin, Head, Department of Environmental Systems Engineering

Courses are offered leading to the Master of Engineering, Master of Science, and Doctor of Philosophy degrees.

Environmental systems engineering is an interdisciplinary field concerned with the engineering aspects of the understanding and control of man's environment. Emphasis is placed on applying basic principles of the sciences through research and design to environmental engineering problems. The unit operations-unit processes approach is emphasized in both academic work and research.

The M.Engr., M.S., and Ph.D. programs of study are planned to augment the student's previous engineering or science background with specialization in the design, operations and management areas of water quality control or air quality control. In addition to students with a B.S. degree in any branch of engineering, students from chemistry, physics, and biology with a strong mathematical background may be admitted to the program with appropriate prerequisites.

The curriculum for the M.S. and M.Engr. degrees is designed to meet the needs of individual students. One calendar year is normally required to complete the requirements for the M.S. and M.Engr. degrees. A formal thesis is optional with the committee which directs the M.S. program of each student. No foreign language is required for the master's degree.

The program of study for the Ph.D. degree is flexible and depends upon the background and objectives of the candidate. The Ph.D. candidate

will select at least one minor from other engineering disciplines or the sciences. The major field of study will be interdisciplinary in nature, consisting of courses in several areas of engineering and the basic sciences with research being guided by ESE faculty. No foreign language is required for the Ph.D. degree.

ESE 601—ENVIRONMENTAL ENGINEERING—3 cr. (3 and 0)

ESE 602—WATER AND WASTE TREATMENT SYSTEMS—3 cr. (3 and 0)

ESE 603—WATER AND WASTE TRANSPORT SYSTEMS—3 cr. (3 and 0)

ESE 643—ENVIRONMENTAL ENGINEERING CHEMISTRY I—2 cr.
      (2 and 0) F

ESE 644—ENVIRONMENTAL ENGINEERING CHEMISTRY LABORA-
      TORY I—2 cr. (0 and 6) F

ESE 701—SPECIAL PROBLEMS—1-4 cr. (1-4 and 0)

Problems are selected in the field of environmental engineering to meet the interests and experience of student and instructor. A bound and printed report is required. For Master of Engineering students only.

ESE 802—PRINCIPLES OF WATER TREATMENT SYSTEMS—4 cr.
      (4 and 0)

An intensive study of the fundamental principles that are of important to water and wastewater treatment systems. Topics that are discussed include the principles of biological and chemical reactions, mass and heat transfer, reactor kinetics, adsorption and ion exchange, classification and thickening, transient response analysis and control theory, and methods of operations research.

ESE 803—LABORATORY IN PRINCIPLES OF WATER TREATMENT—
      1 cr. (0 and 3)

Demonstrations and selected laboratory exercises which illustrate the fundamental principles of water and wastewater treatment systems. Typical topics investigated include respirometer studies, reactor systems, dispersion, gas transfer, adsorption, thickening, and control systems. Emphasis is placed on the relation between theory and experimental results. **Prerequisite:** ESE 802 or concurrent registration in ESE 802.

ESE 804—DESIGN AND OPERATION OF WATER TREATMENT
      SYSTEMS—4 cr. (4 and 0)

An investigation of the design and operational criteria that are significant to the processes employed for the treatment of water and wastewater. Topics discussed include coagulation and flocculation, filtration, adsorption and ion exchange, membrane separation, chemical precipitation and water stabilization, chemical oxidation and disinfection, activated sludge, fixed-film biological reactors, anaerobic digestion, solids handling

and disposal, and municipal and industrial economics. **Prerequisite:** ESE 802, ESE 803.

ESE 805—LABORATORY IN DESIGN AND OPERATION OF WATER
   TREATMENT SYSTEMS—1 cr. (0 and 3)

Laboratory exercises in selected water and wastewater treatment processes. Coagulation, flocculation, filtration, reverse osmosis, softening, activated sludge, anaerobic digestion, and sludge handling and disposal are typical topics studied. Emphasis is directed toward the operation of these processes and on securing suitable design parameters. **Prerequisites:** ESE 802, ESE 803, ESE 804 or concurrent registration in ESE 804.

ESE 806—INTEGRATED PROBLEMS IN WATER TREATMENT
   SYSTEMS—2 cr. (2 and 0)

Integration of the processes involved in water and wastewater treatment into complex systems. Emphasis will be placed on functional design and operation through consideration of process economics and plant control systems. The team approach will be employed in the design and analysis of several integrated water treatment systems. **Prerequisites:** ESE 802, ESE 803, ESE 804, ESE 805.

ESE 846—POLLUTION OF THE AQUATIC ENVIRONMENT—3 cr.
   (3 and 0) S

A study of the effects of pollution resulting from domestic and industrial wastes upon the physical, chemical, and biological characteristics of natural waters.

ESE 847—POLLUTION OF THE AQUATIC ENVIRONMENT LABORA-
   TORY—1 cr. (0 and 3) S

Field and laboratory investigations into physical, chemical, and biological effects resulting from pollution of the aquatic environment.

ESE 848—ENVIRONMENTAL ENGINEERING CHEMISTRY—2 cr.
   (2 and 0) S

Applications of the principles of organic and biochemistry to the problems of environmental control, waste treatment, and bioengineering. **Prerequisite:** ESE 643 or permission of instructor.

ESE 849—ENVIRONMENTAL ENGINEERING CHEMISTRY LABORA-
   TORY II—2 cr. (1 and 3) S, alternate years.

Theory and application of instrumental methods of analysis as applied to measurements for environmental control. Spectroscopy and spectrophotometric techniques, electrochemical analyses, chromatographic methods of analysis, and light scattering and electrophoretic measurements are discussed in detail and demonstrated in the laboratory.

Demonstrations and selected experiments in interfacing analytical instruments with the small digital computer are conducted.

129

ESE 860—ECOLOGICAL MODELS—3 cr. (2 and 3)

Systems analysis applied to ecology. Construction of models which predict ecological consequences of abuses to the environment. Frequency response analysis, energy models, information flow, and transfer functions for population interactions. **Prerequisites:** BioE 601, a course in ecology or directed outside reading.

ESE 861—ENVIRONMENTAL SYSTEMS ENGINEERING SEMINAR— 1 cr. (1 and 0) F, S

A discussion of current advances and research developments in various areas of environmental engineering. Off-campus speakers, students, and faculty will participate.

ESE 862—ENVIRONMENTAL QUALITY CASE STUDY—1 cr. (0 and 3) F

An in-depth analysis and investigation of a significant current or recent situation affecting or involving some facet of environmental quality. The study will be conducted by a team of students and will result in a comprehensive position paper which integrates the pertinent social, political, and economic considerations in the case with the technical aspects.

ESE 881—SPECIAL PROBLEMS—1-4 cr., F, S, SS

Problems are selected in the field of environmental engineering to meet the interests and experience of student and instructor.

ESE 883—SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING— 1-4 cr.

A comprehensive study of a topic in the field of environmental engineering that is not covered in another course. Topics covered will vary to keep pace with current developments. May be taken concurrently with ESE 884 which (if offered) would be a different topic.

ESE 884—SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING— 1-4 cr.

A comprehensive study of a topic in the field of environmental engineering that is not covered in another course. Topics covered will vary to keep pace with current developments. May be taken concurrently with ESE 883 which (if offered) would be a different topic.

ESE 891—RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

ESE 991—DOCTORAL RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

FLUID MECHANICS SEQUENCE

The courses listed are offered by the faculties of the Departments of Chemical Engineering, Engineering Mechanics, and Mechanical Engineer-

ing for students majoring in those departments who desire an area of concentration in fluid mechanics. This integrated sequence provides the opportunity for in-depth penetration of this study area as well as breadth of application to such diverse fields of technology as: propulsion systems, water distribution systems, chemical systems, biological systems, and air and water pollution.

FM 801*—FOUNDATION OF FLUID MECHANICS—3 cr. (3 and 0) F

The basic equations for multi-dimensional flow fields are derived. Analytical techniques for solving laminar inviscid flows are introduced and discussed. Theories of similitude are introduced. **Prerequisite:** Graduate standing and permission of instructor.

FM 811*—EXPERIMENTAL FLUID MECHANICS—3 cr. (2 and 3) S

Techniques and fundamental principles in measuring fluid properties, velocity, pressure, temperature and methods of flow visualization are presented in theory sessions. Details of the instrumentations are introduced in lab sessions. **Prerequisite:** FM 801.

FM 812—THEORY OF INCOMPRESSIBLE IDEAL FLOW—3 cr. (3 and 0) S

Analytical treatment of the flow of an inviscid fluid. Topics to be covered include: superposition of flows, distributing singularities, conformal mapping and non-steady flow problems. **Prerequisite:** FM 801.

FM 814*—TURBULENT BOUNDARY LAYER—3 cr. (3 and 0) S

Semi-empirical theories on Reynolds stress terms are introduced. Analytical methods of solving turbulent boundary layer momentum and energy equations are discussed for flows with pressure gradient and/or heat transfer. Theories pertinent to experimental techniques used for turbulent boundary layer study are presented. **Prerequisite:** FM 801.

FM 815—NUMERICAL METHODS IN FLUID MECHANICS—3 cr. (3 and 0) F

Examines stability and convergence and develops numerical solution techniques. Applications from the literature will be reviewed which will range from hydrodynamic shocks to flow in ocean or lakes, depending on the interest of the class. Finite element techniques, solution of efficiency, generalized coordinate systems, and coordinate extensions will also be discussed. **Prerequisite:** FM 801.

FM 816*—FLOW IN OPEN CHANNELS— 3 cr. (3 and 0) S

Consideration of free surface flow problems including applications of digital computer, concepts of boundary layer theory, uniform and varied flow, the hydraulic jump, design criteria for prismatic channels and transi-

---

*These courses will be offered on **fixed schedule.** All other courses are offered as needed.

tions, and some applications of unsteady flow. **Prerequisite:** Graduate standing and permission of instructor.

FM 817*—NON-NEWTONIAN FLOW—3 cr. (3 and 0) S

Covers rheology, experimental classification, and viscometry of non-Newtonian fluids such as polymer melts and solutions. Also design procedures for flow, mixing and heat transfer of non-Newtonian fluids are considered. **Prerequisite:** Graduate standing and permission of instructor.

FM 841—SEMINAR—1 cr. (1 and 0) F, S

Required for all graduate students with major interest in fluid mechanics.

FM 901—APPLIED HYDRODYNAMICS—3 cr. (3 and 0)

The theories of classical hydrodynamics are applied to multiple body problems. Special emphasis will be given to internal flows. **Prerequisites:** FM 812, 815.

FM 921—TWO-PHASE FLOW—3 cr. (3 and 0)

The basic techniques of analyzing one-dimensional two-phase flows will be developed. Their applicability to a wide variety of practical problems will be demonstrated. Particular attention will be given to the current literature on the "Suspensions of Particles in Fluids." **Prerequisites:** FM 801, 814 or permission of instructor.

FM 931—FREE SURFACE FLOW—3 cr. (3 and 0)

Study of classical hydrodynamic theories applied to deep and shallow wave problems. Special emphasis will be given to flows in estuaries. **Prerequisite:** FM 816.

FM 951—BIO-FLUID MECHANICS—3 cr. (3 and 0)

Pulsating flow in artificial systems and steady flow in capillary distributed systems are studied. **Prerequisite:** FM 801.

MATERIALS ENGINEERING

J. S. Wolf and C. C. Fain, Program Co-Ordinators

Courses are offered leading to the Master of Science degree.

Students who possess a baccalaureate degree in engineering or science may be accepted for graduate study in the Materials Engineering program. This is a multidisciplinary program in which the relationship between the structures and the properties of materials are emphasized in order to provide an understanding of material behaviors in a variety of applications.

To accomplish this understanding, the student is exposed to learning experiences in the fields of chemistry, engineering, mathematics, and

physics in order to comprehend and be able to predict the properties and behaviors of ceramics, metals, and polymers. The student may select areas of concentration in either materials science or the industrial application of materials. Further study in specific areas of interest to the student is accomplished by taking specialized courses associated with his research which, in turn, will culminate in an M.S. thesis.

Mat E 605—PHYSICAL METALLURGY I—3 cr. (3 and 0)

Mat E 606—PHYSICAL METALLURGY II—3 cr. (3 and 0)

Mat E 608—PRINCIPLES OF POLYMER SCIENCE I—3 cr. (3 and 0)

Mat E 609—PRINCIPLES OF POLYMER SCIENCE II—3 cr. (3 and 0)

Mat E 621—MECHANICAL METALLURGY—3 cr. (3 and 0)

Mat E 650—SPECIAL TOPICS IN MATERIALS ENGINEERING—1-4 cr.

Mat E 651—CORROSION OF MATERIALS—3 cr. (2 and 3)

Mat E 661—ELEMENTS OF METALLURGY—3 cr. (2 and 3)

Mat E 662—HEAT TREATMENT OF STEELS—3 cr. (2 and 3)

Mat E 663—METALLURGY OF WELDING AND NON-DESTRUCTIVE TESTING—3 cr. (2 and 3)

Mat E 664—INDUSTRIAL CORROSION OF METALS—3 cr. (2 and 3)

Mat E 665—INTRODUCTION TO PLASTICS—3 cr. (3 and 0)

Mat E 800—SEMINAR IN MATERIALS RESEARCH—1 cr. (1 and 0)
Presentation and discussion of special topics and original research in materials engineering. Required of all materials engineering graduate students each semester in residence. (Credit may be earned for more than one semester.)

Mat E 802—RESEARCH TECHNIQUES IN PHYSICAL METALLURGY— 3 cr. (2 and 3)
A study of advanced x-ray diffraction, field ion microscopy, electron microscopy, neutron diffraction, torsional pendulum, advanced optical microscopic methods, radioactive tracer techniques, methods employed to study metal structure and interpretation of experimental data in terms of metallic structure.

Mat E 805—PHYSICAL METALLURGY I—3 cr. (3 and 0)
A study of the structure and properties of the metallic state, the relation between structural characteristics of the metallic state, and the properties of metals. Topics covered will include: quantum states, free electron theory, wave mechanics, Fermi-Dirac distribution, zone theory, band

theory, types of cohesion, metallic bonding, conductors, semi-conductors and insulators, paramagnetism, diamagnetism, ferromagnetism, antiferromagnetism, point defect, dislocations, anelasticity, solid state transformations, martensitic transformations, structure sensitive and insensitive properties, liquid to solid transformations.

Mat E 806—PHYSICAL METALLURGY II—3 cr. (3 and 0)

A continuation of Mat E 805.

Mat E 807—PHYSICAL PROPERTIES OF POLYMERS—3 cr. (3 and 0)

Application of osmometry, light scattering, equilibrium ultracentrifugation, electrophoresis, viscosity, diffusion, ultracentrifuge sedimentation, flow birefringence, polarimetry, spectroscopy, x-ray and electron diffraction, infrared adsorption, nuclear magnetic resonance, electron microscopy and other techniques to the characterization of polymers. The treatment of experimental data to obtain information on average molecular weight, molecular weight distribution, chemical heterogeneity and molecular configurations. Theory of rubberness. Rheology of concentrated solutions and polymer melts. **Prerequisite:** Permission of instructor.

Mat E 808—MECHANICAL PROPERTIES OF POLYMERS—3 cr.
            (3 and 0)

Study of mechanical behavior of polymers related to molecules and aggregate structure. Viscoelastic responses of amorphous, crystalline and elastomeric materials in stress-strain tests, creep, stress relaxation and dynamic tests. Thermal properties, phase transition, electrical properties, surface properties, impact tests, and effect of fabrication and previous history on mechanical behavior. **Prerequisite:** Permission of instructor.

Mat E 810—DIFFUSION IN SOLIDS—3 cr. (3 and 0)

Solution to diffusion equations for various solid state processes. Atomistic approach to diffusion. Detailed discussion of diffusion in alloys and ionic materials. Special topics presented include surface diffusion, grain boundary diffusion, liquid diffusion, diffusion in glass, and oxidation.

Mat E 811—KINETICS OF HETEROGENEOUS REACTIONS—3 cr.
            (3 and 0)

Theoretical and phenomenological aspects of heterogeneous solid-gas solid-liquid, and solid-solid reactions. Factors influencing stability of phases as a function of composition, temperature, pressure, etc. Nucleation in solids. Rate of growth of one phase into another. Typical morphologies and their origin. Selected examples of different types of solid-solid reactions as typified by the formation of austenite and its decomposition. Recovery, recrystallization, and grain growth.

Mat E 812—METALLURGICAL THERMODYNAMICS—3 cr. (3 and 0)

The application of thermodynamic principles to reactions of metallic materials with one another and with their surroundings. Development of

the thermodynamic properties of materials and the practical consequences thereof. Special emphasis on graphical description of equilibria and the reactions of metallic systems not at equilibrium.

Mat E 814—SURFACE CHEMISTRY OF MATERIALS—3 cr. (3 and 0)

Thermodynamic, kinetic, and chemical factors underlying surface and interfacial phenomena. Intermolecular forces, orientation at interfaces and the origins of surface tension. Capillarity and the effects of surface curvature on bulk phase properties. Thermodynamics of adsorption at interfaces; the Gibbs adsorption isotherm. Electrical phenomena at interfaces; origins of surface potential, structure of the diffuse double-double layer, electrokinetic phenomena. Surface-active agents, contact angles, spreading, and wetting phenomena.

Mat E 815—APPLICATIONS OF HETEROGENEOUS EQUILIBRIA—3 cr. (3 and 0)

Systematic development and geometric character of equilibrium diagrams with special emphasis on condensed phases. Considerations involve the equilibrium and natural solidification of materials including synthesis and analysis of microstructure.

Mat E 820—DEFORMATION MECHANISMS IN SOLIDS—3 cr. (3 and 0)

An introduction to the dislocation theory of solids. Mechanisms of plastic deformation in single crystals and polycrystalline aggregates of metals as well as non-metals will be studied. A study of ductile and brittle fractures will be followed by an analysis of fatigue, creep and stress corrosion cracking in metals. **Prerequisite:** Mat E 304 or equivalent.

Mat E 821—STRENGTH MECHANISMS IN SOLIDS—3 cr. (3 and 0)

An introductory review of significant strengthening mechanisms will be followed by a detailed study of the mechanisms leading to strengthening by solid solution formation, strain hardening, martensitic transformations and age and dispersion hardening. Developments in strengthening of ionic solids, surface effects and fiber composites will also be studied. **Prerequisite:** Mat E 820.

Mat E 831—QUANTUM THEORY OF METALS I—3 cr. (3 and 0)

Systematic development and exploration of the wave mechanics of electrons in metals. Discussion of many electron systems, metallic cohesion, and Brillouin zones with an introduction to Fermi surfaces. **Prerequisite:** Permission of instructor.

Mat E 835—X-RAY METALLOGRAPHY—3 cr. (2 and 3)

The practical utilization, through analysis, of diffraction phenomena as based on the reciprocal lattice concept and with special emphasis upon x-ray diffraction phenomena. Includes introduction to x-ray physics, crystallography, camera and diffractometer techniques, texture analysis, ordering, stress analysis, phase diagram synthesis and crystal defect ef-

fects. Laboratory emphasis is on equipment, pattern analysis, and problem solving techniques. **Prerequisites:** Phys 222 and Math 309, or their equivalents.

Mat E 841—SINTERING AND RELATED PHENOMENA—3 cr. (3 and 0)

Manufacture of metal powders — physical and chemical principles involved, the theory and practice of pressing, sintering and pressureless sintering of powders; powder rolling, extrusion, hot-pressing, explosive forming; grain growth during sintering and its influence on mechanical properties; control of porosity and effect of porosity on mechanical properties; studies of cermets, magnets and electrical equipment produced by powder metallurgy.

Mat E 850—SPECIAL TOPICS IN MATERIALS ENGINEERING—3 cr.
        (3 and 0)

Directed study of advanced topics in materials engineering intended to develop in-depth areas of particular students interest. (Credit may be earned for more than one semester.) **Prerequisite:** Permission of instructor.

Mat E 851—OXIDATION OF METALS AND ALLOYS—3 cr. (3 and 0)

Enumeration and description of the physical processes involved in the high-temperature oxidation of metals and alloys. Consideration of adsorption and solution of gases, nucleation and growth of oxides, defects in ionic lattices, diffusion in ionic solids, and their interplay in both classical and non-classical analyses of oxidation processes. **Prerequisite:** Permission of instructor.

Mat E 891—RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

MECHANICAL ENGINEERING

E. H. Bishop, Head, Department of Mechanical Engineering

Courses are offered leading to the Master of Engineering, Master of Science, and Doctor of Philosophy degrees.

Students will be accepted into the graduate program with backgrounds in physics, applied mathematics, or all branches of engineering. Programs of study may be followed which have majors in applied mechanics, automatic controls, dynamic systems analysis, energy conversion, engineering design, fluid mechanics, heat transfer, machine design and thermodynamics.

ME 601—DESIGN OF MACHINE ELEMENTS—3 cr. (3 and 0)

ME 602—INNOVATIVE DESIGN III—3 cr. (2 and 3)

ME 604—AUTOMATIC CONTROL—3 cr. (3 and 0)

ME 608—INTRODUCTION TO COMPUTER-AIDED DESIGN—3 cr.
(3 and 0)

ME 611—THERMAL POWER SYSTEMS—3 cr. (3 and 0)

ME 622—PRINCIPLES OF TURBOMACHINERY—3 cr. (3 and 0)

ME 625—KINEMATICS: KINEMATIC ANALYSIS OF MACHINES—3 cr.
(3 and 0)

ME 650—VENTILATION DESIGN AND OPERATION—3 cr. (2 and 3)

ME 651—CONTROL OF PHYSICAL STRESSES—3 cr. (3 and 0)

ME 652—SAFETY ENGINEERING—3 cr. (2 and 3)

ME 801—THERMAL ENVIRONMENTAL ENGINEERING—3 cr. (3 and 0)

A study of the effects of the thermal environment upon people, processes, and materials including a detailed analysis of the fundamental theories of refrigeration, psychrometrics, heat and mass transfer processes with moist air, periodic heat transfer in buildings, solar radiation, and cryogenics.

ME 807—MECHANICAL SYSTEMS I—3 cr. (3 and 0)

An integration of selected topics from strength of materials, elasticity, kinematics and dynamics. Topics covered include applications of failure theories of the mechanism of fatigue of machine parts, nature of stress and strain in three dimensional anisotropic engineering materials, computer synthesis and analysis of planar linkages, particle and rigid body dynamics applied to engineering systems, acceleration relative to a moving coordinate system and energy techniques. Application of these topics will be stressed in homework and two projects requiring integration of concepts from all areas presented.

ME 808—MECHANICAL SYSTEMS II—3 cr. (3 and 0)

A continuation of Mechanical Systems I. Will cover equations of elasticity, dynamics of distributed systems, three-dimensional kinematics and Lagrange's equations. As in Mechanical Systems I, application of concepts will be stressed and two design projects will be required.

ME 809—THERMAL SYSTEMS I—3 cr. (3 and 0)

The derivation and the application of the equations of fluid mechanics and heat transfer to the analysis and design of heat transfer and fluid systems. Emphasis is placed on developing the ability to identify and analyze primary problem areas affecting the performance of mechanical engineering thermal and fluid systems.

ME 810—THERMAL SYSTEMS II—3 cr. (3 and 0)

A comprehensive review of the first and second laws, entropy, and general thermodynamics relations. An introduction to statistical thermodynamics and kinetic theory of gases. A systematic examination of power systems with emphasis on performance analysis of real systems.

137

ME 811—GAS DYNAMICS—3 cr. (3 and 0)

Concepts from thermodynamics, one-dimensional gas dynamics, one-dimensional wave motion, normal and oblique shocks. Flow in ducts and wind tunnels. Two-dimensional equation of motion. Small perturbation theory. **Prerequisite: ME 809.**

ME 813—ADVANCED GAS DYNAMICS—3 cr. (3 and 0)

Rayleigh-Janzen method: Prandtl-Glauert Method; Hodograph method and Karman Tsien approximation. Exact solutions in irrotational flow. The method of characteristics of supersonic flows and shock tubes. **Prerequisite: ME 811.**

ME 815—KINETIC THEORY OF GASES—3 cr. (3 and 0)

Kinetic theory of gases, Maxwell velocity distribution, equipartition of energy, Maxwell-Boltzmann statistics, Bose-Einstein statistics and Fermi-Dirac statics. **Prerequisite: ME 810.**

ME 816—ENERGY CONVERSION—3 cr. (3 and 0)

A study of energy conversion by non-mechanical means. Thermionics, thermoelectric effects, fuel cells and magnetohydrodynamics will be covered. **Prerequisite: Permission of instructor.**

ME 824—PROPULSION SYSTEMS—3 cr. (3 and 0)

A study of thermochemical reaction processes employing both the microscopic and macroscopic method of analysis. Detail study of the chemical reaction process and the associated effect of chemical dissociation in the field of thermal jets and rockets. **Prerequisite: ME 411 or equivalent.**

ME 830—HEAT TRANSFER—3 cr. (3 and 0)

Physical properties; derivation of general conduction equation; solutions for steady state and transient one-, two-, and three-dimensional cases. Radiation phenomena; solutions for multibody systems, including gases, liquids and solids. **Prerequisites: ME 304 or equivalent, and Math 208.**

ME 831—HEAT AND MASS TRANSFER—3 cr. (3 and 0)

Derivation of continuity, momentum and energy equations for boundary layer flow; solutions for confined and external flow regimes, with and without phase change. Derivation of mass transfer relations; solutions for mass transfer in laminar and turbulent flow. **Prerequisites: ME 304 or equivalent, and Math 208.**

ME 840—KINEMATICS—3 cr. (3 and 0)

Space mechanisms. Analysis and synthesis of linkages. Coupler curves. Inflection circle curvature. Euler-Savary equation. Polode curvature. Finite displacements.

**ME 842—ADVANCED MECHANICAL ENGINEERING DESIGN I—3 cr.
(3 and 0)**

Optimization techniques, decision theory, probabilistic approaches to design, and the principles of mechanical sciences applied to the analysis and design of machines, devices and engineering systems. **Prerequisite:** ME 401 or permission of instructor.

**ME 843—ADVANCED MECHANICAL ENGINEERING DESIGN II—
3 cr. (3 and 0)**

Continuation of ME 842. **Prerequisite:** ME 842.

ME 845—ACOUSTICS—3 cr. (3 and 0)

The study of the fundamental principles underlying the generation, transmission, and reception of energy in the form of vibrational waves in matter. Acoustic waves, transmission phenomena, absorption of sound waves in fluids and solids are studied. **Prerequisite:** EM 450/650.

ME 867—CONTROL SYSTEM COMPONENTS—3 cr. (3 and 0)

A study of the control systems components from the standpoint of performance specification and for mathematical models and laboratory evaluation of components and systems by transient and frequency response methods. **Prerequisite:** ME 404 or equivalent.

ME 891—RESEARCH—Credit to be arranged.

**ME 893—SELECTED TOPICS IN MECHANICAL ENGINEERING—1-6 cr.
(1-6 and 0)**

A comprehensive study of any topic in the field of mechanical engineering not covered in other courses. (May be repeated for credit.)

ME 894—SEMINAR—1 cr. (1 and 0)

Study of selected original research papers. Selected literature will range from mathematical-theoretical to experimental-applied. Published papers presented by students or invited lecturers will form the basis for discussions relative to new developments in mechanical engineering.

ME 914—MAGNETOHYDRODYNAMICS—3 cr. (3 and 0) S

Review of electrodynamics, conduction of electricity in gases. Equation of motion of magnetohydrodynamics. Solutions for special cases and various approximations. Magnetohydrodynamo waves and shocks. Application to propulsion.

ME 915—ENERGY CONVERSION—3 cr. (3 and 0)

A study of energy conversion by non-mechanical means. Thermionics, thermoelectric effects, fuel cells and magnetohydrodynamics will be covered. **Prerequisite:** Permission of instructor.

ME 930—CONDUCTION HEAT TRANSFER—3 cr. (3 and 0) S

Physical properties; steady conduction in one and two-dimensional systems; periodic and transient systems; heat conduction with change in phase; moving heat sources. **Prerequisite:** ME 407.

ME 931—CONVECTION HEAT TRANSFER—3 cr. (3 and 0) F

Analytical solutions for laminar and turbulent boundary layers; similarity relations for heat convection; heat convection including change of phase. **Prerequisite:** ME 407.

ME 932—RADIATION HEAT TRANSFER—3 cr. (3 and 0) S

Radiation properties; analysis of radiation heat transfer; applications. **Prerequisite:** ME 407.

ME 940—APPLIED PLASTICITY—3 cr. (3 and 0)

Theory of plasticity applied to the mechanics of metal-forming, theoretical and descriptive accounts of tube-shrinking, deep-drawing, extrusion, hot and cold rolling, forging and cutting.

ME 941—THEORY OF LUBRICATION AND WEAR—3 cr. (3 and 0)

Applications of the principles of fluid mechanics, heat transfer, and material behavior to problems associated with bearings, lubrication and rotor dynamics. Friction, wear, hydrostatic and hydrodynamic lubrication, boundary lubrication, thermal effects on bearings, theory of turbulent lubrication and other topics of current interest are presented.

ME 991—DOCTORAL RESEARCH—Credit to be arranged.

The catalog descriptions for the following interdepartmental Automatic Control courses are given on pages 100 to 101.

AC 610—INTRODUCTION TO DIGITAL CONTROL—3 cr. (3 and 0)

AC 810—MODELING AND CONTROL OF ENGINEERING SYSTEMS—
3 cr. (3 and 0)

AC 811—MODERN CONTROL THEORY—3 cr. (3 and 0)

AC 815—NONLINEAR CONTROLS—3 cr. (3 and 0)

AC 820—DIGITAL CONTROL I—3 cr. (3 and 0)

AC 821—DIGITAL CONTROL II—3 cr. (3 and 0)

AC 910—ADAPTIVE AND OPTIMAL CONTROL—3 cr. (3 and 0)

The catalog descriptions for the following interdepartmental Fluid Mechanics are given on pages 130 to 132.

FM 801—FOUNDATION OF FLUID MECHANICS—3 cr. (3 and 0) F

FM 811—EXPERIMENTAL FLUID MECHANICS—3 cr. (2 and 3) F

FM 812—THEORY OF INCOMPRESSIBLE IDEAL FLOW—3 cr.
(3 and 0) S

FM 814—TURBULENT BOUNDARY LAYER—3 cr. (3 and 0) S

FM 815—NUMERICAL METHODS IN FLUID MECHANICS—3 cr.
(3 and 0) F

FM 816—FLOW IN OPEN CHANNELS—3 cr. (3 and 0) S

FM 817—NON-NEWTONIAN FLOW—3 cr. (3 and 0) S

FM 841—SEMINAR—1 cr. (1 and 0) F, S

FM 901—APPLIED HYDRODYNAMICS—3 cr. (3 and 0)

FM 921—TWO-PHASE FLOW—3 cr. (3 and 0)

FM 931—FREE SURFACE FLOW—3 cr. (3 and 0)

FM 951—BIO-FLUID MECHANICS—3 cr. (3 and 0)

SYSTEMS ENGINEERING

E. L. Thomas, Jr., Program Coordinator

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

The Systems Engineering program is an interdisciplinary field of study supported by departments within the College of Engineering. This program is problem oriented rather than theoretical in nature. Systems engineering, in attacking problems, considers the total environment in which the problem resides and uses the tools of operations research, statistics, numerical analysis, computer engineering and simulations in the analysis.

The multidisciplinary Systems Engineering program is designed to provide a balanced study across engineering, and as needed, advanced work in the humanities, all grouped with computer technology. The problem is identified in analysis, solved in synthesis and validated by simulation and other modeling tools.

Students with a bachelor's degree in engineering or sciences may be accepted for graduate study in systems engineering. Students with other

backgrounds may be accepted but will be required to make up certain prerequisite courses before formal entrance into the program.

Students majoring in systems engineering can concentrate in one of the following areas: bioengineering, computer engineering, construction management systems, environmental systems engineering, mechanical engineering, industrial management, or socio-economic systems.

SE 680—METHODS OF OPERATIONAL RESEARCH I—3 cr. (3 and 0)

SE 681—METHODS OF OPERATIONAL RESEARCH II— 3 cr. (3 and 0)

SE 684—ENGINEERING ECONOMIC ANALYSIS—3 cr. (3 and 0)

SE 686—WORK FLOW AND CONTROL—3 cr. (3 and 0)

SE 802—FOUNDATIONS AND METHODOLOGY OF SYSTEMS ENGI-
        NEERING—3 cr. (3 and 0) F
Definition of systems engineering, fundamental concepts of systems engineering, subsystems, environments for systems, microscopic aspects of systems. Problem definitions of technical and economic environment, theory of value and needs and decision making are studied.

SE 803—ENGINEERING APPLICATIONS OF OPTIMIZATION—3 cr.
        (3 and 0) F
Optimization without constraints. Maximizing under constraining conditions. Linear programming, separable programming and quadratic programming. Use of analog and hybrid computers in optimization studies. Optimal control using state-space formulations and dynamic programming.

SE 804—ADVANCED PHYSICAL SYSTEM ANALYSIS—3 cr. (3 and 0) S
Complex problem formulation using component terminal equations and linear graph theory. Instrumentation and measurement processes for multi-terminal subsystems. Nonlinear systems and the state model formulation. Solutions to mixed systems of algebraic and differential equations.

SE 805—ANALYTICAL METHODS OF SYSTEMS ANALYSIS—3 cr.
        (3 and 0)
Application of selected mathematical topics from operations research and systems engineering such as linear algebra, graph theory, topology, calculus of finite differences and operational calculus. **Prerequisite:** Permission of instructor.

SE 808—CONTINUOUS SYSTEMS SIMULATION—3 cr. (3 and 0)
An introduction to feedback type simulation models and their use in analyzing business, governmental, and military programs. The concept of industrial dynamics is stressed along with the simulation language DYNAMO. **Prerequisite:** Permission of instructor.

SE 809—DISCRETE SYSTEMS SIMULATIONS—3 cr. (3 and 0)

An introduction to discrete and Monte Carlo simulation. This type of simulation is used to model and study indeterminant operational systems. The simulation language GPSS is presented and used. **Prerequisite:** Permission of instructor.

SE 860—DYNAMIC PROGRAMMING—3 cr. (3 and 0)

The theory and methodology of dynamic programming. Topics included are calculus of variations, Bellman's Principle of Optimality, multistage optimization countercurrent flow, adaptive control. **Prerequisite:** Permission of instructor.

SE 861—NONLINEAR PROGRAMMING—3 cr. (3 and 0)

The theory and methodology of nonlinear programming including classical optimization techniques, separable programming, stochastic programming, quadratic programming, integer programming, and gradient methods. **Prerequisite:** Permission of instructor.

SE 880—ADVANCED METHODS OF OPERATIONS I—3 cr. (3 and 0)

Application and theory of selected topics from operations research such as linear programming, network analysis, game theory and simulation. **Prerequisite:** Math 301 or equivalent.

SE 881—ADVANCED METHODS OF OPERATIONS RESEARCH II—3 cr. (3 and 0)

A continuation of SE 880. Topics included are nonlinear programming, dynamic programming, queuing theory, and stochastic processes. **Prerequisite:** SE 880.

SE 882—RELIABILITY ENGINEERING—3 cr. (3 and 0)

The statistical study of reliability of life testing. The reliability of series, parallel, and non-serial systems are analyzed. **Prerequisites:** Math 402/602 or equivalent and permission of instructor.

SE 885—DESIGN AND ANALYSIS OF SIMULATION MODELS—3 cr. (3 and 0)

A theoretical study of the design and validation of simulation models of the operations research type. Included is an advanced analysis of the statistical properties of input data of these models. **Prerequisites:** SE 809 and Ex St 805 or equivalent.

SE 886—OPERATIONS RESEARCH IN PRODUCTION CONTROL I—3 cr. (3 and 0)

The latest techniques in scientific inventory management, scheduling, and forecasting are presented. Operations research, statistics, and computer methods are used along with case studies.

SE 887—OPERATIONS RESEARCH IN PRODUCTION CONTROL II—
    3 cr. (3 and 0) S

A continuation of SE 886. **Prerequisite:** SE 886.

SE 890—SPECIAL TOPICS IN SYSTEMS ENGINEERING—1-6 cr.
    (1-6 and 0)

A comprehensive study of special topics in the field of systems engineering not covered in other courses. Special emphasis will be placed on studies of the current literature and results of recent and current research. The topics will be expected to change from year to year in keeping with developments in the field. Can be repeated for additional credit.

SE 891—RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

SE 895—SYSTEMS ENGINEERING SEMINAR—1 cr. (1 and 0)

This seminar involves the graduate student in studies and discussions of specific industrial and governmental applications of systems engineering throughout the life cycle of the system. In addition, the course requires graduate students to present and lead discussions on current research and advanced techniques in systems engineering. **Prerequisite:** Permission of instructor.

SE 991—DOCTORAL RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

WATER RESOURCES ENGINEERING

B. C. Dysart III, Program Coordinator

Courses are offered leading to the Master of Engineering and Master of Science degrees.

Water resources engineering is an interdisciplinary graduate program encompassing several departments and colleges within the University. The area of emphasis within the program are water resources planning and management, surface water systems, ocean and coastal resources, and water-soil transport systems. The program is designed to provide training to meet the modern water resources challenges encountered in careers with industry, government agencies, and consulting firms.

The M.S. and M.Engr. curricula in Water Resources Engineering programs are designed to enhance and build upon the student's previous engineering or sciences background. The program is directed by a core faculty with representation from departments in the College of Engineering as well as several supporting departments in other colleges within the University.

The major and minor work can be selected from the offerings of a wide variety of departments in addition to the Water Resources Engineering program course listing. Both thesis and non-thesis options are available for the Master of Science degree.

WRE 650—WATER RESOURCES ENGINEERING—3 cr. (3 and 0)

WRE 660—PHYSICAL OCEANOGRAPHY—3 cr. (3 and 0)

WRE 661—OCEANOGRAPHICAL ENGINEERING—3 cr. (3 and 0)

WRE 811—CLIMATOLOGY—3 cr. (3 and 0)

Study of the physical factors that affect climate and the development of the general circulation patterns of the world. The climates of the world are discussed and related to the activities of man. **Prerequisite:** Permission of instructor.

WRE 812—METEOROLOGY—3 cr. (3 and 0)

A course designed to provide the student with a physical description of the atmosphere and its interactions with the earth. Topics include condensation and precipitation processes, energy exchange, wind systems, and weather development.

WRE 865—HYDROLOGY I—3 cr. (3 and 0)

A study of the hydrologic cycle as a hydrologic system. Most of this course deals with deterministic hydrology. All aspects of physical hydrology are treated with emphasis on a balanced approach to ground water hydrology and surface water hydrology. Other topics include meteorology, infiltration, soil moisture, and evapotranspiration. Probability analysis and partial system synthesis by unit hydrograph techniques are also studied. **Prerequisite:** Permission of instructor.

WRE 866—HYDROLOGY II—3 cr. (3 and 0)

A continuation of WRE 865. A portion of the semester deals with deterministic hydrology with emphasis on parametric hydrology including system synthesis and correlation analysis. Statistical hydrology, including time series analysis and stochastic hydrology, makes up the second part of the course. **Prerequisite:** WRE 865 or permission of instructor.

WRE 870—STREAM AND ESTUARINE ANALYSIS—3 cr. (3 and 0)

An integrated survey of the principal physical, chemical, and biological processes and relationships which exist in streams and estuaries. Emphasis is placed upon the estuarine environment, with free-flowing streams considered as a special case, and the several mechanisms which describe the transport of conservative and non-conservative materials through the estuarine system. The estuary is considered as a resource, and techniques

145

for its management are presented. **Prerequisite:** EM 320 or permission of instructor.

WRE 871—COASTAL HYDRODYNAMICS—3 cr. (3 and 0)

A unified treatment of applied hydrodynamics to coastal waters will be presented. The topics to be covered include gravity wave theory, tidal wave phenomenon, oceanic turbulence, and mathematical modeling of estuaries and bays. **Prerequisite:** EM 320.

WRE 872—MARINE POLLUTION CONTROL—2 cr. (2 and 0)

A survey of current technology and problems related to water quality management in the marine environment. Included will be both coastal and estuarine problems. In addition to a broad review of such issues, in-depth consideration will be given to several particularly important areas such as submarine outfall systems, disposal of dredged material and waste-water sludges, thermal and oil pollution, water quality instrumentation, monitoring, and surveillance in the marine environment, and design of oceanographic surveys required for water quality control. **Prerequisites:** EM 320 and ESE 601 or equivalent.

WRE 875—WATER RESOURCES PLANNING—3 cr. (3 and 0)

A comprehensive treatment of water resources planning with emphasis on river basin and regional aspects. Major topics considered include the purposes and objectives of water resources development, historical review of water resources development in the United States, changing emphasis over time, current practice and guidelines as well as new approaches and techniques, a review of public and private sector involvement in water resources planning and development, formulation of alternative plans and their analysis, public participation and resolution of conflicts, institutional and social dimensions of water resources planning, and plan implementation. Water quality and water quantity, and their interactions, are included in the planning process. **Prerequisite:** Permission of instructor.

WRE 876—WATER RESOURCES SYSTEMS—3 cr. (3 and 0)

A broad consideration of the water resources systems area. Particular emphasis is given to the application of current operations research and systems engineering techniques and their use in the analysis, evaluation, design, operation and management of water resources systems. Among the types of systems considered are water quality, hydrologic, integrated multipurpose systems including reservoirs, regional environmental control systems, power-generating facilities, and industrial water supply and pollution abatement systems. **Prerequisite:** Permission of instructor.

WRE 881—SPECIAL PROBLEMS IN WATER RESOURCES ENGINEER-
ING—1-4 cr. (1-4 and 0)

Individual directed study in some phase of water resources engineering. Emphasis may be on water quality, water quantity, the social-economic-

political aspects, or a blend thereof. The special problem topic is designed to utilize knowledge gained in formal course work and to further prepare the student for his particular professional goals. (May be taken more than one semester).

WRE 883—SELECTED TOPICS IN WATER RESOURCES ENGINEERING
—1-3 cr. (1-3 and 0)

An in-depth study of any topic in the broad field of water resources engineering which is not considered in existing courses. Emphasis is placed upon current developments in water resources. Topics covered will vary as necessary to keep pace with recent developments and to satisfy emerging needs in professional practice. (May be taken more than one semester.)

WRE 891—RESEARCH—Credit to be arranged.

College of Forest and Recreation Resources

W. H. D. McGregor, Dean

The College of Forest and Recreation Resources is concerned with the management, use, and stewardship of all our forest resources and with improving the quality of life through rewarding use of leisure. These two general areas of study offer broad opportunities in the management of our forest and recreation resources for their maximum service to present and future generations.

Graduate programs are available leading to the degrees Master of Science, Master of Forestry, and Master of Recreation and Park Administration.

FORESTRY

R. M. Allen, Head, Department of Forestry

Courses are offered leading to the Master of Science and Master of Forestry degrees.

Enrollment in the Master of Science and Master of Forestry programs is open to students having baccalaureate degrees in Forestry, Wood Utilization, and disciplines related to these fields. The candidate may be required to satisfy undergraduate deficiencies before being admitted to full status. A formal thesis is required for the Master of Science degree. For the Master of Forestry degree, a non-thesis degree, a minimum of 36 semester hours of graduate course work must be completed with at least 18 of the required hours from courses numbered 700 or above.

For 601—LOGGING AND MILLING—3 cr. (2 and 3) S

For 602—FOREST MENSURATION—3 cr. (2 and 3) S

For 603—FOREST SOILS SEMINAR—1 cr. (1 and 0) F

For 604—FOREST ECONOMICS—3 cr. (3 and 0) S

For 606—WOOD AND WOOD FIBER IDENTIFICATION—2 cr. (1 and 3) S

For 608—AERIAL PHOTOGRAPHS IN FORESTRY—3 cr. (2 and 3) F

For 609—MULTIPLE-USE FORESTRY—3 cr. (3 and 0) F

For 610—SILVICULTURE—4 cr. (3 and 3) S

For 611—HARVESTING FOREST PRODUCTS—3 cr. (2 and 3) S

For 612—FOREST PROTECTION—2 cr. (2 and 0) S

For 614—MANAGEMENT PLANS—1 cr. (0 and 3) S

For 616—FOREST POLICY AND ADMINISTRATION—2 cr. (2 and 0) S

For 617—FOREST MANAGEMENT AND REGULATION—4 cr. (3 and 3) F

For 618—FOREST VALUATION—3 cr. (3 and 0) S

For 620—FOREST PRODUCTS—(2 and 0) F

For 621—WOOD PROPERTIES I—3 cr. (2 and 3) F

For 622—WOOD PROPERTIES II—3 cr. (2 and 3) S

For 623—LECTURES IN FORESTRY—2-4 cr. (2-4 and 0-3)

For 624—FOREST GENETICS AND TREE BREEDING—3 cr. (3 and 0) S

For 801—DATA PROCESSING IN FORESTRY PROBLEMS—3 cr. (2 and 3) F

Illustration, analysis and discussion of specific approaches used in forestry problems for handling, arranging and analyzing large volumes of field data and for presentation in concise, meaningful form.

For 802—ADVANCED MENSURATION—3 cr. (2 and 3) S

A continuation of For 602 with special emphasis on specialized sampling techniques and statistical methods often required only in forestry, on the compilation of timber volume tables, and on forest survey problems. **Prerequisites:** Ex St 301, For 602 or permission of instructor.

For 803—PHOTO-INTERPRETATION—3 cr. (2 and 3) F

Current methodology in aerial photo interpretation techniques, flight plans, taking and processing aerial photographs, and using the aerial photographs in timber inventories and cruising. **Prerequisites:** Ex St 301, For 602 or permission of instructor.

For 804—ADVANCED FOREST ECONOMICS—3 cr. (2 and 3) S

Examination, discussion and application of economic principles to forestry problems in the use of land, labor and capital. A study of the use of theory to problems of resource allocation and efficiency in forest management. **Prerequisites:** For 604, 618, or permission of instructor.

For 805—COST STUDIES IN HARVESTING AND PROCESSING—3 cr. (2 and 3)

An evaluation of selected cost studies in harvesting and processing problems. Major emphasis to be placed on the recognition, measurement, and analysis of the individual elements of cost which constitute total cost of an operation. Current problem data will be collected and analyzed and

problem solutions will be presented in the form of written reports. **Prerequisite:** For 601, or permission of instructor.

For 807—SPECIAL PROBLEMS IN FORESTRY—Credit to be arranged.
F, S, S

Special problems in forestry research, unrelated to a thesis, but designed for training in research methods.

For 891—RESEARCH—Credit to be arranged. F, S, SS

RECREATION AND PARK ADMINISTRATION

H. Brantley, Head, Department of Recreation and Park Administration

Courses are offered leading to the Master of Recreation and Park Administration degree.

Five areas of specialization are available to candidates in this field: (1) Recreation Administration; (2) Recreation Resource Management; (3) Comprehensive Recreation Planning; (4) Rehabilitative Recreation; and (5) Interpretation. A student may be admitted to full status without prerequisites other than those required of all graduate students. However, in some instances, the department, the student's major advisor, or his advisory committee may require that certain undergraduate deficiencies be satisfied before he is accepted for the graduate program. The undergraduate requirements will differ for the various areas of specialization. A minimum of thirty semester hours are required with at least nine taken outside the Department as a part of the student's supporting area of interest. Generally successful work experience in a recreation related position will be required of those whose academic record is not sufficient for full status admission.

RPA 600—SUPERVISION OF RECREATION PERSONNEL, PATTERNS, AND PROCESSES—3 cr. (3 and 0)

RPA 602—RECREATION ADMINISTRATION—3 cr. (3 and 0)

RPA 606—RECREATION FOR THE ILL AND HANDICAPPED—3 cr. (3 and 0)

RPA 607—METHODS OF ENVIRONMENTAL INTERPRETATION—3 cr. (2 and 3)

RPA 701—PHILOSOPHICAL FOUNDATIONS OF RECREATION AND PARK ADMINISTRATION—3 cr. (3 and 0)

In-depth exploration of some current theories and philosophies in the field of recreation as it is influenced by and has influence on leisure and man's rapidly changing environment in America. A concerted effort is

made to enable each student to develop his own professional philosophy of recreation and leisure for the world of tomorrow.

RPA 702—GROUP PROCESSES IN LEISURE SERVICE—3 cr. (3 and 0)

Considers how the student can become better equipped in human relations' skills and can know more about the interpersonal needs and problems of individuals and groups. The student will gain an understanding of how others affect him and how he affects others, and will become more effective as a professional in the field as recreator and park administrator, supervisor, interpreter and educator.

RPA 703—SEMINAR IN RECREATION AND PARK ADMINISTRATION —3 cr. (3 and 0)

A comprehensive study and discussion of case problems relating to the administration of a park and recreation agency.

RPA 704—COMPREHENSIVE RECREATION PLANNING—3 cr. (3 and 0)

A critical examination of comprehensive recreation planning theories and practices at federal, state and local levels. Students will also undertake selected case study projects in cooperation with other university departments and governmental agencies.

RPA 705—RECREATIONAL ASPECTS OF WATER RESOURCES—3 cr. (3 and 0)

Recreation's relationship to water, the history and legislative background, governmental involvement, current research related to planning, pollution, and demand, and future policy decisions are included.

RPA 706—URBAN RECREATION ANALYSIS—3 cr. (3 and 0)

It is designed to provide students with a basic understanding of the principles involved in providing recreation services in urban areas.

RPA 707—PRINCIPLES OF ENVIRONMENTAL INTERPRETATION— 3 cr. (3 and 0)

A study of the methods of providing learning experiences in the out-of-doors with focus on the meaning, scope and values of interpretation.

RPA 708—SELECTED TOPICS—3 cr. (3 and 0)

An examination of the problems of recreation and leisure through a directed reading program and seminar. In addition to readings required of all students, each individual will study, in depth, problems areas of his specialization.

RPA 709—SPECIAL PROBLEMS—1-3 cr. (1-3 and 0)

Directed individual comprehensive investigation of a special problem. Subject matter may vary in areas of interest or experience of the student

and the instructor. Designed to utilize knowledge gained in formal courses, to provide experience and training in research, and to prepare the student for his professional goals. A report of findings is required. Variable credit may be earned during any semester. A maximum of three credits may be earned.

RPA 710—CURRENT ISSUES IN RECREATION—1 cr. (1 and 0)

A seminar on current topics with special emphasis on student preparation, organization and communication of material and ideas not covered in formal courses. May be taken up to three semesters for credit.

College of Industrial Management and Textile Science

W. D. Trevillian, Dean

The College of Industrial Management and Textile Science offers a variety of graduate programs which are designed to equip the students for professional careers in business, industry, government, and academe. As indicated, some of these programs are offered in cooperation or jointly with other colleges on the Clemson University campus, and in one instance a joint program is offered with another university.

The programs include advanced degrees in Business Administration, Economics, Management, Engineering Management, Management Science, Textile Science, Textile and Polymer Science, and Textile Chemistry. Research is required for degree candidates in all programs; the Ph.D. programs include teaching experience as well as research.

ACCOUNTING

C. C. Davis, Acting Head, Department of Accounting and Finance

Advanced degrees are not awarded in accounting or finance. Courses are offered to provide electives for students in other areas.

Acct 605—ADVANCED FEDERAL TAXES—3 cr. (3 and 0)

Acct 610—BUDGETING AND EXECUTIVE CONTROL—3 cr. (3 and 0) F, S

Acct 611—ADVANCED ACCOUNTING—3 cr. (3 and 0)

Acct 615—AUDITING—3 cr. (3 and 0)

Acct 616—AUDITING PRACTICE AND PROCEDURE—3 cr. (3 and 0)

Fin 602—CAPITAL BUDGETING—3 cr. (3 and 0)

ECONOMICS

T. B. Yandle, Head, Department of Economics

Courses are offered leading to the Master of Arts degree.

Students desiring to enroll in this curriculum will need at least twelve hours of undergraduate economics to include a course in intermediate

price theory, mathematics to include some calculus, and a course in statistics. Where necessary the economic theory, mathematics and statistics courses may be taken at Clemson before or early in the program.

The graduate program will include one course in quantification and one in statistics as part of the major.

A reading knowledge of one modern foreign language is required for completion of the Master of Arts degree. Additional information about this requirement may be found on pages 34 and 35.

Econ 603—DEVELOPMENT OF ECONOMIC THOUGHT—3 cr. (3 and 0)

Econ 607—NATIONAL INCOME AND EMPLOYMENT ANALYSIS—3 cr. (3 and 0) F, S

Econ 608—ARBITRATION—3 cr. (3 and 0)

Econ 604—COMPARATIVE ECONOMIC SYSTEMS—3 cr. (3 and 0)

Econ 610—ECONOMIC DEVELOPMENT—3 cr. (3 and 0)

Econ 612—INTERNATIONAL TRADE—3 cr. (3 and 0) S

Econ 613—INTERNATIONAL FINANCE—3 cr. (3 and 0)

Econ 616—DEVELOPMENT OF THE MODERN ECONOMY—3 cr. (3 and 0) F

Econ 619—ECONOMICS OF DEFENSE—3 cr. (3 and 0)

Econ 620—ECONOMICS OF TAXATION—3 cr. (3 and 0) F

Econ 621—URBAN ECONOMICS—3 cr. (3 and 0)

Econ 622—MONETARY THEORY AND POLICY—3 cr. (3 and 0)

Econ 623—ECONOMICS OF HOUSING—3 cr. (3 and 0)

Econ 624—THE ORGANIZATION OF INDUSTRIES—3 cr. (3 and 0) F

Econ 650—ECONOMICS OF THE CONSUMER AND THE FIRM IN A MARKET SYSTEM—3 cr. (3 and 0)

Econ 651—ECONOMICS OF EMPLOYMENT, THE PRICE LEVEL, AND GROWTH—3 cr. (3 and 0)

Econ 800—ADVANCED ECONOMIC ANALYSIS—3 cr. (3 and 0)
An extensive and critical examination of demand and supply, and marginal analysis. Some consideration is given to linear programming as an analytical tool in solving economic problems.

Econ 802—ADVANCED ECONOMIC CONCEPTS AND APPLICATIONS
 I—3 cr. (3 and 0)

A progressively more rigorous development of price theory under alternative product and resource market structures. **Prerequisite:** Permission of the Instructor.

Econ 803—ADVANCED ECONOMIC CONCEPTS AND APPLICATIONS
 II—3 cr. (3 and 0)

A continuation of Econ 802 consisting of selected topics, such as the demand for capital, industrial structures, labor markets, and monetary phenomena, developed through the intensive examination of current literature. **Prerequisite:** Econ 802.

Econ 806—INTERNATIONAL TRADE THEORY—3 cr. (3 and 0)

The theory of free trade from Ricardo to the present; the theory and application of optimal and second-best tariffs; recent empirical testing of trade and tariff theory. **Prerequisites:** Econ 314, Econ 802 or permission of instructor.

Econ 808—SEMINAR IN PUBLIC EMPLOYEE LABOR RELATIONS—
 3 cr. (3 and 0)

A study of labor relations in the public sector; an analysis of employer-employee relationships in government institutions, factors affecting these relationships, including the potential role of public employee unions in the decision-making process.

Econ 811—SEMINAR IN LABOR ECONOMICS—3 cr. (3 and 0)

A study of wage and employment theory, labor markets, labor history and current problems in labor and manpower economics.

Econ 812—SEMINAR IN THE DEVELOPMENT OF ECONOMIC
 THOUGHT—3 cr. (3 and 0) F

Intensive study of selected topics concerning the historical development of economic ideas, doctrines, and theories. Students are expected to conduct original research in areas related to the topic of the seminar.

Econ 813—SEMINAR IN COMMUNITY GOODS AND ENVIRONMENTAL
 QUALITY—3 cr. (3 and 0) F, even numbered years.

A study in pricing and distribution which emphasizes their effects upon economic welfare. Particular emphasis is given to those goods allocated by government purchase for joint consumption and to those distributed by rationing. Alternate plans for allocating public goods are discussed. **Prerequisite:** Econ 314 or equivalent.

Econ 814—WELFARE ECONOMICS—3 cr. (3 and 0)

A study of how economic activity affects the welfare of society. The course deals with ways of measuring welfare; political aspects of welfare

economics; the effects stemming from particular market imperfections; and how taxes, subsidies, and prices can be used to maximize welfare.

Econ 820—SEMINAR IN THE ECONOMICS OF TAXATION—3 cr.
(3 and 0)

A study of the effects of particular taxes on particular prices, outputs and economic activity. Students will select specific taxes and prepare papers dealing with theoretical discussions of the tax and empirical results that have come from the imposition of the tax in various forms.

Econ 821—ECONOMIC THEORY I—3 cr. (3 and 0) F

A study of the use of theory in the analysis of problems and behavior of industries, firms, and consumers under various market conditions.

Econ 822—ECONOMIC THEORY II—3 cr. (3 and 0) S

A study of macroeconomic theory involving static and dynamic models and their use in the analysis of economic problems and policies.

Econ 831—SEMINAR IN URBAN DEVELOPMENT ECONOMICS—3 cr.
(3 and 0)

Economic analysis of the development of urban areas within the system of cities. Central place theory and general equilibrium models of interregional economic activity with emphasis on central place systems, spatial interaction, and stochastic processes. Internal development of the city with focus on housing and land use patterns, transportation, and urban form.

Econ 891—RESEARCH—Credit to be arranged.

Econ 900—SEMINAR IN ADVANCED ECONOMIC THEORY—3 cr.
(3 and 0) F, odd numbered years.

A study of selected topics that have been and are being discussed in the scholarly journals.

ENGINEERING MANAGEMENT

B. J. Todd, Head, Department of Industrial Management

Courses are offered leading to the Doctor of Philosophy degree.

The Department of Industrial Management offers the Ph.D. in engineering management in cooperation with the College of Engineering.

The program is interdisciplinary and is primarily designed to develop a high-level manager-scholar capable of applying the most advanced con-

---

Note: All candidates for the Ph.D. degree in engineering management are required to take responsibility for and instruct an undergraduate course in either management, economics, engineering or mathematics.

cepts and methods of management science, administrative theory and research techniques to engineering and scientific projects and enterprises. In addition to a management core, supporting courses are required in economics and statistical theory. An elective policy allows a student to select his engineering option (12 credits) from the following areas: environmental planning and management, water resources planning and management, food and agricultural management systems, transportation, industrial systems, engineering analysis systems, computer application and simulation, computer organization and system structure, programming systems, computing systems and energy transmission and distribution. Entering students are required to have completed or to schedule in their first semester, basic courses in economics, accounting, statistics and calculus.

E Mgt 910—SEMINAR IN OPERATIONS MANAGEMENT—2 cr. (2 and 0)

This seminar is devoted to a detailed study of new methodological developments, both analytical and philosophical, in the field of operations management. The orientation is toward development of the theory of management science and the converting of management theory to practice while considering the behavioral and economic aspects of the problem. **Prerequisite:** Permission of instructor.

E Mgt 911—SEMINAR IN DECISION THEORY—2 cr. (2 and 0) F

The individualistic approach of micro-economic theory is utilized in an exploration of decision making, interaction and consensus of individuals as they function in groups. Recent theoretical, legal, and empirical literature which has been inspired by political markets is intensively critiqued. The manager's confrontation of the dynamics of consent, both within and in the firm's negotiations with public bodies, is emphasized.

E Mgt 912—SEMINAR IN FINANCE—3 cr. (3 and 0) S

The seminar in finance involves original research in the collection, analysis, and reporting of financial data as supplemented by published material. Evaluation of individual student projects in particular and financial problems in general is achieved through discussion around a conference table. **Prerequisite:** Mgt 802 and permission of instructor.

E Mgt 913—SYSTEMS ANALYSIS—3 cr. (3 and 0)

The industrial firm is examined from the premise that the functional areas of management-marketing, research, production, and investment are highly interrelated and that this "system" can best be understood by examining the relationships between policies, firm structure and management decisions. Several simulation type models will be built to demonstrate a systems behavior through time as these components are varied.

E Mgt 991—DOCTORAL RESEARCH—Credit to be arranged.

MANAGEMENT

B. J. Todd, Head, Department of Industrial Management

Courses are offered leading to the Master of Science degree.

Work for this degree will consist of a minimum of 31 semester hours beyond the bachelor's degree. All students will take a core curriculum of 16 hours in the areas of quantitative economic analysis, corporate finance, managerial policy, operations management, human resource management and systems simulation. Electives and a minor area of study will be selected from the disciplines of management, economics, engineering and mathematics or statistics. Proficiency in computer programming and statistics is a department requirement.

A thesis or non-thesis option is allowed. For the non-thesis program at least one formal paper or report of substantial content evidencing the student's ability to do original effective writing is required. This research and writing requirement carries one semester hour credit and must be approved by the student's major advisor.

The Department of Industrial Management also jointly administers with the Department of Economics and Business of Furman University, the Master of Business Administration degree (M.B.A.). Classes are held on the Furman University campus in Greenville, South Carolina. The program is primarily for the industrial manager/engineer who is employed on a full time basis. Further information may be obtained by writing The Director, Clemson-Furman M.B.A. Program, Furman University, Greenville, South Carolina 29613.

H Adm 610—HOSPITAL INTERNSHIP—3 cr. (0 and 9)

H Adm 800—THE FUNCTION AND ORGANIZATION OF HOSPITALS
AND HEALTH SERVICES ADMINISTRATION—3 cr.
(3 and 0)
An overview of organization, function, place in the community and society of hospitals, individual health services and public health services. This course in conjunction with an administrative internship will prepare the student for major responsibilities in the area of health service administration.

IM 601—QUANTITATIVE MARKETING ANALYSIS—3 cr.
(3 and 0) F, S

IM 602—OPERATIONS PLANNING AND CONTROL—3 cr. (3 and 0) F, S

IM 604—MANAGERIAL ECONOMICS—3 cr. (3 and 0) F, S

IM 605—ECONOMICS OF TRANSPORTATION—3 cr. (3 and 0) F

IM 606—THEORY OF INDUSTRIAL LOCATION—3 cr. (3 and 0) S

158

IM 608—WORK SIMPLIFICATION AND STANDARDIZATION—3 cr.
(3 and 0) F, S

IM 612—MARKETING MANAGEMENT—3 cr. (3 and 0) S

IM 615—MANAGERIAL DECISION MAKING—3 cr. (3 and 0) F

IM 616—MANAGEMENT OF HUMAN RESOURCES—3 cr. (3 and 0)

IM 617—MANUFACTURING LOGISTICS—3 cr. (3 and 0) F

IM 618—MANAGEMENT INFORMATION SYSTEMS—3 cr. (3 and 0)

IM 620—MANAGEMENT OF DEFENSE EXPENDITURES—3 cr.
(3 and 0) F

Mgt 800—MANAGEMENT GAMING—1 cr. (0 and 3)

The student is introduced to management game literature, writes the computer program for a minimum of two case book simulations and is required (as a class project) to conceive and write the computer program for an original management game or alternatively to severely critique an already-published game. The purpose of this course is to insure that the student is thoroughly familiar with the techniques and criticism of management games as educational adjuncts.

Mgt 801—QUANTITATIVE ECONOMIC ANALYSIS—3 cr. (3 and 0)

A mathematical formulation of economic theory with respect to its applications in management decision making. Emphasis is placed on analytical ideas and the rigorous techniques of economic analysis. **Prerequisite:** IM 404/604, or permission of instructor.

Mgt 802—FINANCE—3 cr. (3 and 0) F

The analysis of the financial condition of business firms as a means of recognizing current and long-term financial needs. Emphasis on selection of the most feasible actions necessary to secure the best possible financing under varied circumstances.

Mgt 803—OPERATIONS MANAGEMENT—3 cr. (3 and 0)

A rigorous study of industrial applications of modern statistical techniques. The course gives the student an understanding of the theory and application of such techniques as evolutionary operations, exponential smoothing, cumulative sums, adaptive controls, critical path methods, response surfaces and fractional factorial experiments. **Prerequisites:** Math 405/605 and IM 402/602 or equivalent.

Mgt 804—MANAGERIAL POLICY—3 cr. (3 and 0) F

A course in management policy making. The course emphasizes determining objectives and developing sound policies for achieving them. Managerial Policy builds upon and integrates the other graduate courses. The case method is used extensively. Written and oral presentations.

Mgt 805—QUALITY CONTROL—3 cr. (3 and 0)

The organization and management of the quality function in industry are covered. Statistical techniques employed in industrial quality control are emphasized, including recent developments in this field. **Prerequisite:** Prior satisfaction of the statistics requirement (by course or exam) of the Industrial Management Department.

Mgt 810—MANAGEMENT AND THE LAW—3 cr. (3 and 0)

A study of the legal environment in which managers operate. Specific attention is directed toward the legal processes, institutions and machinery and those areas in the substantive law, including both private law and governmental regulations, that affect the various managerial functions. **Prerequisite:** IM 322 or equivalent or permission of instructor.

Mgt 811—ADVANCED MARKETING ANALYSIS—3 cr. (3 and 0) F

A seminar in marketing in which the topic is approached from the viewpoint of highest level management. The decision-making process in this respect will be treated extensively. **Prerequisite:** IM 412/612 or permission of instructor.

Mgt 812—TRANSPORTATION PLANNING AND POLICY—3 cr. (3 and 0)

This course reviews transportation policy and planning in the U. S. from 1789 to the present day. Various transport modes are examined with respect to economic efficiency and environmental effect. Particular attention is focused on the feasibility and likely results of substituting one mode for another in the context of an integrated transportation system that must function effectively within environmental constraints. U. S. transports needs, policy and plans will also be analyzed in the context of an integrated world transportation system. The underlying premise of the course is that domestic and international transportation policy and planning will receive increasing attention from both government and the private sector in the last quarter of the 20th century. **Prerequisites:** Permission of instructor.

Mgt 816—MANAGEMENT OF HUMAN RESOURCES—3 cr. (3 and 0) S

A more advanced consideration of the topics covered in IM 416. **Prerequisite:** IM 416 or permission of instructor.

Mgt 891—RESEARCH—Credit to be arranged.

MANAGEMENT SCIENCE

C. V. Aucoin, Program Coordinator

J. W. Kenelly, Head, Department of Mathematical Sciences

B. J. Todd, Head, Department of Industrial Management

Courses are offered leading to the Doctor of Philosophy degree.

The Departments of Industrial Management and Mathematical Sciences jointly offer and administer a program leading to the Ph.D. in Management Science. The program encourages the enrollment of the superior student who has a demonstrated aptitude for quantative analysis and a primary interest in scientific management research and practice, i.e., application and development of the growing array of statistical and quantitative techniques increasingly being utilized in management decision-making by the larger and more sophisticated American, foreign and multi-national firms. Such techniques include probability models, statistical analysis, linear, nonlinear and dynamic programming and decision theory. The program structure is a unique blend of courses in statistical theory, operations research, functional areas of management, econometrics and economics. Courses in particular areas complement and reinforce the curriculum as a balanced offering of advanced work in each field contributing to the degree.

Mgt Sc 611—INTRODUCTION TO ECONOMETRICS—3 cr. (3 and 0)

Mgt Sc 613—MANAGEMENT SCIENCE I—3 cr. (3 and 0) F

Mgt Sc 614—STATISTICAL ANALYSIS—3 cr. (3 and 0) F

Mgt Sc 806—REGIONAL SCIENCE METHODS—3 cr. (3 and 0) F

This course examines the major contributions to regional growth theory, regional development and planning. A number of topics are considered, including: location, theory, theory of spatial organizations, the role of resources and migration in regional development, the definition of regions, the concept of planning regions, objectives and measures of regional development, regional investment criteria, regional input-output analysis, regional linear programming model, and regional income and product accounts. Attention is focused on major policy questions as well as the analytical tools of regional science. **Prerequisite:** Permission of instructor.

Mgt Sc 807—ECONOMETRIC METHODS I— 3 cr. (3 and 0)

The role and uses of statistical inference in the analysis of economic phenomena; the problem of spanning the gap from an economic model to its statistical counterpart; measurement problems and their solution arising from the statistical model and the nature of the data; limitations and interpretation of results of economic measurement from statistical techniques. Topics include the problems of specification, aggregation, identification, multicolinearity and autocorrelation. Attention is also given to expectations models and simultaneous stochastic equations. **Prerequisites:** Math 405/605, 411/611, or permission of instructor.

Mgt Sc 808—ECONOMETRIC METHODS II—3 cr. (3 and 0) S

A continuation of Mgt Sc 807 with emphasis on current economic models and estimation procedures. **Prerequisite:** Mgt Sc 807.

Mgt Sc 812—MANAGEMENT SCIENCE II—3 cr. (3 and 0)

A continuation of Management Science I; both deterministic and probabilistic models will be considered, and topics incude dynamic programming, integer programming, nonlinear programming, queueing theory, Markov processes, and simulation. Attention will also be given to investment analysis, and to business and industrial application of mathematical programming. **Prerequisite:** Mgt Sc 613, or permission of instructor.

The following courses are offered by the Department of Mathematical Sciences as part of the core curriculum for this program. Descriptions of the 800 and 900 level courses are found on pages 189 to 201.

Comp Sc 621—INTRODUCTION TO ASSEMBLER LANGUAGE PROGRAMMING—3 cr. (3 and 0)

Comp Sc 622—ADVANCED ASSEMBLER LANGUAGE PROGRAMMING —3 cr. (3 and 0)

Comp Sc 623—FUNDAMENTALS OF SOFTWARE DESIGN—3 cr. (3 and 0)

Math 602—THEORY OF PROBABILITY—3 cr. (3 and 0)

Math 603—STATISTICAL INFERENCE—3 cr. (3 and 0)

Math 628—NUMERICAL LINEAR ALGEBRA—3 cr. (3 and 0)

Math 629—NUMERICAL ANALYSIS—3 cr. (3 and 0)

Math 652—LINEAR PROGRAMMING—3 cr. (3 and 0)

Math 671—APPLIED STATISTICAL DECISION THEORY—3 cr. (3 and 0)

Math 673—INTRODUCTION TO NONLINEAR OPTIMIZATION—3 cr. (3 and 0)

Math 801—GENERAL LINEAR HYPOTHESIS I—3 cr. (3 and 0)

Math 802—GENERAL LINEAR HYPOTHESIS II—3 cr. (3 and 0)

Math 803—STOCHASTIC PROCESSES I—3 cr. (3 and 0)

Math 804—STOCHASTIC PROCESSES II—3 cr. (3 and 0)

Math 809—TIME SERIES ANALYSIS, FORECASTING AND CONTROL— 3 cr. (3 and 0)

Math 811—NONLINEAR PROGRAMMING—3 cr. (3 and 0)

Math 812—DYNAMIC PROGRAMMING—3 cr. (3 and 0)

Math 813—ADVANCED LINEAR PROGRAMMING—3 cr. (3 and 0)

Math 863—DIGITAL ANALYSIS I—3 cr. (3 and 0)

Math 864—DIGITAL ANALYSIS II—3 cr. (3 and 0)

Math 988—SPECIAL TOPICS IN OPERATIONS RESEARCH—1-3 cr. (1-3 and 0)

TEXTILE CHEMISTRY

E. I. Stearns, Head, Department of Textiles

Courses are offered leading to the Master of Science degree and to the Doctor of Philosophy degree with a major in Textile and Polymer Science. The Doctor of Philosophy degree in Chemistry with a major in Textile Chemistry is awarded by the Department of Chemistry in conjunction with the Textile Department.

Candidates with Bachelor's degrees in textile chemistry, textile science, the physical or life sciences engineering, or related disciplines will be accepted into this program provided that they have training in chemistry, physics and mathematics. The student's major area of study normally will be in polymer chemistry, fiber chemistry, the chemistry of dyeing and/or finishing of fibers and textiles, or the chemistry of composite systems. His minor area of study usually will be in chemistry, physics, engineering, life sciences, or mathematics. Each candidate for the Master of Science degree will conduct an original, independent, scientific investigation in his major area. He will report the results and conclusions from his research in his thesis.

TC 615—INTRODUCTION TO POLYMER SCIENCE AND ENGINEERING —3 cr. (3 and 0)

TC 616—CHEMICAL PREPARATION OF TEXTILES—3 cr. (2 and 3)

TC 657—DYEING AND FINISHING I— 3 cr. (3 and 0)

TC 658—DYEING AND FINISHING II—3 cr. (3 and 0)

TC 659—DYEING AND FINISHING LABORATORY—1 cr. (0 and 3)

TC 666—TEXTILE UNIT OPERATIONS—3 cr. (3 and 0)

TC 675—CELLULOSE CHEMISTRY—2 cr. (2 and 0)

TC 811—POLYMER SCIENCE I—3 cr. (3 and 0)

The chemistry, preparation, kinetics and polymerization, mechanisms of polymerizations and reactions, structures, properties, and fabrication of polymers, copolymers, terpolymers, etc., with emphasis on fiber forming polymers and polymer solution chemistry and methods for molecular characterization, are considered in depth.

TC 812—POLYMER SCIENCE II—3 cr. (3 and 0)

Sorption phenomena are treated by the generally applicable theory of molecular clustering. Light scattering from solutions and from fibers, molecular weight (MW) and MW distributions, transport properties, viscoelastic behavior, fiber drawing, and degradation of polymers are considered in depth emphasizing inter-relationships of properties with particular attention to fiber forming polymers.

TC 821—CHEMISTRY OF NATURAL POLYMERS I— 3 cr. (3 and 0)

The chemistry of natural polymers with emphasis on cellulose and fibrous proteins. Detailed study of monosaccharides serves as the basis for study of cellulose and related polysaccharides including degradation and substitution reactions. Globular and fibrous proteins are treated in terms of structure, conformation, and chemistry of constituent amino acids.

TC 822—CHEMISTRY OF NATURAL POLYMERS II—3 cr. (3 and 0)

Chemistry of the amino acids is considered as a basis for the study of polypeptides and proteins. The synthesis and chemical reactions of both globular and fibrous proteins is studied in depth. **Prerequiste:** TC 315 or TC 821 or permission of instructor.

TC 831—PHYSICAL CHEMISTRY OF DYEING—3 cr. (3 and 0)

An advanced treatment of the fundamental properties of dye systems. The use of kinetic and thermodynamic data to correlate dye and fiber structure with proposed dyeing mechanisms, kinetics of diffusions in dyeing processes, theory of color and its use in dyeing operations. **Prerequisite:** TC 457/657.

TC 891—RESEARCH—Credit to be arranged.

TEXTILE SCIENCE

E. I. Stearns, Head, Department of Textiles

Courses are offered leading to the Master of Science degree with a major in Textile Science. In addition, the department offers courses leading to the Doctor of Philosophy degree with a major in Textile and Polymer Science.

Candidates with Bachelor's degrees in textile chemistry, textile science, the physical or life sciences, engineering, or related disciplines will be admitted to these programs. A student's chosen major area of study usually will be in fiber science, polymer science, or textile technology. His minor area of study normally will be in the life or physical sciences, engineering, mathematics, or management. Each student will complete an original, independent, scientific or technical investigation and report his results and conclusions in his thesis.

Text 601—POLYMER AND FIBER MECHANICS—3 cr. (3 and 0)

Text 603—FIBER PROCESSING III—3 cr. (2 and 3)

Text 604—FIBER PROCESSING IV—3 cr. (2 and 3)

Text 611—FABRIC DEVELOPMENT III—3 cr. (2 and 3)

Text 612—FABRIC DEVELOPMENT IV—3 cr. (2 and 3)

Text 621—FIBER SCIENCE—3 cr. (2 and 3)

Text 622—PROPERTIES OF TEXTILE STRUCTURES—3 cr. (2 and 3)

Text 626—INSTRUMENTATION—3 cr. (3 and 0)

Text 640—COLOR SCIENCE—3 cr. (3 and 0)

Text 660—TEXTILE PROCESSES—3 cr. (3 and 0)

Text 821—FIBER PHYSICS I—3 cr. (3 and 0)
Concepts and theories of fiber structure. Methods of investigating natural and man-made fiber structure. Examination of various interpretations of fiber structure which are based upon the methods used to investigate structure. Analytical and empirical models of fiber structure.

Text 822—FIBER PHYSICS II—3 cr. (3 and 0)
A study of the relationships between and dependence upon microstructural and macrostructural phenomena in polymeric fibers, introduction to anisotropic elasticity, tensile and shear behavior, fracture, dynamic properties, viscoelasticity and fatigue. **Prerequisite:** Text 821.

Text 830—TEXTILE PHYSICS—3 cr. (3 and 0)
The physical principles necessary to study of the properties of fibers, yarns, and fabrics are examined in some depth. Electromagnetic and mechanical properties of textile materials and instrumental methods for measuring properties are analyzed in some detail.

Text 835—TEXTILE STRUCTURES I—3 cr. (3 and 0)
A study in depth of the pioneering works relating fiber properties to yarn properties: yarn geometry, fiber arrangements in twisted yarns, extension and breakage of continuous filament yarns, and deformation of staple fiber yarns.

Text 836—TEXTILE STRUCTURES II—3 cr. (3 and 0)
A study in depth of the pioneering works relating fiber properties to yarn properties: analysis of cloth geometry and mechanics, conventional yarn bearing fabrics, tensile properties of woven structures, fabric shear and buckling, and the geometry and mechanics of knitted fabrics.

Text 837—COMPOSITE STRUCTURES—3 cr. (3 and 0)

Advanced study of the structures and properties of composite structures with particular emphasis on the fundamentals of synthetic sheet materials and analysis of the chemical and physical structure of laminated sheets, sponge, film, and molded sheet materials.

Text 840—SPECTROPHOTOMETRY—3 cr. (2 and 3)

Application of modern instruments and computers to color matching and control of color in the industrial environment.

Text 866—FIBER FORMATION—3 cr. (3 and 0)

The formation of fibers by wet, dry, and melt spinning are studied in depth with emphasis on rheology of solutions and melts, fiber structure, stretching and drawing processes, and the inter-relationships of polymer properties and processes that determine fiber properties.

Text 870—ADVANCES IN TEXTILE MANUFACTURING—3 cr. (3 and 0)

Comparisons among cotton, woolen, and worsted processing systems with respect to suitability to fiber characteristics, processing of fiber blends, modern yarn production, non-woven fabrics, and the latest developments in textile machinery.

Text 880—SELECTED TOPICS—3 cr. (3 and 0)

Comprehensive studies of selected topics not covered in other courses in Textile Chemistry or Textile Science.

Text 891—RESEARCH—Credit to be arranged.

Text 991—DOCTORAL RESEARCH—Credit to be arranged.

College of Liberal Arts

H. M. Cox, Dean

R. W. Moran, Head, Department of English

Courses are offered leading to the Master of Arts degree.

A student desiring to pursue graduate study in English should present for admission to the M.A. degree program at least 12 semester hour credits of undergraduate work in English above the sophomore level while those seeking admission to the M.Ed. degree program with emphasis in English must have completed at least 9 semester hours of such credits. The credits should include a course each in the English language, Shakespeare, and American Literature, and students deficient in these requirements may seek admission on a provisional basis.

Applicants for the M.A. degree may complete either 24 hours of approved graduate courses and 6 hours of thesis credit or 36 hours of course work with no thesis. The M.Ed. program with emphasis in English requires 30 hours of course work with a minimum of 6 and a maximum of 12 hours in the College of Education.

In addition to the requirements of the Graduate School, candidates for the M.A. or M.Ed. degree must satisfy the following departmental requirements:

1. Demonstrated proficiency in composition.

2. Completion of English 890, Introduction to Research.

3. Completion of English 603 or 801 (required of graduate assistants but recommended for all).

4. A reading knowledge of an approved foreign language (M.A. program only).

5. A comprehensive oral examination.

Engl 602—THE ENGLISH LANGUAGE—3 cr. (3 and 0) S

Engl 603—COMPOSITION FOR TEACHERS—3 cr. (3 and 0)

Engl 604—STRUCTURE OF MODERN ENGLISH—3 cr. (3 and 0) F, S

Engl 605—SHAKESPEARE—3 cr. (3 and 0) F, S

Engl 606—SHAKESPEARE—3 cr. (3 and 0) S

Engl 609—CHAUCER—3 cr. (3 and 0) F

Engl 610—MIDDLE ENGLISH LITERATURE—3 cr. (3 and 0)

Engl 611—THE CLASSICS IN TRANSLATION—3 cr. (3 and 0)

Engl 613—CLASSICAL DRAMA—3 cr. (3 and 0) F

Engl 614—MEDIEVAL DRAMA—3 cr. (3 and 0)

Engl 616—MODERN DRAMA—3 cr. (3 and 0) S

Engl 622—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0)

Engl 623—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0)

Engl 624—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0)

Engl 625—THE ROMANTIC REVIVAL—3 cr. (3 and 0) F

Engl 627—VICTORIAN POETRY—3 cr. (3 and 0) S

Engl 629—NINETEENTH CENTURY PROSE—3 cr. (3 and 0)

Engl 631—THE RESTORATION AND EIGHTEENTH CENTURY—3 cr.
        (3 and 0) S

Engl 635—SOUTHERN LITERATURE—3 cr. (3 and 0) F

Engl 636—MILTON AND HIS AGE—3 cr. (3 and 0) S

Engl 637—THE EIGHTEENTH CENTURY ENGLISH NOVEL—3 cr.
        (3 and 0) F

Engl 638—TWENTIETH CENTURY POETRY—3 cr. (3 and 0) F

Engl 639—TWENTIETH CENTURY FICTION—3 cr. (3 and 0) S

Engl 640—APPLIED LITERARY CRITICISM—3 cr. (3 and 0)

Engl 641—CONTINENTAL FICTION IN TRANSLATION—3 cr. (3 and 0)

Engl 643—SEVENTEENTH CENTURY POETRY AND PROSE—3 cr.
        (3 and 0)

Engl 645—RENAISSANCE NON-DRAMATIC LITERATURE—3 cr.
        (3 and 0)

Engl 646—TUDOR-STUART DRAMA—3 cr. (3 and 0)

Engl 647—THE AMERICAN NOVEL—3 cr. (3 and 0)

Engl 648—AMERICAN HUMOR—3 cr. (3 and 0)

Engl 661—STUDIES IN ENGLISH LITERATURE TO 1700—3 cr. (3 and 0)

Engl 662—STUDIES IN ENGLISH LITERATURE SINCE 1700—3 cr.
        (3 and 0)

Engl 740—BLACK AMERICAN LITERATURE FOR TEACHERS—3 cr.
(3 and 0)

Studies in Black American literature from the beginning to the present, selected to meet the need of teachers.

Engl 751—CHILDREN'S LITERATURE FOR TEACHERS—3 cr. (3 and 0)

Studies in literature suitable for the elementary grades, selected to meet the needs of teachers.

Engl 761—ENGLISH LITERATURE FOR TEACHERS I—3 cr. (3 and 0)

Studies in English literature from **Beowulf** to 1700, selected to meet the needs of teachers.

Engl 762—ENGLISH LITERATURE FOR TEACHERS II—3 cr. (3 and 0)

Studies in English literature from 1700 to the present, selected to meet the needs of teachers.

Engl 801—THE TEACHING OF ENGLISH—3 cr. (3 and 0)

The teaching of grammar, composition, and literature. Required of all teaching assistants seeking an M.A. and all students seeking the M.Ed. Recommended for English teachers.

Engl 802—STUDIES IN MIDDLE ENGLISH LITERATURE—3 cr.
(3 and 0)

Topics embrace the principal works in verse and prose from c. 1100-1500.

Engl 803—STUDIES IN RENAISSANCE ENGLISH LITERATURE—3 cr.
(3 and 0)

Topics embrace the principal works in verse and prose from c. 1500-1700.

Engl 804—STUDIES IN NEO-CLASSIC AND ROMANTIC LITERA-
TURE—3 cr. (3 and 0)

Topics embrace the principal works in verse and prose from c. 1700-1832.

Engl 805—STUDIES IN VICTORIAN AND MODERN ENGLISH LITERA-
TURE—3 cr. (3 and 0)

Topics embrace the principal works in verse and prose from c. 1832 to the present.

Engl 810—STUDIES IN COLONIAL AND REVOLUTIONARY AMERI-
CAN LITERATURE—3 cr. (3 and 0)

Topics embrace the principal works in verse and prose from c. 1607-1830.

Engl 811—STUDIES IN ROMANTIC AND REALISTIC AMERICAN LIT-
ERATURE—3 cr. (3 and 0)

Topics embrace the principal works in verse and prose from 1830-1900.

**Engl 812—STUDIES IN MODERN AMERICAN LITERATURE—3 cr.
(3 and 0)**

Topics embrace the principal works in verse and prose from c. 1900 to the present.

**Engl 820—STUDIES IN THEORETICAL AND APPLIED LITERARY
CRITICISM—3 cr. (3 and 0)**

Topics embrace the principal statements of literary critics from the classical era to the present.

Engl 825—STUDIES IN LITERARY GENRES—3 cr. (3 and 0)

Topics embrace the principal literary genres.

Engl 830—STUDIES IN LINGUISTICS—3 cr. (3 and 0)

Topics embrace the concepts of traditional and modern grammarians as well as the development of the English language.

Engl 840—STUDIES IN WORLD LITERATURE—3 cr. (3 and 0)

Topics embrace masterpieces of Oriental and Occidental writers and related works.

Engl 881—DIRECTED READING—3 cr. (3 and 0)

Tutorial work in linguistics or American, British, or European literature outside the scope of existing courses. **Prerequisite:** Permission of head of the department.

Engl 890—INTRODUCTION TO RESEARCH—1 cr. (1 and 0)

Introduction to literary history and research; the use of libraries and bibliographical tools; the exposition of scholarship. Required of all candidates for the master's degree.

Engl 891—RESEARCH—Credit to be arranged.

HISTORY

A. Schaffer, Head, Department of History

Courses are offered leading to the Master of Arts degree.

A student who wishes to pursue graduate study toward a Master of Arts degree in history must have earned an overall grade-point ratio of 2.5 on his undergraduate work, including a grade-point ratio of 3.0 on a minimum of 24 semester hours of history, for admission to the program.

During his graduate study he will be expected to demonstrate a reading knowledge of either French or German and to be prepared to do research for his thesis in primary materials beyond those held by the Clemson Library.

Hist 610—HISTORY OF COLONIAL AMERICA—3 cr. (3 and 0)

Hist 611—UNITED STATES, 1783-1850—3 cr. (3 and 0)

Hist 612—UNITED STATES, 1850-1900—3 cr. (3 and 0)

Hist 613—UNITED STATES HISTORY, 1890-1933—3 cr. (3 and 0)

Hist 614—THE UNITED STATES SINCE 1933—3 cr. (3 and 0)

Hist 673—MEDIEVAL HISTORY—3 cr. (3 and 0)

Hist 675—THE RENAISSANCE—3 cr. (3 and 0)

Hist 676—EARLY MODERN EUROPE—3 cr. (3 and 0)

Hist 679—EUROPE, 1789-1850—3 cr. (3 and 0)

Hist 680—EUROPE, 1850-1914—3 cr. (3 and 0)

Hist 682—INTERNATIONAL RELATIONS SINCE 1914—3 cr. (3 and 0)

Hist 715—HISTORY OF THE BLACK AMERICAN—3 cr. (3 and 0)

This course is designed to provide public school teachers with a perspective as to the relative position of the Black American at various times in American History. Not open to candidates for the Master of Arts or Master of Education degrees in History.

Hist 719—UNITED STATES HISTORY SINCE 1900—3 cr. (3 and 0)

A survey of American history from 1900 to the present. Some attention and historical background will be given to current problems of ecology, race relations, automation and unemployment, education, domestic and foreign commerce, and social disorganization. Not open to candidates for the Master of Arts or Master of Education degrees in History.

Hist 732—MODERNIZATION OF EAST ASIA—3 cr. (3 and 0)

The history of China, Japan and Korea in the Twentieth Century with emphasis on social and political changes which resulted from the acceptance of Western ideas. Not open to candidates for the Master of Arts or Master of Education degrees in History.

Hist 741—COMPARATIVE HISTORY OF THE AMERICAS—3 cr.
(3 and 0)

An examination of the concept of a unique Western Hemispheric identity through a comparative analysis of common and divergent historical institutions and experiences. The course will consider such topics as conquest and colonization, slavery and race relations, frontiers, land patterns, industrialization and urbanization, and twentieth-century reform movements. Not open to candidates for the Master of Arts or Master of Education degrees in History.

Hist 811—INTRODUCTION TO HISTORICAL RESEARCH—3 cr. (3 and 0)

Hist 813—MEDIEVAL HISTORIOGRAPHY—3 cr. (3 and 0)

An examination of the major historical works of Europe to 1500.

Hist 814—MODERN EUROPEAN HISTORIOGRAPHY—3 cr. (3 and 0)

An examination of the major historical works of Europe since 1500.

Hist 821—STUDIES IN EIGHTEENTH CENTURY UNITED STATES
HISTORY—3 cr. (3 and 0)

This course is designed to meet the research needs of students having an interest in 18th Century United States History. The particular emphasis in period or area of study will depend on the teacher who offers the course.

Hist 822—STUDIES IN NINETEENTH CENTURY UNITED STATES
HISTORY—3 cr. (3 and 0)

This course is designed to meet the research needs of students having an interest in 19th Century United States History. The particular emphasis in period or area of study will depend on the teacher who offers the course.

Hist 823—STUDIES IN TWENTIETH CENTURY UNITED STATES
HISTORY—3 cr. (3 and 0)

This course is designed to meet the research needs of students having an interest in 20th Century United States History. The particular emphasis in period or area of study will depend on the teacher who offers the course.

Hist 824—SEMINAR IN THE AMERICAN SOUTH—3 cr. (3 and 0)

Hist 861—SEMINAR IN MEDIEVAL ENGLAND—3 cr. (3 and 0)

Political and institutional development with emphasis on government records. **Prerequisites:** Hist 361, 363 or equivalents.

Hist 862—SEMINAR IN MEDIEVAL ENGLAND TO 1485—3 cr. (3 and 0)

Political and intellectual development with emphasis on chronicles and local records. **Prerequisites:** Hist 361, 363 or equivalents.

Hist 863—SEMINAR IN TUDOR ENGLAND—3 cr. (3 and 0)
Prerequisites: Hist 361, 363 or equivalents.

Hist 864—SEMINAR IN STUART ENGLAND—3 cr. (3 and 0)
Prerequisites: Hist 361, 363 or equivalents.

Hist 865—SEMINAR IN MODERN ENGLAND SINCE 1715—3 cr. (3 and 0)

The emphasis will be on imperial politics. **Prerequisites:** Hist 361, 363 or equivalents.

Hist 866—SEMINAR IN MODERN ENGLAND SINCE 1715—3 cr. (3 and 0)

The emphasis will be on imperial politics. **Prerequisites:** Hist 361, 363 or equivalents.

Hist 891—RESEARCH—Credit to be arranged.

Phil 825—SEMINAR IN PHILOSOPHY OF SCIENCE—3 cr. (3 and 0)

A study of methods, principles, and problems of scientific explanation including such topics as meaning, verification, confirmation, distinctions drawn between various types of scientific laws, types of definitions, formal models, and probable inferences.

POLITICAL SCIENCE

C. W. Dunn, Head, Department of Political Science

Advanced degrees are not awarded in political science. Courses are offered to provide electives for students in other areas.

Pol Sc 609—DIRECTED STUDY IN AMERICAN INSTITUTIONS—3 cr. (3 and 0)

Pol Sc 622—PROBLEMS OF PUBLIC ADMINISTRATION—3 cr. (3 and 0)

Pol Sc 623—MUNICIPAL ADMINISTRATION—3 cr. (3 and 0)

Pol Sc 625—GOVERNMENTAL BUDGETARY PROCESS—3 cr. (3 and 0)

Pol Sc 626—GOVERNMENT ORGANIZATION THEORY—3 cr. (3 and 0)

Pol Sc 628—AMERICAN DEFENSE POLICY ANALYSIS—3 cr. (3 and 0)

Pol Sc 629—AMERICAN POLITICS AND EDUCATION—3 cr. (3 and 0)

Pol Sc 632—AMERICAN CONSTITUTIONAL LAW I—3 cr. (3 and 0)

Pol Sc 633—AMERICAN CONSTITUTIONAL LAW II—3 cr. (3 and 0)

Pol Sc 642—POLITICAL PARTIES AND POLITICS—3 cr. (3 and 0)

Pol Sc 662—INTERNATIONAL ORGANIZATIONS—3 cr. (3 and 0)

PSYCHOLOGY

C. B. Caffrey, Head, Department of Psychology

Advanced degrees are not awarded in psychology. Courses are offered to provide electives for students in other areas.

Psych 602—ABNORMAL PSYCHOLOGY—3 cr. (3 and 0)

Psych 622—CROSS-CULTURAL STUDIES IN DEVELOPMENTAL PSYCHOLOGY—3 cr. (3 and 0)

Psych 642—SENSORY PROCESSES—3 cr. (3 and 0)

Psych 690—SPECIAL TOPICS IN PSYCHIATRY AND NEUROLOGY—
3 cr. (3 and 0)

Psych 699—SEMINAR IN CURRENT RESEARCH IN PSYCHOLOGY II—
3 cr. (3 and 0)

SOCIOLOGY

J. Lowe, Head, Department of Sociology

J. E. Faris, Head, Department of Agricultural Economics and Rural Sociology

Advanced degrees are not awarded in sociology. Courses are offered to provide a minor for students majoring in other areas.

RS 601—HUMAN ECOLOGY—3 cr. (3 and 0)

RS 659—THE COMMUNITY—3 cr. (3 and 0)

RS 661—RURAL LEADERSHIP—3 cr. (3 and 0)

RS 801—RURAL SOCIAL SYSTEMS—3 cr. (3 and 0)
Designed to provide the advanced student with a brief review of the basic working concepts of rural sociology and a knowledge of the basic institutions of rural life and to acquaint the student with the techniques used in applying scientific methods and theory toward understanding the social structure of rural life. **Prerequisite:** Permission of instructor.

RS 881—SPECIAL PROBLEMS IN RURAL SOCIAL RESEARCH—3 cr.
(3 and 0)
Study of recent research problems and literature in rural sociology, including a review of appropriate published material, with emphasis upon research design, analysis, theoretical generalizations, and application programs. **Prerequisite:** Six semester hours of 600-level sociology and/or rural sociology courses of permission of instructor.

Soc 611—CLASSICAL SOCIOLOGICAL THEORY—3 cr. (3 and 0)

Soc 621—CONTEMPORARY SOCIOLOGICAL THEORY—3 cr. (3 and 0)

Soc 631—COMPLEX ORGANIZATIONS—3 cr. (3 and 0)

Soc 641—SOCIAL STRATIFICATION—3 cr. (3 and 0)

Soc 651—SOCIOLOGY OF MEDICINE—3 cr. (3 and 0)

Soc 781—RACE RELATIONS—3 cr. (3 and 0)
The study of the problem of racial and ethnic groups in adjusting to American society.

College of Nursing

G. Labecki, Dean

The College of Nursing offers a graduate program in nursing leading to the degree Master of Science. The major is in Family Health Nursing and is accompanied by an emphasis in one of six clinical specialty areas and in nursing education. The clinical specialties include adult health nursing, child-health nursing, gerontological nursing, maternity-infant nursing, parent-child nursing, and rehabilitation.

Applicants must possess a Bachelor of Science degree with a nursing major. Preference will be given to students holding degrees in nursing from schools and colleges accredited by the National League for Nursing.

The Master of Science degree is awarded upon the satisfactory completion of a minimum of 32 semester hours of approved graduate credits. The thesis is optional, and a student who elects the non-thesis option will be required to take, in lieu of research, nine (9) additional semester hours of electives or to take the nursing education sequence.

Nurs 801—FAMILY HEALTH NURSING—3 cr. (1 and 6)

Nursing assessment and application of modern concepts of care to the nuclear and extended family; the physiological and psychosocial nature of health and illness, forces for health and illness, the dynamics of family health, the helping relationship, crises intervention. Incorporates the longitudinal analysis of the care of selected families and the clinical area of study.

Nurs 807—SEMINAR—1-3 cr.

Advanced study of research methodology with emphasis on research in clinical nursing. Consideration of ethics in research with human subjects. Includes presentation of selected original research papers and other topics and activities related to developments in nursing; research activity does not include thesis advisement.

Nurs 812—THE DYNAMICS OF COMMUNITY HEALTH—3 cr. (3 and 0)

The relation of family health to community. Epidemiological appraisal of community health. The significance of process in planning and decision making. The values guiding the use and availability of health resources.

Nurs 815—THE PROMOTION AND MAINTENANCE OF HEALTH—3 cr. (1 and 6)

Incorporates the longitudinal analysis of the study of families selected in Nursing 801. The continuity and coordination of health care. Collabo-

ration among the professionals. The continuing expansion of concepts of care. Emerging system of health maintenance. Definition of health.

Nurs 827—FOUNDATIONS OF NURSING EDUCATION—3 cr. (3 and 0)

Philosophies which have an influence on the development of nursing education. Consideration is given to the influence of experimentalism and existentialism. The influences of contemporary theorists such as McGrath, Orem, Phoenix, M. Rogers, Skinner and Tyler are included.

Nurs 828—THE COLLEGE TEACHER OF NURSING—3 cr. (3 and 0)

Consideration of the role and responsibilities of the nurse teacher in senior and community college programs of nursing. Includes curriculum development, use of teaching methods and materials, and the clinical laboratory.

Nurs 830—THE CLINICAL SPECIALTY IN NURSING—6 cr. (3 and 9)

Theory and practice in a selected clinical specialty with emphasis on the extended role in nursing. The contribution of the clinical specialist to the comprehensive care of the family is emphasized.

Nurs 881—SPECIAL PROBLEMS—Credit to be arranged.

The exploration of a problem in nursing, including a philosophical stance and the development, testing and evaluation of hypotheses. Problems selected will be in the area of clinical specialization. Investigation may be done in an off-campus setting. Approval of the study and periodic conferences are to be arranged with major advisor in clinical specialty. A printed and bound copy of the report is to be submitted.

Nurs 891—RESEARCH—Credit to be arranged.

Research activities related to thesis; a minimum of six hours required.

College of Sciences

H. E. Vogel, Dean

The College of Sciences offers graduate programs leading to advanced degrees in almost all of the areas within the college. The Master of Science degree is awarded in Biochemistry, Botany, Chemistry, Mathematics, Microbiology, Physics, and Zoology. Programs leading to the Doctor of Philosophy degree are available in Biochemistry, Chemistry, Mathematics, Physics and Zoology.

The graduate programs leading to the Ph.D. with major emphasis in either Botany or Microbiology are available through an interdepartmental Plant Physiology program. In addition, the degree of Ph.D. with a major in Management Science is awarded jointly with the Departments of Industrial Management and Mathematical Sciences. Although there are no graduate degrees offered in the field of Geology, courses are available which may be used towards a minor concentration in this field.

All of the graduate programs offered in this college emphasize a broad academic foundation in the disciplinary area combined with intensive study and research in a specific area culminating in a thesis or dissertation.

Although this college does not award any professional level graduate degrees, courses specifically designed for professional level graduate work are available in almost all departments with special attention being paid to secondary level public school teachers who wish to take a major concentration in the sciences while pursuing a professional degree in education.

BIOCHEMISTRY

J. M. Shively, Head, Department of Biochemistry

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

Enrollment in the Biochemistry program is open to students who possess baccalaureate degrees in the agricultural, biological, or physical sciences, or engineering. Entering students are expected to have a record of sound academic achievement in mathematical, physical, and biological sciences. Students who have deficiencies will be admitted to the program, but will be required to correct these deficiencies during the first year.

Degree requirements (see also Graduate School requirements).

Attendance and participation in departmental seminars is mandatory.

177

Biochemistry 623, 624, 625, and 626 (8 cr. hr.) constitute the core of the Biochemistry program. All students are expected to complete these courses if they have not had their equivalent at another accredited institution.

The Master of Science degree requires (in addition to the core courses): A minimum of 16 credit hours of course work. Twelve (12) of the 16 credits must be in 800-level courses. A minimum of four (4) credits must be in biochemistry courses. A thesis is required.

The Doctor of Philosophy degree requires (in addition to the core courses): A minimum of twenty-seven credit hours of course work with 15 credits in 800-level biochemistry courses and 12 credits in an approved minor area.

Successful completion of written and oral comprehensive exams (after three semesters in residence) will admit the student to candidacy for the Doctor of Philosophy degree.

Bioch 606—PHYSIOLOGICAL CHEMISTRY—3 cr. (3 and 0)

Bioch 608—PHYSIOLOGICAL CHEMISTRY LABORATORY—1 cr.
    (0 and 3)

Bioch 623—PRINCIPLES OF BIOCHEMISTRY—3 cr. (3 and 0)

Bioch 624—PRINCIPLES OF BIOCHEMISTRY—3 cr. (3 and 0)

Bioch 625—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Bioch 626—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Bioch 810—BIOCHEMICAL TECHNIQUES—1-3 cr. (0 and 3-9)
Physical and chemical techniques for the analysis of biological materials. Emphasis is on instrumentation. **Prerequisites:** Bioch 623, 625 or Bioch 606, 608 or permission of instructor.

Bioch 815—LIPIDS AND BIOMEMBRANES—3 cr. (3 and 0)
The isolation, chemical and physical properties, and metabolism of lipids; and the purification, structure, function, and biosynthesis of bio-membranes. **Prerequisites:** Bioch 623 and 624 or permission of instructor.

Bioch 817—CHEMISTRY AND METABOLISM OF HORMONES—3 cr.
    (3 and 0)
The isolation, assay, and chemistry of the various hormones are discussed. The hormonal control of metabolism and body functions as well as endocrinopathies of hormone imbalance are also studied. **Prerequisites:** Bioch 623 and 624 or permission of instructor.

Bioch 819—INTERMEDIARY METABOLISM—3 cr. (3 and 0)

This course deals with the dynamic processes of intermediary metabolism emphasizing the control of catabolism and anabolism in both plants and animals. Current ideas will be included and integrated with a broad range of information including such topics as cyclic nucleotides and membrane structure. The subject matter will be covered in lectures, in guided reading of original literature both current and classical, and in discussion. **Prerequisites:** Bioch 623 and 624 or permission of instructor.

Bioch 820—NUCLEIC ACIDS AND PROTEIN BIOSYNTHESIS—3 cr. (3 and 0)

The isolation, composition, structure, maturation and functions of nucleic acids leading to a discussion of mechanisms of protein synthesis. The course will be taught to draw similarities and differences between procaryotic and eucaryotic cells. Each student will review a recent paper in the literature, report on it, and write a potential experimental research proposal. **Prerequisites:** Bioch 623 and 624 or permission of instructor.

Bioch 821—PROTEINS—3 cr. (3 and 0)

The isolation, composition, structure, and properties of proteins. Methods of isolation, analysis, and characterization will be discussed along with the properties of "unusual" protein systems. **Prerequisite:** Bioch 623 or permission of instructor.

Bioch 822—ENZYMES—3 cr. (3 and 0)

An advanced course on kinetics, mechanism of action, inhibition and general properties of enzymes. **Prerequisite:** Bioch 623.

Bioch 823—CARBOHYDRATES—2 cr. (2 and 0)

The types, distribution, biological functions, reactions and energetics of the biosynthesis and degradation of carbohydrates. **Prerequisite:** Bioch 623.

Bioch 824—CELLULAR REGULATION AT THE MOLECULAR LEVEL— 3 cr. (3 and 0)

This is an advanced course on cellular regulation at the translational and transcriptional level. The students will be expected to present recent papers from the literature and also write a research proposal. **Prerequisite:** Bioch 820 or permission of the instructor.

Bioch 831—PHYSICAL BIOCHEMISTRY—3 cr. (3 and 0)

Description and theory of the physical methods and instrumentation used in the analyses of biological macromolecules. Special attention will be given to the description of the physical processes which occur. **Prerequisites:** Bioch 423/623 and one semester of physical chemistry with permission of instructor.

Bioch 851—BIOCHEMISTRY SEMINAR—1 cr. (1 and 0)

A review of current topics in biochemistry by graduate students in biochemistry and interested staff members.

Bioch 871—ADVANCED TOPICS—1-3 cr. (1-3 and 0)

Advanced topics will include offerings in bioenergetics, metabolic control mechanisms, biochemistry of unusual systems and current advances in the more traditional areas. The particular topic to be discussed each semester will be announced prior to registration. **Prerequisite:** Permission of instructor.

Bioch 891—RESEARCH—Credit to be arranged.

Bioch 991—DOCTORAL RESEARCH—Credit to be arranged.

BOTANY

C. J. Umphlett, Head, Department of Botany

The Master of Science degree is offered in Botany.

The Doctor of Philosophy degree is offered in plant physiology in an interdepartmental program. (See page 66.)

Students who desire pursuit of graduate work in botany or plant physiology should have sound undergraduate training in the biological and physical sciences, especially botany and chemistry. This training may be received in an undergraduate curriculum in botany, biology, or chemistry, or in one of the agricultural plant sciences, such as agronomy, forestry, or horticulture.

Bot 611—INTRODUCTORY MYCOLOGY—3 cr. (2 and 3)

Bot 613—PHYCOLOGY—3 cr. (2 and 3)

Bot 621—PLANT PHYSIOLOGY—4 cr. (3 and 3)

Bot 631—INTRODUCTORY PLANT TAXONOMY—3 cr. (2 and 3)

Bot 632—PLANT GEOGRAPHY—3 cr. (2 and 3)

Bot 641—PLANT ECOLOGY—3 cr. (2 and 3)

Bot 646—BIOLOGICAL OCEANOLOGY—4 cr. (3 and 3)

Bot 651—PLANT ANATOMY—4 cr. (3 and 3)

Bot 655—VASCULAR PLANT MORPHOLOGY—4 cr. (3 and 3)

Bot 661—CYTOLOGY—4 cr. (3 and 2)

180

Bot 701—EVOLUTIONARY BOTANY FOR TEACHERS—3 cr.
(2 and 3) F, SS

A survey of plant kingdom, with emphasis on the evolutionary relationships of plant divisions based primarily on morphology. The first part of the course will deal with the non-vascular plants, and the latter part will survey the vascular plants. Open only to teachers or those in the Master of Education degree program.

Bot 702—MODERN BOTANICAL CONCEPTS FOR TEACHERS—3 cr.
(3 and 0) S, SS

A study of selected topics in plant science, stressing functional processes in plants. Includes topics in the areas of physiology, ecology, genetics, and evolution. Open only to teachers or those in the Master of Education degree program.

Bot 805—SPECIAL PROBLEMS IN BOTANY—Credit to be arranged.

Original investigation of special problems in botany or plant physiology which are not related to a thesis but designed to provide experience and training in research. **Prerequisite:** Permission of instructor.

Bot 807—SEMINAR—1 cr. (1 and 0) F, S

A review of areas of the botanical sciences not covered by formal courses, with special emphasis on the review of literature, and organization and presentation of material by students.

(May be taken for credit only twice.)

Bot 811—ADVANCED MYCOLOGY I—4 cr. (3 and 3), S, odd numbered years.

Modern and classic involvements in the biology of the cells, organisms and populations of lower fungi, (Phycomycetes.) **Prerequisite:** Bot 651 or permission of instructor.

Bot 812—ADVANCED MYCOLOGY II—4 cr. (3 and 3), F, odd numbered years.

Modern and classic involvements in the biology of the cells, organisms, and populations of higher fungi (Ascomycetes and Basidiomycetes). **Prerequisites:** Bot 611 or permission of instructor.

Bot 815—PHYCOLOGY COLLOQUIM—3 cr. (3 and 0)

A discussion of phenomena associated with algae. Discussion topics are taken from current scientific literature and open to students a forum for criticizing research; for conceiving new ideas for research; for developing research outlines and proposals; and for incorporating knowledge gleaned from Phycology into a more inclusive understanding of physical and biological systems. **Prerequisite**: Bot 413/613 or permission of instructor.

Bot 821—INORGANIC PLANT METABOLISM—4 cr. (3 and 3) F, odd numbered years.

A consideration of plant, soil, water, nutrient relations, permeability, uptake and translocation, transpiration, and mineral nutrition. **Prerequisite:** Bot 421/621 or permission of instructor.

Bot 822—ORGANIC PLANT METABOLISM—3 cr. (3 and 0), even numbered years.

A consideration of respiration and photosynthesis; synthesis, translocation, storage, transformation and degradation of organic materials, fats, carbohydrates, proteins, pigments and enzymes. **Prerequisites:** Bot 421/621, organic chemistry, or permission of instructor.

Bot 823—PLANT GROWTH & DEVELOPMENT—3 cr. (3 and 0), even numbered years.

A consideration of vegetative and reproductive growth and development, from seed to maturity, flowering, fruiting and senescence. Also natural and synthetic growth, regulators, and morphogenesis. **Prerequisites:** Bot 421/621, organic chemistry, or permission of instructor.

Bot 824—MODE OF ACTION OF GROWTH SUBSTANCES—4 cr. (3 and 3), S, odd numbered years.

Detailed consideration of the physiology and biochemistry of both natural and synthetic growth regulators, hormones, growth retardants, herbicides, and other inhibitors. The methodology and mechanism of action will be discussed. **Prerequisites:** Bot 621, General Biochemistry, or Bot 822 or permission of the instructor.

Bot 826—PHYSIOLOGY OF THE FUNGI—3 cr. (3 and 0), S, even numbered years.

Discussions of fungal growth and cultivation, organic and inorganic metabolism, reproductive physiology, physiology as a taxonomic tool, and ecological interactions of fungi from a physiological viewpoint. **Prerequisites:** Bot 611, Bot 621, Bioch 423, or permission of instructor.

Bot 831—ADVANCED PLANT TAXONOMY—3 cr. (2 and 3), S, even numbered years.

A field oriented course with emphasis on the collection and identification of the spring flora of the area including some of the basic principles of plant classification and the relationships and characteristics of the major groups of vascular plants. **Prerequisite:** Bot 631 or permission of instructor.

Bot 891—RESEARCH—Credit to be arranged.

Bot 991—DOCTORAL RESEARCH—Credit to be arranged.

For those students enrolled in the Plant Physiology Ph.D. program with an emphasis in Botany.

CHEMISTRY

H. G. Spencer, Head, Department of Chemistry and Geology

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

An entering graduate student should have a record of sound academic achievement in an undergraduate chemistry curriculum.

Although additional courses are desirable, courses in general, analytical, organic and physical chemistry, and basic courses in physics and calculus, generally provide the preparation necessary for the students to enroll in courses carrying graduate credit. While minor deficiencies may be removed during the course of graduate study, major deficiencies will require undergraduate course work during the first year of study.

Entering graduate students are given placement examinations in four fields of chemistry — analytical, inorganic, organic and physical. Results of these examinations and a review of the student's undergraduate record and graduate study objectives assist his adviser in selecting the appropriate courses for the beginning student.

Research areas available to the student include analytical, inorganic, organic, physical, textile and biochemistry.

In addition to the requirements of the Graduate School, students must satisfy the following departmental requirements:

For the Master of Science degree. The courses to be completed for this degree normally include advanced courses in several areas of chemistry. A thesis is required.

For the Doctor of Philosophy degree. For those students who have not had a course in atomic and molecular structure, Ch 435/635 is required.

Qualification to pursue the degree is accomplished by completing a core of four courses with at least a B average during the first two years of graduate study. The required courses are taken from four areas of chemistry: one each from physical and organic, and two other areas chosen from analytical, inorganic and biochemistry. In lieu of these courses, qualification may be accomplished by examination.

A comprehensive examination of the cumulative type is required in the major field of specialization. The examination consists of a series of eight written examinations given monthly beginning immediately after completing three semesters in residence. An oral presentation before the student's advisory committee follows the successful completion of the cumulative examinations.

183

The Ph.D. in Chemistry with Emphasis in Textile Chemistry. The student in this program completes the general qualification and comprehensive requirements specified above for the Ph.D. in chemistry, with the exception that the comprehensive examination is a single written examination followed by an oral examination administered by the student's advisory committee.

Since the program requires the cooperative effort of both the Department of Chemistry and the Department of Textiles, a coordinating committee representing the two departments guides its academic procedures and requirements.

Teaching in undergraduate courses is an integral part of graduate work in chemistry and is required of all graduate students.

Ch 602—INORGANIC CHEMISTRY—3 cr. (3 and 0)

Ch 603—INORGANIC CHEMISTRY—3 cr. (3 and 0)

Ch 611—INSTRUMENTAL ANALYSIS—4 cr. (2 and 6)

Ch 613—QUANTITATIVE ANALYSIS—3 cr. (3 and 0)

Ch 615—QUANTITATIVE ANALYSIS LABORATORY—2 cr. (0 and 6)

Ch 617—QUANTITATIVE ANALYSIS LABORATORY—1 cr. (0 and 3)

Ch 621—ADVANCED ORGANIC CHEMISTRY—3 cr. (3 and 0)

Ch 622—ADVANCED ORGANIC CHEMISTRY LABORATORY—2 cr. (0 and 6)

Ch 631—PHYSICAL CHEMISTRY—3 cr. (3 and 0)

Ch 632—PHYSICAL CHEMISTRY—3 cr. (3 and 0)

Ch 635—ATOMIC AND MOLECULAR STRUCTURE—3 cr. (3 and 0)

Ch 636—SPECTROSCOPY LABORATORY—2 cr. (0 and 6)

Ch 639—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 640—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 654—INORGANIC SYNTHESIS—2 cr. (0 and 6)

Ch 672—ORGANIC SYNTHESIS—4 cr. (2 and 6)

Ch 691—INTRODUCTION TO RADIOCHEMISTRY—3 cr. (2 and 3)

Ch 700—PHYSICAL SCIENCE IN ELEMENTARY SCHOOL—CHEMISTRY—3 cr. (2 and 3)

The course is for the purpose of assisting the teacher in selecting, carry-

ing out, and discussing experiments which can be performed with limited equipment and time in the elementary school. The experiments are those which are useful in teaching basic chemical principles.

Ch 701—REVIEW OF GENERAL CHEMISTRY—3 cr. (3 and 0)

A lecture course designed to deal with the basic principles generally presented in a general chemistry course. Emphasis will be placed upon the explanation of observed facts in terms of modern atomic and molecular structure. Enrollment limited to secondary school teachers.

Ch 702—CHEMISTRY FOR HIGH SCHOOL TEACHERS—3 cr. (2 and 3)

A thorough development of modern chemical topics selected to meet the expressed needs of the students. Fundamental concepts in organic, bio-organic and physical chemistry are normally included. The laboratory provides experience in the performance and interpretation of illustrative experiments.

Ch 703—SPECIAL PROBLEMS IN CHEMISTRY FOR SECONDARY SCHOOL—3-6 cr. (3-6 and 0)

Primarily directed, individual study for the purpose of designing experiments and teaching materials or an in-depth study of one or more advanced topics. Seminars will be used as a teaching and evaluation procedure. Each participant should complete a project which can be used in his or her teaching situation. Restricted to secondary school teachers. May be repeated for additional credit.

Ch 805—THEORETICAL INORGANIC CHEMISTRY—3 cr. (3 and 0)

The application of modern theory to inorganic chemistry. **Prerequisites:** Ch 402/602 and 435/635, or permission of instructor.

Ch 807—CHEMISTRY OF THE TRANSITION ELEMENTS—3 cr. (3 and 0)

The chemistry of the transition elements with special emphasis on the coordination compounds formed by these elements. **Prerequisite:** Ch 402/602.

Ch 808—CHEMISTRY OF THE NON-METALLIC ELEMENTS—3 cr. (3 and 0)

The inorganic chemistry of the non-metallic elements, especially boron, silicon, phosphorous, and sulfur. **Prerequisite:** Ch 402/602.

Ch 811—ANALYTICAL CHEMISTRY—3 cr. (3 and 0)

A survey of the art of analytical chemistry. Topics included are: sample selection, sample treatment, the practical aspects of instrumentation, and the analytical chemistry of seventy chemical elements and several organic functional groups. The emphasis is upon the understanding of complete, economically feasible, analytical procedures for the determination of the components of complex mixtures.

Ch 812—CHEMICAL SPECTROSCOPIC METHODS—3 cr. (2 and 3)

A study and practice of emission and absorption spectroscopy, chemical microscopy, and X-ray diffraction and fluorescence techniques in analytical chemistry. The emphasis is on the theory and operation of the instruments.

Ch 814—ELECTROANALYTICAL CHEMISTRY—3 cr. (2 and 3)

A study of modern eletrochemistry as applied to analytical chemistry, including both theory and practical application.

Ch 821—ORGANIC CHEMISTRY I—3 cr. (3 and 0)

A study of the theroretical concepts of organic chemistry and the mechanisms of organic reactions. **Prerequisite:** Ch 621 or permission of the instructor.

Ch 822—ORGANIC CHEMISTRY II—3 cr. (3 and 0)

A study of modern synthetic organic chemistry and stereochemistry. **Prerequisite:** Ch 621 or permission of the instructor.

Ch 824—FUNDAMENTAL PRINCIPLES OF POLYMER CHEMISTRY— 3 cr. (3 and 0)

The organic chemistry of natural and synthetic macromolecules.

Ch 831—CHEMICAL THERMODYNAMICS—3 cr. (3 and 0)

Primarily a study of classical thermodynamics, with emphasis on theory and significance of energetics and on systems of variable composition. **Prerequisite:** Ch 331/631 or its equivalent.

Ch 834—STATISTICAL THERMODYNAMICS—3 cr. (3 and 0)

A treatment of statistical thermodynamics. **Prerequisite:** Ch 831.

Ch 835—CHEMICAL KINETICS—3 cr. (3 and 0)

A study of rate processes and reaction mechanisms. Topics such as the following are treated: order of reaction, theory rate of processes, relation of reaction rates to mechanism, homogenous and heterogeneous catalysis, experimental methods, chain reactions, diffusion, and effects of solvent, temperature and pressure on reaction rates and mechanisms. Lectures are supplemented by assigned problems, and a paper and oral examination of a topic of special interest to the individual student.

Ch 837—QUANTUM CHEMISTRY—3 cr. (3 and 0)

A study of the mathematical and conceptual formulation of the quantum theory of the electronic structure of atoms and molecules. Emphasis is placed on the eigenvalue solution of the one-dimensional Schroedinger equation and application of this method to chemical problems.

Ch 840—TECHNIQUES OF EXPERIMENTAL CHEMISTRY—3 cr. (1 and 6)

Theory and practice in the major experimental techniques used in chemical research. Techniques are selected from: NMR; chromatography; IR, visible, UV and ORD/CD spectrophotometry; glassblowing and high vacuum techniques; mass spectrometry; ESR; Mossbauer spectrometry and tracer analysis.

Ch 851—SEMINAR—1-2 cr.

(May be taken more than one semester.)

Ch 861—PRINCIPLES OF BIOCHEMISTRY—3 cr. (3 and 0) S

A rigorous, quantitative treatment of the properties of biological molecules using the modern techniques of organic, physical and analytical chemistry to study structural relationships and biological activity. **Prerequisites:** Satisfactory performance on placement examinations in organic and physical chemistry.

Ch 891—RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

Ch 906—SPECIAL TOPICS IN INORGANIC CHEMISTRY—1-4 cr.
    (1-4 and 0)

Advanced topics including crystals, non-aqueous solvents, chemical application of group theory, rare-earth elements and non-stoichiometric compounds will be treated according to the interests of the students. (May be taken more than one semester.)

Ch 910—SPECIAL TOPICS IN ANALYTICAL CHEMISTRY—1-4 cr.
    (1-4 and 0)

One or more current topics such as separation methods, advanced electrochemistry, new techniques in analytical chemistry, organic analytical reagents, data acquisition and processing, instrument-computer interfacing, etc. will be treated according to the interests of the students. (May be taken more than one semester.)

Ch 920—ADVANCED TOPICS IN ORGANIC CHEMISTRY—1-4 cr.
    (1-4 and 0)

An advanced study of one or more topics in organic chemistry. Topics such as heterocyclic compounds; stereochemistry, natural products, organometallic chemistry, photochemistry, etc., will be treated according to the interest of the students. (May be taken more than one semester.)

Ch 930—ADVANCED TOPICS IN PHYSICAL CHEMISTRY—1-4 cr.
    (1-4 and 0)

An advanced study of one or more topics in physical chemistry. Topics such as special problems in molecular spectroscopy, molecular orbital treatments, applications of group theory to chemical structure, irreversible thermodynamics, special topics in statistical mechanics, etc., will be treated according to the interest of the students. (May be taken more than one semester.)

Ch 950—MICROANALYTICAL TECHNIQUES—3 cr. (1 and 6)

Designed to perfect the laboratory technique of the advanced graduate students. Procedures followed are those used to analyze organic compounds for elemental composition.

Ch 991—DOCTORAL RESEARCH—Credit to be arranged.

(May be taken more than one semester.)

GEOLOGY

P. K. Birkhead, Program Coordinator

Advanced degrees are not awarded in geology. Courses are offered as a minor for students majoring in other areas.

Geol 600—ENVIRONMENTAL GEOLOGY—3 cr. (3 and 0)

Geol 602—STRUCTURAL GEOLOGY—3 cr. (3 and 0)

Geol 603—INVERTEBRATE PALEONTOLOGY—3 cr. (2 and 3)

Geol 604—ECONOMIC GEOLOGY—3 cr. (3 and 0)

Geol 605—GEOMORPHOLOGY—4 cr. (3 and 3)

Geol 606—MINERALOGY—3 cr. (2 and 3)

Geol 607—QUATERNARY GEOLOGY—3 cr. (2 and 2)

Geol 608—GEOHYDROLOGY—3 cr. (3 and 0)

Geol 609—PETROLOGY—3 cr. (2 and 3)

Geol 610—OPTICAL MINERALOGY—3 cr. (1 and 4)

Geol 611—RESEARCH PROBLEMS—1-3 cr. (0 and 3-9)

Geol 613—STRATIGRAPHY AND SEDIMENTATION—3 cr. (3 and 0)

Geol 615—GEOLOGY PRACTICED IN INDUSTRY AND GOVERNMENT —3 cr. (3 and 0)

Geol 700—EARTH SCIENCE I—3 cr. (2 and 3)

Physical geology for secondary school teachers of earth science and physical sciences. A study of materials of the earth's crust, processes of formation and change, geologic features of the earth. Field trips provide for observation of materials, operating processes, and results of processes in nature.

Geol 750—EARTH SCIENCE II—3 cr. (2 and 3)

Historical geology for secondary school teachers of earth science and physical sciences. A study of the record of change of the earth, both physi-

cal and biological, through geologic time to the present; lab demonstration and field trips illustrate methods used in deciphering the record as presented.

MATHEMATICAL SCIENCES

J. W. Kenelly, Head, Department of Mathematical Sciences

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

Students seeking the master's degree may choose a thesis or non-thesis option. Work for the non-thesis master's degree will consist of a minimum of thirty-one semester hours.

Students are admitted to candidacy for the Doctor of Philosophy degree upon the successful completion of a written qualifying examination on the subject matter of the major and minor fields.

The Ph.D. in Management Science. The Departments of Industrial Management and Mathematical Sciences jointly offer and administer a Ph.D. program in Management Science. A description of the program and listing of courses offered by the two departments is listed on pages 160 to 163.

The Department of Mathematical Sciences offers a Computer Science option in its Master of Science and Doctor of Philosophy degree programs. In addition to courses in Computer Science, the student chooses courses from the core curriculum appropriate for this option.

Comp Sc 609—INTRODUCTION TO NUMERICAL ANALYSIS I—3 cr. (3 and 0)

Comp Sc 610—INTRODUCTION TO NUMERICAL ANALYSIS II—3 cr. (3 and 0)

Comp Sc 621—INTRODUCTION TO ASSEMBLER LANGUAGE PROGRAMMING—3 cr. (3 and 0)

Comp Sc 622—ADVANCED ASSEMBLER LANGUAGE PROGRAMMING —3 cr. (3 and 0)

Comp Sc 623—FUNDAMENTALS OF SOFTWARE DESIGN—3 cr. (3 and 0)

Comp Sc 628—ALGORITHMIC LANGUAGES AND COMPILERS—3 cr. (3 and 0)

Comp Sc 640—LIST PROCESSING—3 cr. (3 and 0)

Comp Sc 660—PERIPHERALS AND FILE DESIGN—3 cr. (3 and 0)

Comp Sc 662—DESIGN OF DATA MANAGEMENT SYSTEMS—3 cr.
        (3 and 0)

Math 601—STATISTICAL THEORY AND METHODS I—3 cr. (3 and 0)

Math 602—THEORY OF PROBABILITY—3 cr. (3 and 0)

Math 603—STATISTICAL INFERENCE—3 cr. (3 and 0)

Math 604—INTRODUCTION TO STOCHASTIC PROCESSES—3 cr.
        (3 and 0)

Math 605—STATISTICAL THEORY AND METHODS II—3 cr. (3 and 0)

Math 607—PARTIAL DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)

Math 608—TOPICS IN GEOMETRY—3 cr. (3 and 0)

Math 609—STATISTICAL THEORY AND METHODS III—3 cr. (3 and 0)

Math 611—LINEAR ALGEBRA—3 cr. (3 and 0)

Math 612—INTRODUCTION TO MODERN ALGEBRA—3 cr. (3 and 0)

Math 613—MODERN ALGEBRA—3 cr. (3 and 0)

Math 615—INTRODUCTION TO TOPOLOGY—3 cr. (3 and 0)

Math 617—MATHEMATICAL PROGRAMS—3 cr. (3 and 0)

Math 619—APPLIED COMBINATORIAL ALGEBRA I—3 cr. (3 and 0)

Math 620—APPLIED COMBINATORIAL ALGEBRA II—3 cr. (3 and 0)

Math 628—NUMERICAL LINEAR ALGEBRA—3 cr. (3 and 0)

Math 629—NUMERICAL ANALYSIS—3 cr. (3 and 0)

Math 635—COMPLEX VARIABLES—3 cr. (3 and 0)

Math 652—LINEAR PROGRAMMING—3 cr. (3 and 0)

Math 653—ADVANCED CALCULUS I—3 cr. (3 and 0)

Math 654—ADVANCED CALCULUS II—3 cr. (3 and 0)

Math 657—APPLIED MATHEMATICS I—3 cr. (3 and 0)

Math 658—APPLIED MATHEMATICS II—3 cr. (3 and 0)

Math 663—MATHEMATICAL ANALYSIS I—3 cr. (3 and 0)

Math 664—MATHEMATICAL ANALYSIS II—3 cr. (3 and 0)

Math 671—APPLIED STATISTICAL DECISION THEORY—3 cr. (3 and 0)

Math 673—INTRODUCTION TO NONLINEAR OPTIMIZATION—3 cr.
(3 and 0)

Math 701—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—NUMBER SYSTEMS I—3 cr. (3 and 0)

Sets and cardinal numbers. Development of the base ten number system. Other number systems ancient and modern, including other number bases. Historical development of place value. The importance of zero in number systems. Arithmetic properties of whole numbers. Construction of the integers and the rational numbers using sets. Primes and composites. Arithmetic properties of the rationals. Irrationals and the incommensurables of the Greeks. Order properties of the real number system. Dedekind cuts. Density of real number system Open to all graduate students in education except those majoring in Secondary Education.

Math 702—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—NUMBER SYSTEMS II—3 cr. (3 and 0)

A continuation of Math 701. Open to all graduate students in Education except those majoring in Secondary Education. **Prerequisite:** Math 701.

Math 703—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—GEOMETRY—3 cr. (3 and 0)

An introduction to concepts of geometry. Topics included are informal geometry, measurement of geometric figures, metric measurements, deductive geometry, functions in geometry, coordinate and vector geometry. Open to all graduate students in education execpt those majoring in Secondary Education.

Math 705—MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—ALGEBRA, PROBABILITY, & STATISTICS—
3 cr. (3 and 0)

A survey course in the fundamentals of elementary algebra, elementary probability, and descriptive statistics. Open to all graduate students in education except those majoring in Secondary Education.

Math 711—MODERN ALGEBRAIC CONCEPTS I—3 cr. (3 and 0)

An introduction to the terminology, concepts, and methods of modern abstract algebra. Topics will include a discussion of groups, rings, integral domains, and fields. Numerous examples will be given to illustrate the various algebraic systems and elementary properties of each will be discussed. Restricted to graduate students in Secondary Education.

Math 712—MODERN ALGEBRAIC CONCEPTS II—3 cr. (3 and 0)

A review and continuation of Math 711 including a study of the theory of groups and rings. Restricted to graduate students in Secondary Education.

Math 721—MATRIX ALGEBRA I—3 cr. (3 and 0)

An introduction to determinants, matrices, vectors, vector spaces, and linear transformations. Systems of equations are used to introduce matrices. Restricted to graduate students in Secondary Education.

Math 722—MATRIX ALGEBRA II—3 cr. (3 and 0)

A review and continuation of Math 721. A study of linear transformations, similarity, polynominals and polynominal matrices, and matrix analysis. Restricted to graduate students in Secondary Education.

Math 725—COMBINATORIAL MATHEMATICS FOR TEACHERS—3 cr.
        (3 and 0)

Topics chosen from the following subjects: permutations, combinations, generating functions, recurrence relations, principle of inclusion-exclusion, partitions, Latin squares, block designs, finite geometries, graphs, codes, Polya's theorem, recreational mathematics. Restricted to graduate students in Secondary Education.

Math 730—MODERN GEOMETRY FOR TEACHERS—3 cr. (3 and 0)

Concepts of Euclidean geometry reviewed and extended by means of coordinates, vectors, and matrices. Special attention given to conic sections. Restricted to graduate students in Secondary Education.

Math 731—NON-EUCLIDEAN GEOMETRY—3 cr. (3 and 0)

A discussion of Euclid's fifth postulate and the discovery of Non-Euclidean geometry, followed by a detailed study of hyperbolic plane geometry. Restricted to graduate students in Secondary Education.

Math 732—PROJECTIVE GEOMETRY—3 cr. (3 and 0)

Both analytic and synthetic methods are used to develop the properties of projective geometry and its subgeometries, ranging from affine to Euclidean geometry. Restricted to graduate students in Secondary Education.

Math 741—INTRODUCTION TO LINEAR PROGRAMMING WITH
        APPLICATIONS—3 cr. (3 and 0)

Development of the mathematical theory of the simplex algorithm beginning with a survey of mathematical background required. The topics surveyed will include matrix algebra, systems of linear equations, and vector spaces. Emphasis on the formulation of problems. Restricted to graduate students in Secondary Education.

Math 751—FUNDAMENTAL CONCEPTS OF CALCULUS I—3 cr.
        (3 and 0)

Set theory, real number system, functions and relations, metric sets and limits, continuity and differentiation, integration. Restricted to graduate students in Secondary Education. **Prerequisite:** One year of undergraduate calculus.

Math 752—FUNDAMENTAL CONCEPTS OF CALCULUS II—3 cr. (3 and 0)

Vector and Euclidean space, topology of Euclidean n-space, differential calculus of functions of several variables, integral calculus of functions of several variables. Restricted to graduate students in Secondary Education. **Prerequisite:** Math 751.

Math 761—PROBABILITY AND STATISTICS—3 cr. (3 and 0)

Probability, conditional probability, descriptive statistics, random variables, probability functions, binomial distribution, normal distribution, sampling, estimation, decision making. Restricted to graduate students in Secondary Education.

Math 771—NUMERICAL METHODS IN SECONDARY MATHEMATICS I —3 cr. (3 and 0)

This course is designed to service secondary school teachers with an interest in updating traditional techniques for the teaching of high school mathematics by introducing computer methods for the investigation of processes and the reinforcement of concepts. Emphasis is placed on the development of programs which require the participants to "invent" algorithms to solve problems which are in the typical high school mathematics course. In addition to learning to use a general purpose programming language, participants will become proficient in the teaching of this same language to high school students. Restricted to graduate students in Secondary Education.

Math 772—NUMERICAL METHODS IN SECONDARY MATHEMATICS II—3 cr. (3 and 0)

A continuation of Math 771. Restricted to graduate students in Secondary Education. **Prerequisite:** Math 771.

Math 781—HISTORY OF MATHEMATICS—3 cr. (3 and 0)

A survey of the development of mathematics beginning with ancient numeration systems, continuing through the origins of geometry and irrational numbers in classical and Alexandrian Greek periods, and extending through the development of calculus. Cantor's set theory. Controversy over Euclid's Fifth Postulate. Completeness of the real numbers. The mathematics of the infinite and its applications. Origins of probability and statistics, abstract algebra, topology, computing machines and mathematical logic. Restricted to graduate students in Education. **Prerequisite:** One year of calculus at the college level.

Math 783—THEORY OF NUMBERS—3 cr. (3 and 0)

A study of the properties of the integers. Topics will include divisors and prime numbers, fundamental properties of congruence, polynominal and primitive roots, quadratic residues. Restricted to graduate students in Secondary Education. **Prerequisite:** One year of calculus at the college level.

Math 791—MATHEMATICAL PROBLEMS IN THE CURRICULUM—
3 cr. (3 and 0)

A study of mathematical problems in the curriculum of the elementary or secondary school. Restricted to graduate students in Elementary or Secondary Education.

Math 801—GENERAL LINEAR HYPOTHESIS I—3 cr. (3 and 0)

Topics include: least-square estimates, Gauss-Markoss theorem, confidence ellipsoids and confidence intervals for estimable functions, test of hypothesis, one-two and, higher-way layouts, the analysis of variance for other models. **Prerequisites:** Math 403/603 and 411/611.

Math 802—GENERAL LINEAR HYPOTHESIS II— 3 cr. (3 and 0)

A continuation of Math 801.

Math 803—STOCHASTIC PROCESSES I—3 cr. (3 and 0)

Principal topics include: theory and analysis of time series, recurrent events, Markov chains, random walks, renewal theory, application to communication theory, and operation research. **Prerequisite:** Math 404/604.

Math 804—STOCHASTIC METHODS IN PROBABILITY AND STATIS-
TICS II—3 cr. (3 and 0)

Conditional expectation, conditional variance, best predictor, introduction to multivariate analysis, introduction to stochastic processes, application of mathematical and stochastic models. **Prerequisites:** Math 405/605 and 411/611.

Math 806—NONPARAMETRIC STATISTICS—3 cr. (3 and 0)

Principal topics include: order statistics, tolerance limits, rank-order statistics, Kolmogorov-Emirnov one-sample statistics, Chi-square goodness-of-fit test, two-sample problem, linear rank statistics, asymtotic relative efficiency. **Prerequisite:** Math 402/602.

Math 807—MATHEMATICAL STATISTICS I—3 cr. (3 and 0)

A discussion, without utilizing measure theory, of advanced topics in mathematical statistics. Principal topics include methods of estimation, properties of estimators, confidence level theory, Bayesian and fiducial inference, foundations of hypothesis testing, multivariate normal distribution, simultaneous interval estimation, nonparametric inference. **Prerequisites:** Math 403/603, 411/611, 454/654.

Math 808—MATHEMATICAL STATISTICS II—3 cr. (3 and 0)

A continuation of Math 807.

Math 809—TIME SERIES ANALYSIS, FORECASTING AND CONTROL—
3 cr. (3 and 0)

Modeling and forecasting random processes; autocorrelation functions and spectral densities; model identification, estimation and diagnostic

checking; transfer function models; feedforward and feedback control schemes. **Prerequisites:** Math 402/602, 405/605, or equivalent.

Math 811—NONLINEAR PROGRAMMING—3 cr. (3 and 0)

A theoretical development of nonlinear optimization with applications. Main topics include: classical optimization, convex and concave functions, separable programming, quadratic programming, and gradient methods. **Prerequisites:** Math 452/652, 453/653.

Math 812—DYNAMIC PROGRAMMING—3 cr. (3 and 0)

The study of deterministic and stochastic multistage decision processes. Topics include: Mitten sufficiency, existence and uniqueness theorems, approximation in policy space, multistage games, Markovian decision processes, surveillance theory, and the Pontryagin maximum principle. **Prerequisites:** Math 452/652, 454/654.

Math 813—ADVANCED MATHEMATICAL PROGRAMMING—3 cr. (3 and 0)

Convexity and Kuhn-Tucker theory; complementarity, geometric programming; integer programming algorithms, network flows; penalty function methods; maximum principle; methods of fixed point approximations, introduction to game theory. **Prerequisite:** Math 452/652.

Math 815—DATA STRUCTURES—3 cr. (3 and 0)

Representation and transformation of information; formal descriptions of processes and data structures; tree and list structures, push-down stacks, string and formula manipulation, hashing techniques; interrelation between data structure and program structure; storage allocation methods. **Prerequisite:** Computational maturity and permission of instructor.

Math 817—STOCHASTIC MODELS IN OPERATIONS RESEARCH I— 3 cr. (3 and 0)

Introduction to stochastic control, structure of sequential decision processes. Stochastic inventory models, recursive computation of optimal policies. Discrete parameter finite Markov decision processes, various optimality criteria, computation by policy improvement and other methods, existence of optimal stationary policies, stopping-rule problems; examples from financial management maintenance and reliability, search, queueing and shortest path. **Prerequisites:** Math 602-604.

Math 818—STOCHASTIC MODELS IN OPERATIONS RESEARCH II— 3 cr. (3 and 0)

Introduction to queueing theory; Markovian queues, repairman problems, queues with an embedded Markov structure, the queue GI/G/1, queues with a large number of servers, decision making in queues. Introduction to reliability theory; failure distributions, stochastic models for complex systems, maintenance and replacement policies, reliability properties of multi-component structures. **Prerequisites:** Math 602-604.

Math 821—REAL ANALYSIS I—3 cr. (3 and 0)

Hausdorff and metric spaces, cardinal and ordinal numbers, rings and algebras of sets, exterior and interior measure, completion of measures, Borel and Lebesque measures in Euclidean n-space, integration theory associated with a measure, types of convergence, derivatives. **Prerequisite:** Math 454/654.

Math 822—REAL ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 821.

Math 823—COMPLEX ANALYSIS I—3 cr. (3 and 0)

Topological concepts, complex integration, local and global properties of analytic functions, power series, representation theorems, calculus of residues. Designed for non-engineering majors. **Prerequisite:** Math 464/664.

Math 824—COMPLEX ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 823 with an introduction to topological analysis.

Math 825—ORDINARY DIFFERENTIAL EQUATIONS I—3 cr. (3 and 0)

Existence and uniqueness theorems, dependence on initial conditions and parameter, linear differential equations, self adjoint eigenvalue problems, oscillation and comparison theorems. **Prerequisite:** Math 454/654 and 411/611 or 464/664.

Math 826—ORDINARY DIFFERENTIAL EQUATIONS II—3 cr. (3 and 0)

Perturbations of systems having a periodic solution, stability, Poincare-Bendixson theory, use of fixed point theorems, almost periodic solutions and integral manifolds. **Prerequisite:** Math 825.

Math 831—FOURIER SERIES—3 cr. (3 and 0)

Fourier series with applications to the solution of boundary value problems in the partial differential equations of physics and engineering; and introduction to Bessel functions and Legendre polynominals, with applications. **Prerequisites:** Math 464/664.

Math 833—OPERATIONAL MATHEMATICS—3 cr. (3 and 0)

A study of the operational properties of the Laplace and other integral transforms. The applications are chiefly to problems in engineering and physics that involve differential equations, with emphasis on boundary value problems in partial differential equations. **Prerequisite:** Math 454/654.

Math 837—CALCULUS OF VARIATIONS—3 cr. (3 and 0)

The fundamental theory of the calculus of variation. Variable end points. The parametric problem. The isoperimetric problem. Fundamental sufficiency theorems. **Prerequisite:** Math 454/654 or 464/664.

Math 839—INTEGRAL EQUATIONS—3 cr. (3 and 0)

Basic theory. Relationships to linear differential initial value problems. Fredholm theory. Linear Fredholm integral equations of the first and second kind. Hilbert-Schmidt theory. Volterra equation. **Prerequisite:** Math 464/664.

Math 841—APPLIED MATHEMATICS I—3 cr. (3 and 0)

Linear spaces, spectral theory of operators. Green's function. Eigenvalue problems of ordinary differential equations. Partial differential equations. **Prerequisites:** Math 464/664 and 853.

Math 842—APPLIED MATHEMATICS II—3 cr. (3 and 0)

A continuation of Math 841.

Math 850—COMPUTATIONAL PROBLEMS IN DISCRETE STRUC-
         TURES—3 cr. (3 and 0)

Digital representation and application of basic discrete structures: sets, relations, graphs, diagraphs, automata, unary algebras. The computational analog of product structure will be presented in each case. **Prerequisite:** Computational maturity and permission of instructor.

Math 851—ABSTRACT ALGEBRA I—3 cr. (3 and 0)

A review of the fundamental theory of Math 412 and 413, a study of finite groups including permutation groups, p-groups, the Sylow theorems and the structure of finite abelian groups. Groups with chair conditions, the Krull-Schmidt and Jordan-Holder theorems. Solvable, nilpotent and free groups. Galois theory, finite fields and the Wedderburn theorem.

Math 852—ABSTRACT ALGEBRA II—3 cr. (3 and 0)

A continuation of Math 851 including a study of the structure of rings and introductions to other algebraic systems.

Math 853—ADVANCED LINEAR ALGEBRA—3 cr. (3 and 0)

Properties of finite dimensional vector spaces: bases, dimensions, transformations, projections and orthogonality. **Prerequisites:** Math 411/611 and Math 412/612.

Math 854—THEORY OF GRAPHS I—3 cr. (3 and 0)

Connectedness, path problems, trees, matching theorems, directed graphs, fundamental numbers of the theory of graphs, groups and graphs. **Prerequisite:** Permission of instructor.

Math 855—COMBINATORIAL ANALYSIS I—3 cr. (3 and 0)

Topics selected from combinations, permutations, permutations with restricted position, Polya's theorem, principle of inclusion and exclusion, partitions, recurrence relations, generating functions, Mobius inversion,

enumeration techniques, Ramsey numbers, finite projective and affine geometrics, Latin rectangles, orthgonal arrays, block designs, error detecting and error correcting codes. **Prerequisite:** Math 411/611.

Math 861—ADVANCED NUMERICAL ANALYSIS I— 3 cr. (3 and 0)

Advanced treatment of topics selected from the following: interpolation and approximation, numerical quadrature, numerical solution of functional differential equations, integral equations and overdetermined linear systems, eigenvalue problems, approximation using splines. **Prerequisites:** Math 428/628, 429/629 and digital computer experience.

Math 862—ADVANCED NUMERICAL ANALYSIS II— 3 cr. (3 and 0)

A continuation of Math 861.

Math 863—DIGITAL ANALYSIS I—3 cr. (3 and 0)

Introduction to experimental mathematics, pseudo-stochastic processes, analytical and algebraic formulations of time-independent simulation, continuous-time simulation and discrete-time simulation. Digital optimization, Fibonacci search, ravine search, gradient methods. Selected topics from current research in digital analysis. **Prerequisites:** Math 411/611, 429/629, 453/653 and digital computer experience.

Math 864—DIGITAL ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 863.

Math 865—CALCULUS OF FINITE DIFFERENCES—3 cr. (3 and 0)

Difference operators, summation formulas, functions important in the calculus of finite differences, existence and uniqueness theorems of difference equations, orthogonal polynominals. **Prerequisite:** Math 454/654.

Math 871—GENERAL TOPOLOGY I—3 cr. (3 and 0)

Definitions and elementary properties of a topological space, subspaces, quotient and product spaces, Moore-Smith convergence, separation axioms and consequences, metrization theorems, introduction to homotopy theory uniformities and axiomatic boundedness. **Prerequisite:** Math 454/654.

Math 872—GENERAL TOPOLOGY II—3 cr. (3 and 0)

A continuation of Math 871.

Math 873—ALGEBRAIC TOPOLOGY—3 cr. (3 and 0)

Homology and cohomology in complexes. Applications to fixed point theorems. Introduction to homotopy theory. Singular homology theory; the cohomology ring. Introduction to manifolds, fibre spaces, and sheaf theory. **Prerequisites:** Math 413/613 and 871.

Math 875—CONVEXITY—3 cr. (3 and 0)

Hyperplanes and separation theorems, characterizations of convex sets, local convexity, Helly-type theorems, convex functions.

Math 881—HISTORY OF MATHEMATICS—3 cr. (3 and 0)

A survey of the development of mathematics. Use of reference material supplements the text, and class discussion is expected. **Prerequisite:** Permission of instructor.

Math 891—RESEARCH—Credit to be arranged.

Math 901—PROBABILITY THEORY I—3 cr. (3 and 0)

Axomatic theory of probabilities. General concepts and tools of probability theory are developed to discuss sums of independent random variables and their limit properties. Principal topics: Cartesian product of infinity, many measurable spaces, Daniel-Kolmogoroff theorems, Borel-Cantelli's lemma, monotone class theorem, modes of convergence, characteristic functions, infinitely divisible distributions, central limit theorems, law of large numbers, ergodic theorems. **Prerequisites:** Math 402/602 and 822.

Math 902—PROBABILITY THEORY II—3 cr. (3 and 0)

A continuation of Math 901. Conditioning and limit properties of sums of dependent random variables. Principal topics: conditioning, martingales, calculus in quadratic means.

Math 905—DECISION THEORY I—3 cr. (3 and 0)

Basic topics include: classes of decision functions, estimators, properties of estimators, methods of deriving estimators, testing of hypotheses, uniformly most powerful tests, methods of deriving tests. **Prerequisites:** Math 403/603 and 822.

Math 906—DECISION THEORY II—3 cr. (3 and 0)

A continuation of Math 905.

Math 907—MULTIVARIATE ANALYSIS—3 cr. (3 and 0)

Principal topics include: multivariate normal distribution, Wishart distribution, Hotelling's T^2 distribution, estimation of parameters, test of hypotheses on vector means and covariance matrices. **Prerequisite:** Math 802.

Math 920—INTRODUCTION TO HARMONIC ANALYSIS—3 cr. (3 and 0)

Topics include trigonometric functions and series, summability methods, convergence and summability of Fourier series, Fourier integrals, Fourier transforms, the Banach algebra L^1 (R) and ideals in L^1. **Prerequisites:** Math 822 and 824.

Math 923—INTRODUCTION TO THE THEORY OF DISTRIBUTION— 3 cr. (3 and 0)

Topics include: linear topological spaces, generalized functions, support of distributions, distributions, convolutions of distributions, Fourier trans-

forms of distributions, and connection with analytic functions. **Prerequisites:** Math 822 and 824.

Math 925—TOPICS IN DYNAMICAL SYSTEMS—3 cr. (3 and 0)

The subject matter is to be chosen from current research problems of interest; e.g., dissipative and conservative systems, integral equations, integral manifolds, functional differential equations and nonlinear operaators. **Prerequisite:** Math 825 or permission of instructor.

Math 927—FUNCTIONAL ANALYSIS I—3 cr. (3 and 0)

A study of Hilbert, normed, Banach and topological linear spaces; linear operators in these spaces; Hahn-Banach, uniform boundedness, and closed-graph theorems; applications to problems in analysis; spectral theory for linear operators. **Prerequisite:** Math 822.

Math 928—FUNCTIONAL ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 927.

Math 951—GROUP THEORY—3 cr. (3 and 0)

A further study of groups including: extensions, linear groups, infinite abelian groups, word problems, group representations. **Prerequisite:** Math 851.

Math 952—RING THEORY—3 cr. (3 and 0)

Injective and projective modules, exact sequences, Wedderburn-Artin theorem, various radicals, rings with minimum condition. **Prerequisites:** Math 851 and 852.

Math 954—THEORY OF GRAPHS II—3 cr. (3 and 0)

A continuation of Math 854.

Math 955—COMBINATORIAL ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 855.

Math 956—FIELD THEORY—3 cr. (3 and 0)

A further study of fields including: valuations, ideals, algebraic number fields, Dedekind fields, and additional topics in finite fields. **Prerequisites:** Math 851 and 852.

Math 957—SEMIGROUP THEORY—3 cr. (3 and 0)

An introduction to the algebraic theory of semigroups: elementary concepts, ideals and related concepts, minimal conditions, inverse semigroups, various representations, decompositions and extensions. **Prerequisite:** Math 851 or permission of instructor.

The following Special Topics courses consist of subject matter chosen from current research problems of interest. Students will be active participants in the course.

Math 980—SPECIAL TOPICS IN PROBABILITY—1-3 cr. (1-3 and 0)

Math 981—SPECIAL TOPICS IN MATHEMATICAL STATISTICS— 1-3 cr. (1-3 and 0)

Math 982—SPECIAL TOPICS IN ANALYSIS—1-3 cr. (1-3 and 0)

Math 983—SPECIAL TOPICS IN FUNCTIONAL ANALYSIS—1-3 cr. (1-3 and 0)

Math 984—SPECIAL TOPICS IN APPLIED MATHEMATICS—1-3 cr. (1-3 and 0)

Math 985—SPECIAL TOPICS IN ALGEBRA—1-3 cr. (1-3 and 0)

Math 986—SPECIAL TOPICS IN CONVEXITY—1-3 cr. (1-3 and 0)

Math 987—SPECIAL TOPICS IN NUMERICAL PROCESSES—1-3 cr. (1-3 and 0)

Math 988—SPECIAL TOPICS IN OPERATIONS RESEARCH—1-3 cr. (1-3 and 0)

Math 989—SPECIAL TOPICS IN INFORMATION PROCESSING—1-3 cr. (1-3 and 0)

This course content will be variable, covering various topics from the fields of computer science and data processing.

Math 991—DOCTORAL RESEARCH—Credit to be arranged.

MICROBIOLOGY

M. J. B. Paynter, Head, Department of Microbiology

Courses are offered leading to the Master of Science degree. The Doctor of Philosophy degree is offered in Plant Physiology with an emphasis in Microbiology.

Graduate work in microbiology requires sound undergraduate training in the biological and physical sciences. This training may be received in an undergraduate program in biology (botany, microbiology, or zoology), chemistry or in one of the agricultural sciences. Undergraduate work in bacteriology or microbiology is desirable but not necessary.

Micro 600—PUBLIC HEALTH MICROBIOLOGY—3 cr. (3 and 0) S

Micro 601—ADVANCED BACTERIOLOGY—4 cr. (2 and 6) F

Micro 602—DAIRY MICROBIOLOGY—3 cr. (2 and 3) S, even numbered years.

Micro 604—FOOD MICROBIOLOGY—3 cr. (2 and 3) S, odd numbered years.

Micro 605—GENERAL MICROBIOLOGY—4 cr. (3 and 3) F, S, SS

Micro 610—SOIL MICROBIOLOGY—3 cr. (2 and 3) S, even numbered years.

Micro 611—PATHOGENIC BACTERIOLOGY—4 cr. (3 and 3) S

Micro 612—BACTERIAL PHYSIOLOGY—4 cr. (3 and 3) S

Micro 613—INDUSTRIAL MICROBIOLOGY—3 cr. (2 and 3) F.

Micro 614—BASIC IMMUNOLOGY—3 cr. (2 and 3) F

Micro 615—MICROBIAL GENETICS—4 cr. (3 and 3) F

Micro 616—INTRODUCTORY VIROLOGY—3 cr. (3 and 0) F

Micro 801—BACTERIAL TAXONOMY—3 cr. (2 and 3) F, odd numbered years.

The history of determinative bacteriology and the basic morphological, cultural, and physiological differences used in distinguishing between the various taxonomic groups of bacteria. Opportunity is given in the laboratory to isolate and identify bacteria from natural sources. **Prerequisites:** Micro 401/601 and organic chemistry. May be taken concurrently with Micro 401/601.

Micro 802—BACTERIOLOGICAL TECHNIC—4 cr. (2 and 6) F

Analytical and experimental procedures used in bacteriology, including techniques for studying bacterial cytology, physiology, and metabolism. Designed to give students experience in more advanced methods of investigation.

Micro 803—SPECIAL PROBLEMS IN MICROBIOLOGY—Credit to be arranged.

Original research on special problems in microbiology not related to the thesis.

Micro 804—CURRENT TOPICS IN MICROBIOLOGY—1 cr. (1 and 0)

An evaluation of current research literature in the various areas of microbiology. Specific publications will be critically evaluated in terms of their merit. Required of all microbiology graduate students. May be repeated for credit.

Micro 807—SEMINAR—1 cr. (1 and 0)

A study of areas of microbiology not covered by formal courses with special emphasis on the review of literature, and organization and presentation of material by students. (May be taken for credit only twice.)

Micro 810—SOIL MICROBIOLOGY—3 cr. (2 and 3) S, odd numbered years.

Characterization and ecology of soil microorganisms. Interrelations of soil microbial populations; associative and antagonistic effects. Effects of soil microorganisms on plant growth. Relations of plant rhizospheres to nutritional groups of microorganisms. **Prerequisite:** Micro 401/601 or 410/610.

Micro 811—BACTERIAL CYTOLOGY AND PHYSIOLOGY—4 cr. (4 and 0) S, odd numbered years.

A consideration of the structure, chemistry and physiology of the various bacterial cell components; the physiology of bacterial growth and reproduction in batch, continuous and synchronous cultures; the economy of the bacterial cell, including endogenous metabolism and maintenance requirements; the physiology of bacterial death; and the regulation of enzyme and nucleic acids syntheses. **Prerequisites:** Micro 305/605; Bioch 423/623 and 424/624 or concurrent registration in Bioch 424/624; Math 206, or permission of instructor.

Micro 812—BACTERIAL METABOLISM—3 cr. (3 and 0) S, even numbered years.

A consideration of the various biochemical pathways occurring in bacterial cells. Topics discussed include: the fermentations of carbohydrates and related compounds and of nitrogenous organic compounds; anaerobic and aerobic respiration, including electron transport systems and oxidative phosphorylation; bacterial photosynthesis; nitrogen fixation; the biosyntheses of amino acids, purines, pyrimidines, lipids, proteins, nucleic acids and polysaccharides. **Prerequisites:** Micro 305/605; Bioch 423/623 and 424/624 or concurrent registration in Bioch 424/614; Math 206 or permission of instructor.

Micro 813—BACTERIAL CYTOLOGY AND PHYSIOLOGY LABORATORY—2 cr. (0 and 6) S, odd numbered years.

Experiments to illustrate fundamental principles discussed in Micro 811. Students will participate in designing each experiment. **Prerequisites:** Micro 305/605; Bioch 423/623 and 424/624 or concurrent registration in Bioch 424/624; Math 206, or permission of instructor.

Micro 814—BACTERIAL METABOLISM LABORATORY—2 cr. (0 and 6) S, even numbered years.

Experiments to illustrate fundamental principles discussed in Micro 812. Students will participate in designing each experiment. **Prerequisites:** Micro 305/605; Bioch 423/623 and 424/624 or concurrent registration in Bioch 424/624; Math 206, or permission of instructor.

Micro 815—ADVANCED MICROBIAL GENETICS—3 cr. (3 and 0) S, odd numbered years.

An in-depth study of current developments in microbial genetics. Topics discussed will include: the integration of genetics and biochemistry, the analysis of genetic fine structure in microorganisms; the nature of bacterial variation and the expression of mutations; population dynamics; the physio-chemical mechanisms of heredity; regulation of gene action in microorganisms; the physiology and genetics of virulent and lysogenic bacteriophages. Readings and discussion will center on the current research literature. **Prerequisite:** Micro 415/615.

Micro 891—RESEARCH—Credit to be arranged.

Micro 991—DOCTORAL RESEARCH—Credit to be arranged.

For those students enrolled in the Plant Physiology Ph.D. program with an emphasis in Microbiology.

PHYSICS

J. P. McKelvey, Head, Department of Physics and Astronomy

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees.

For the Master of Science degree:

1. A student is admitted to candidacy for the Master of Science degree upon the completion of a written qualifying examination covering major and minor fields. This examination must be completed one semester before the date on which the degree is expected.

2. It is usually recommended that students submit a thesis to fulfill the requirements for the M.S. degree. A non-degree option is available, however, for students who may wish for cogent reasons, not to submit a master's thesis. In the non-thesis option, a minimum of 36 credit hours is required, including 6 credit hours of Phys 890, Directed Activities in Applied Physics. A written report must be submitted in connection with this activity.

3. A final oral examination is required on the subject matter of the major and minor fields, and on the thesis or the Directed Activities report in the non-thesis option.

4. A program leading to the M.S. degree in physics with a concentration in health physics is available for students with interests in this area. The credit requirements and the requirements related to the thesis or Directed Activities report do not differ from those stated above, but

204

a different selection of course work, including 6 credits of health physics or biophysics and 9 credits of work in biology, biochemistry, or chemistry is prescribed for such students.

For the Doctor of Philosophy degree:

1. A student who entered with a Bachelor's degree will take the qualifying examination for the Master of Science degree. If he performs to the satisfaction of the faculty, he may by-pass the master's degree if he chooses. Otherwise he must obtain the Master of Science degree before he can be considered for continuance in the doctoral program.

2. Students are admitted to candidacy for the Doctor of Philosophy degree upon the successful completion of a written qualifying examination on the subject matter of the major and minor fields. This examination must be completed at least one academic year prior to the date on which the degree is expected.

3. The student must take a final oral examination on the dissertation only. This examination must be taken at least three weeks prior to the convocation in which the degree is expected.

Teaching in undergraduate courses is an integral part of graduate study in physics and is required of all graduate students.

No degrees are offered in Astronomy. Courses are offered to provide electives for students in other areas. Directed research in Astronomy is available in the Department of Physics and Astronomy.

Astr 604—ASTRODYNAMICS—3 cr. (3 and 0)

Astr 607—INTRODUCTION TO ASTROPHYSICS—3 cr. (3 and 0)

Astr 608—INTRODUCTION TO GALACTIC ASTRONOMY—3 cr. (3 and 0)

Astr 612—SPHERICAL ASTRONOMY—3 cr. (3 and 0)

Astr 621—INTRODUCTION TO RADIO ASTRONOMY—3 cr. (3 and 0)

Astr 701—SOLAR SYSTEM ASTRONOMY FOR HIGH SCHOOL
            TEACHERS—3 cr. (3 and 0)

A lecture and observation course designed to introduce the concepts and descriptions basic to modern astronomy. Emphasis will be placed on a survey of the solar system, with fundamental physical principles being introduced as needed. Planetarium demonstrations and observing sessions will be included.

Astr 711—STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS—
3 cr. (3 and 0)

A lecture and observation course. Emphasis will be placed on stellar and galactic astronomy. A brief survey of energy sources and other topics of current interest will be discussed. Planetarium programs and observing sessions will be included.

Phys 617—INTRODUCTION TO BIOPHYSICS I—3 cr. (3 and 0)

Phys 618—INTRODUCTION TO BIOPHYSICS II—3 cr. (3 and 0)

Phys 621—MECHANICS I—3 cr. (3 and 0)

Phys 622—MECHANICS II—3 cr. (3 and 0)

Phys 625—EXPERIMENTAL PHYSICS I—4 cr. (2 and 6)

Phys 626—EXPERIMENTAL PHYSICS II—4 cr. (2 and 6)

Phys 632—PHYSICAL OPTICS AND INTRODUCTION TO
SPECTROSCOPY—3 cr. (3 and 0)

Phys 640—ELECTRICITY AND MAGNETISM I—3 cr. (3 and 0)

Phys 641—ELECTRICITY AND MAGNETISM II—3 cr. (3 and 0)

Phys 646—SOLID STATE PHYSICS—3 cr. (3 and 0)

Phys 652—NUCLEAR AND PARTICLE PHYSICS—3 cr. (3 and 0)

Phys 655—QUANTUM PHYSICS I—3 cr. (3 and 0)

Phys 656—QUANTUM PHYSICS II—3 cr. (3 and 0)

Phys 657—BASIC HEALTH AND RADIOLOGICAL PHYSICS I—3 cr.
(3 and 0)

Phys 658—BASIC HEALTH AND RADIOLOGICAL PHYSICS II—3 cr.
(3 and 0)

Phys 660—CONTEMPORARY PHYSICS FOR HIGH SCHOOL TEACHERS
—3 cr. (3 and 0)

Phys 665—THERMODYNAMICS AND STATISTICAL MECHANICS—
3 cr. (3 and 0)

Phys 671—ELECTRON MICROSCOPY—3 cr. (2 and 3)

Phys 673—X-RAY CRYSTALLOGRAPHY—3 cr. (2 and 3)

Phys 700—PHYSICAL SCIENCE IN ELEMENTARY SCHOOL—PHYSICS
—3 cr. (3 and 0)

A study of the physical sciences at a level appropriate for teaching elementary school students. Emphasis will be placed on demonstrations and

experiments that can be conducted with equipment available to elementary school teachers. Topics mainly involve physics and astronomy.

Phys 701—PHYSICS FOR HIGH SCHOOL TEACHERS I—4 cr. (3 and 3)

Introduction to the fundamental ideas of time, space, and matter. Motion, optics, and waves are discussed. Laboratory experiments form an integral part of the course.

Phys 702—PHYSICS FOR HIGH SCHOOL TEACHERS II—4 cr. (3 and 3)

A continuation of Phys 701. Newton's law of motion, universal gravitation, conservation laws, electricity and magnetism are discussed. **Prerequisite:** Phys 701 or permission of instructor.

Phys 703—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Topics discussed include the Rutherford model of the atom, molecular description of matter, quantum theory of matter, nuclear forces, radioactivity, and special relativity.

Phys 715—EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS I—4 cr. (2 and 4)

An introduction to experimental techniques employed in the determination of fundamental quantities in classical and modern physics. Emphasized are those experiments which may be demonstrated in the classroom and which broaden the concepts of physics.

Phys 716—EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS II—4 cr. (2 and 4)

A continuation of Phys 715.

Phys 723—WEATHER SCIENCE FOR SCIENCE TEACHERS—3 cr. (3 and 0)

A survey of meteorological phenomena with emphasis on non-mathematical descriptions of atmospheric physics principles. Topics include solar and terrestrial radiation, adiabatic processes and cloud formation, local severe storms, global circulation patterns, air mass motions and fronts.

Phys 811—METHODS OF THEORETICAL PHYSICS I—3 cr. (3 and 0)

A course in which students are introduced to the analytical methods and techniques which are used in theoretical physics. Topics to be considered are vector and tensor analysis as applied to physical problems, the use of matrices and groups in classical and quantum mechanics, complex variables and the partial differential equation of physics.

Phys 812—METHODS OF THEORETICAL PHYSICS II—3 cr. (3 and 0)

A continuation of Physics 811. Topics will include the use of integral transforms, integral equations, special functions, calculus of variations and numerical approximations in the solution of physical problems.

Phys 813—ADVANCED THERMODYNAMICS AND STATISTICAL
       MECHANICS I—3 cr. (3 and 0)

Advanced topics in thermodynamics including thermodynamic poten-
tials, phase transitions, and very low temperatures. The Botlzmann in-
tegrodifferential equation and the kinetic theory of gases and plasmas.
Classical statistical mechanics.

Phys 814—ADVANCED THERMODYNAMICS AND STATISTICAL
       MECHANICS II—3 cr. (3 and 0)

Quantum statistical mechanics; the microcanonical, the canonical, and
the grand canonical ensemble theories. The ideal Fermi gas and the ideal
Bose gas. Special topics in advanced statistical mechanics.

Phys 821—CLASSICAL MECHANICS I—3 cr. (3 and 0)

Dynamics of particles, variational principles and Lagrange's equations,
two body central force problems, dynamics of rigid bodies. Matrix formu-
lations freely used.

Phys 822—CLASSICAL MECHANICS II—3 cr. (3 and 0)

Special relativity in classical mechanics, Hamilton's equations, canonical
transformations, Hamilton-Jacobi theory, small oscillations.

Phys 841—ELECTRODYNAMICS I—3 cr. (3 and 0)

The field theory of electromagnetism. Maxwell's equations and their ap-
plication to the study of electromagnetic wave production and propagation,
wave optics and theories of interference and diffraction.

Phys 842—ELECTRODYNAMICS II—3 cr. (3 and 0)

The production and propagation of electromagnetic waves are studied
using Maxwell's equations as a starting point. Discussions of wave guides,
diffraction phenomenon, and boundary effects are included. An introduc-
tion to the theory of electrons and microscopic phenomena is given.

Phys 845—SOLID STATE PHYSICS I—3 cr. (3 and 0)

The study of the physical properties of crystalline solids. The topics
treated are crystalline state determination by diffraction methods, theories
of specific heat, properties of metallic lattices and alloys, lattice energy
and ferroelectrics.

Phys 846—SOLID STATE PHYSICS II—3 cr. (3 and 0)

A continuation of Phys 845, but includes the electronic properties of
solids. The topics treated are band theory of solids, physics of semi-
conductors, theories of magnetism and magnetic resonance phenomena.

Phys 853—NUCLEAR PHYSICS I—3 cr. (3 and 0)

A study of selected topics in nuclear structure, nuclear forces and nuclear
interaction processes. Shell structure, spins, and magnetic moments of
nuclear particles are studied.

Phys 854—NUCLEAR PHYSICS II—3 cr. (3 and 0)

High energy radiation processes, nuclear reactions including nuclear fission; scattering; natural and induced nuclear disintegration.

Phys 856—CRYSTALLOGRAPHY—3 cr. (3 and 0)

A systematic study of the external and internal symmetry of crystals as revealed by their physical properties .

Phys 875—SEMINAR IN CONTEMPORARY PHYSICS—1-3 cr.
(1-3 and 0)

A joint study by graduate students and interested members of the faculty of some areas of physics which is currently being extensively investigated.

Phys 890—DIRECTED ACTIVITIES IN APPLIED PHYSICS—Variable credit.

Credit is earned through training and work on problems of a practical nature. Activities are supervised by departmental faculty or by an appropriate adjunct professor. A written description of the student's activities in the course will be submitted to the course supervisor at the completion of the activity. Maximum credit limits are 6 credit hours in a semester and 3 credit hours in a single summer session. Grades are determined on a Pass-Fail basis.

Phys 891—RESEARCH—Credit to be arranged.

Phys 922—HYDRODYNAMICS—3 cr. (3 and 0)

The mathematical theory of the motions of an ideal fluid including effects produced by moving submerged bodies; theory of waves, ripples and vortices; effects of viscosity.

Phys 951—QUANTUM MECHANICS I—3 cr. (3 and 0)

Review of wave mechanics; operator algebra and theory of representation; approximate methods for stationary problems; theory of scattering applied to atomic and nuclear problems.

Phys 952—QUANTUM MECHANICS II—3 cr. (3 and 0)

Continuation of Phys 951 including time dependent perturbations; radiation absorption and emission; relativistic quantum mechanics; introduction to quantum electrodynamics.

Phys 955—ADVANCED MODERN PHYSICS I—3 cr. (3 and 0)

An application of quantum mechanics and relativity theory to selected topics of recent interest in physics; atomic and nuclear structure, radioactivity and nuclear stability, molecular structure, and theory of solids are considered.

Phys 956—ADVANCED MODERN PHYSICS II—3 cr. (3 and 0)

A continuation of Phys 955. Topics of special interest to instructor and students will be considered.

Phys 966—RELATIVITY—3 cr. (3 and 0)

Gives a survey of the special and general theory of relativity including tensor calculus, the Lorentz transformation and three experimental tests of the general theory: (1) planetary motion and the advance of the perihelion of Mercury, (2) the bending of light rays in gravitational fields, and (3) the gravitational shift of spectral lines.

Phys 991—DOCTORAL RESEARCH— Credit to be arranged.

(May be taken more than one semester.)

ZOOLOGY

C. W. Helms, Head, Department of Zoology

Courses are offered leading to the Master of Science and the Doctor of Philosophy degrees.

Requirements for the M.S. degree include 24 semester hours of course work, six (6) hours of research, an acceptable thesis, and satisfactory performance in a final oral examination. Requirements for the Ph.D. degree include written qualifying and oral comprehensive examinations, research, a dissertation, and satisfactory performance in a final oral defense. While there are no required numbers of hours of course work for the doctorate beyond 18 semester hours of research, breadth and depth of preparation in the life sciences will be expected of each candidate.

Zool 603—PROTOZOOLOGY—3 cr. (2 and 3) S

Zool 604—ANIMAL PATHOLOGY—3 cr. (2 and 3) S

Zool 605—ANIMAL HISTOLOGY—3 cr. (2 and 3) F

Zool 610—LIMNOLOGY—3 cr. (2 and 3) F

Zool 611—ANIMAL ECOLOGY—3 cr. (2 and 3) F, S

Zool 621—ADVANCED INVERTEBRATE ZOOLOGY—4 cr. (3 and 3)

Zool 656—PARASITOLOGY—4 cr. (3 and 3) S

Zool 658—CELL PHYSIOLOGY—3 cr. (2 and 3) S

Zool 660—GENERAL PHYSIOLOGY—3 cr. (2 and 3) F, S, SS

Zool 661—ANATOMY—3 cr. (3 and 0) S

Zool 662—HERPETOLOGY—3 cr. (2 and 3) F

Zool 663—ICHTHYOLOGY—3 cr. (2 and 3) S

Zool 664—MAMMALOGY—3 cr. (2 and 3) F

Zool 665—ORNITHOLOGY—3 cr. (2 and 3) S

Zool 670—ANIMAL BEHAVIOR—3 cr. (2 and 3) F

Zool 674—INVERTEBRATE ENDOCRINOLOGY—3 cr. (2 and 3) S

Zool 675—GENERAL ENDOCRINOLOGY—3 cr. (2 and 3) F

Zool 680—DEVELOPMENTAL BIOLOGY—3 cr. (3 and 0) S

Zool 681—DEVELOPMENTAL BIOLOGY LABORATORY—1 cr.
(0 and 3) S

Zool 700—MODERN DEVELOPMENTS IN ZOOLOGY FOR HIGH
SCHOOL TEACHERS— 3 cr. (3 and 0) SS

Designed to acquaint secondary biology teachers with contemporary developments in the field of zoology. This will be a lecture only course and will include advances in teaching methods and advances in new equipment and technology.

Zool 701—MAN'S IMPACT ON ECOLOGY—3 cr. (3 and 0) SS

The fundamental relationship of man to his environment as it has developed from prehistoric time to the present. Current overpopulation and pollution will be stressed.

Zool 702—FIELD METHODS IN ZOOLOGY FOR HIGH SCHOOL
TEACHERS—3 cr. (2 and 3) SS

A non-technical lecture and field laboratory course designed to acquaint the secondary teacher with local fauna. Collection, identification, and use in the teaching laboratory will be stressed.

Zool 801—ANIMAL HISTOLOGY—3 cr. (2 and 3) F, odd numbered years.

An advanced study in the microscopic structures of the tissues and organs of the animal body and the relation of histology to physiology and pathology.

Zool 802—HISTOLOGICAL TECHNIQUES—3 cr. (1 and 6) F, odd numbered years.

The fixing, staining, sectioning and identification of tissues, glands and organs of animals. **Prerequisites:** Zool 101 and 103.

211

Zool 803—POPULATION DYNAMICS—4 cr. (2 and 6) S, even numbered years.

A study of fundamental mechanisms basic to the regulation of natural animal populations. A laboratory research project in population dynamics will complement the theory.

Zool 810—BEHAVORIAL ECOLOGY—3 cr. (3 and 0) F, odd numbered years.

An in depth study of the behavior of animals and the ecological context in which various behaviors are shown. The course will stress both the empirical and theoretical aspects of behavioral ecology at the individual, population and community levels. **Prerequisites:** Zool 411/611, Zool 470/670, or permission of instructor.

Zool 812—SEMINAR—1 cr. (1 and 0) F, S, SS

A review of the current literature in the fields of zoology.

Zool 813—EVOLUTION—3 cr. (3 and 0) S, even numbered years.

Covers the principles which have governed the evolution of plants and animals and also of the relationships of the phyla and classes which are the results of this process.

Zool 815—PHYSIOLOGICAL ECOLOGY—4 cr. (3 and 3) F, even numbered years.

A detailed analysis of the physiological and biochemical adaptations of invertebrates and vertebrates toward various natural environmental parameters. Field trips will acquaint the student with the natural macro- and micro-environments of individual species. Field measurements of the parameters of the environment will be undertaken and laboratory studies will furnish the student with a detailed knowledge of various physiological adaptations to these parameters.

Zool 830—HISTOCHEMISTRY-CYTOCHEMISTRY—3 cr. (2 and 3)

Orientation to procedures which allow valid inferences to be drawn concerning identity, quantity, and location of chemical moieties and endymatic activities within intact (non-homogenized) cells or tissues under control and experimental conditions, in normal and pathological states, and in different physiological conditions.

Zool 835—INTERPRETIVE ELECTRON MICROSCOPY—2 cr. (2 and 0) S, even numbered years.

This is an advanced study of cell structure as viewed through the electron microscope. Characteristic structural features of cells from various tissues, and tissues from various organisms at different phylogenetic levels, will be stressed. **Prerequisite:** An Ph 801 or permission of instructor.

Zool 840—COMPARATIVE ANIMAL PHYSIOLOGY I—4 cr. (3 and 3)

An advanced level comparative study of physiological processes as they occur in different groups throughout the animal kingdom. This course deals with environment-organism interaction and is organized on a function-system, rather than a taxonomic basis. **Prerequisites:** Zool 458/658, 460/660 or permission of instructor.

Zool 841—COMPARATIVE ANIMAL PHYSIOLOGY II—4 cr. (3 and 3)

A continuation of Zool 840 but dealing with effector and integrative systems. **Prerequisite:** Zool 840 or permission of instructor.

Zool 845—ADVANCED CELL PHYSIOLOGY—4 cr. (3 and 3)

An advanced course on problems of cell function including energetics, membrane transport, metabolic pathways, contractility and properties of excitable membranes. Emphasis will be placed on a chemical and physical approach to the subject. **Prerequisite:** Zool 458/658 or permission of instructor.

Zool 852—PRINCIPLES AND METHODS OF SYSTEMATIC ZOOLOGY—
2 cr. (2 and 0) F, even numbered years.

Presents the problems which confront the taxonomist in the zoological sciences and the conventional practices which have been developed to handle them.

Zool 863—SPECIAL PROBLEMS— 1-4 cr. F, S, SS

Original investigation of special problems in zoology which are not related to a thesis but designed to provide experience and training in research or specialized areas of zoology. **Prerequisite:** Permission of instructor.

Zool 891—RESEARCH—Credit to be arranged. F, S, S S

Zool 991—DOCTORAL RESEARCH—Credit to be arranged. F, S, S S

INDEX

214

INDEX (Continued)

INDEX (Continued)

DIRECTORY FOR CORRESPONDENCE

Mailing Address:

Clemson University, Clemson, South Carolina 29631

University Switchboard: (803) 656-3311

Graduate Study:

Address the Dean of Graduate Studies and University Research. Telephone — 656-3195

Registration and Class Schedules:

Address the Registrar. Telephone — 656-2284

Assistantships:

Address the Head of the Department of proposed major.

Transcripts:

Address the Registrar. Telephone — 656-2284

Veterans Affairs:

Address the Registrar. Telephone — 656-2284

International Student Affairs:

Address Foreign Student Office, University Union, Telephone — 656-2460

Housing:

Married Students — Address Housing Office. Telephone — 656-2012

Single Students — Address Residence Hall Office. Telephone — 656-2260

Public School Teachers Information:

Agricultural Education. Telephone — 656-3300

Elementary and Secondary Education. Telephone — 656-3484

Industrial Education. Telephone — 656-3447

Off-Campus Courses — Office of Educational Services. Telephone — 656-3486

The business and administrative offices of the University are open between the hours of 8:00 A.M. to 12:00 noon and 1:00 P.M. to 4:30 P.M. Monday through Friday for 12 months of the year except for official University holidays.