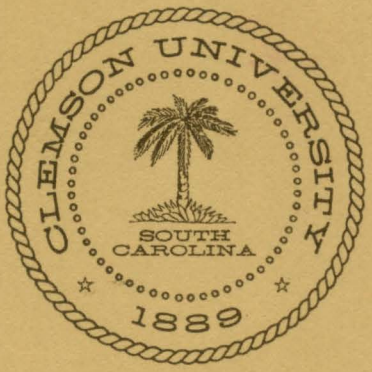
THE GRADUATE SCHOOL

1968-1969

CLEMSON



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CLEMSON UNIVERSITY

RECORD

ANNOUNCEMENTS OF THE GRADUATE SCHOOL FOR 1968-1969

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COURSES OF STUDY

CHECK LIST ON GRADUATE SCHOOL PROCEDURES

The graduate student should be especially careful to follow this check list:

1. Select in consultation with the appropriate Department Head a major adviser and/or advisory committee. (See pages 22, 26)

2. Submit Plan for Graduate Study (G. S. Form 2 or G. S. Form 2d) (See page 34.)

3. If necessary, submit request for changes in Plan for Graduate Study. (See page 34.)

4. Satisfy any prescribed foreign language examination and other qualifying examinations prerequisite to admission to candidacy. (See page 27.)

5. Apply for admission to candidacy for a degree (G. S. Form 4) after completing at least half the prescribed residence and course work and after passing any prescribed qualifying examinations. (See pages 27, 34.)

6. Place formal order for diploma with the Director of Admissions and Registration and pay diploma fee within 4 weeks following opening of final semester of enrollment or by May 27 for summer graduation. (See page 38.)

7. Submit completed thesis or dissertation to advisory committee chairman and arrange for final examination by the advisory committee. (See pages 23, 28.)

8. Pay binding fee to the Bursar and submit approve copies of thesis to the Dean of the Graduate School. Doctoral candidates pay for abstract publication in **Dissertation Abstracts.** (See page 37.)

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

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UNIVERSITY CALENDAR

SESSION 1967-68

Second Semester

Matriculation, new students	January 3
Registration, all students	January 5, 6
Classes begin, abbreviated class schedule	January 8
Last day to order diploma for May graduation	February 2
Graduate School foreign language examination	February 3
Spring holidays begin at noon	March 9
Classes resume	March 18
Graduate School foreign language examination	March 23
Honors and Awards Day— classes suspended at 12 noon	April 3
Reading Day	April 23
Examinations begin	April 24
Faculty meeting to consider candidates for graduation	May 3
Commencement	May 4

SUMMER SESSIONS 1968

First Session

Matriculation and registration	May 13
Classes begin	May 14
Last day to order a diploma for August graduation	May 27
Graduate School foreign language examination	June 8
Examinations	June 19, 20

Second Session

Matriculation, new students	June 24
Matriculation and registration	June 25
Classes begin	June 26
Classes meet	June 29
Graduate School foreign language examination	July 13
Examinations	July 31, August 1
Graduation	August 3

SESSION 1968-69

First Semester

Matriculation, new students	August 19, 20
Matriculation, registration, current students	August 20, 21
Late registration fee applies at noon	August 22
Classes begin, abbreviated class schedule	August 23
Last day for matriculation	August 29
Last day to add a subject	September 5
Last day to order diploma for mid-year graduation	September 19
Graduate School foreign language examination	November 2
Clemson-Carolina game—Classes suspended	November 23
Thanksgiving holidays	November 28-30
Reading Day	December 6
Examinations begin	December 7
Faculty meeting to consider candidates for graduation	December 16
Mid-year graduation	December 17

Second Semester

Graduate School foreign language examination	March 23
Matriculation, new students	January 6
Registration, all students	January 8, 9
Late registration fee applies at noon	January 9
Classes begin, abbreviated class schedule	January 10
Last day to order diploma for May graduation	February 6
Graduate School foreign language examination	February 8
Spring holidays begin at noon	March 15
Classes resume	March 24
Graduate School foreign language examination	March 29
Honors and Awards Day—classes suspended at 12 noon	April 9
Reading Day	April 29
Examinations begin	April 30
Faculty meeting to consider candidates for graduation	May 9
Commencement	May 10

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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 fifty-six graduate curriculums under the Colleges of Agriculture and Biological Sciences, Arts and Sciences, and Engineering, and the Schools of Architecture, Education, and Industrial Management and Textile Science form a background of training 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 GRADUATE SCHOOL

The Graduate School exists to formulate policies and standards, and to unify administrative procedures concerning all graduate work at Clemson. The Dean of the Graduate School serves as chairman of the Graduate Council, a policy-making body appointed from the general faculties of the University and including the academic deans as ex officio members.

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

THE UNIVERSITY LIBRARY

The Main 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 more than 400,000 volumes of books, periodicals and government publications. In addition to the Main Library there are departmental libraries.

Forty-five newspapers and 5000 serial titles — periodicals, reports, bulletins and the like — are received regularly. About 700 of these are foreign publications and 1800 are abstracted in Chemical Abstracts. Microfilm and microcard readers are provided for consulting material in microtext.

Library service is maintained for 95 hours a week in the Main Library. With the exception of adjustments in the schedule during holiday periods, the library hours are as follows:

Monday through Friday	7:45 a.m. to 11:00 p.m.
Saturday	7:45 a.m. to 6:00 p.m.
Sunday	2:00 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.

MEDICAL EXAMINATIONS

Completion of a medical history and physical examination record is required of all new students entering Clemson University for the first time and all former students not in attendance for a period of 3 years or more. This examination must be completed by the student and the student's own physician or the Health Service of the school from which he graduates or transfers. This examination will be reported on a special form provided for this purpose

by the Director of Admissions and Registration. The new four page form revised August 1965 should be used. No other form is acceptable. This form will be sent after provisional acceptance is granted. No new student will receive final acceptance until this certificate is completed and has been received by the Director of the Student Health Service.

The University requires that all new students have a current tetanus toxoid series or booster (within three years), a smallpox vaccination within four years and immunization against poliomyelitis. The oral (Sabin) type vaccine is preferred. All new students are also required to have a skin test for tuberculosis within one year prior to admission. If this test is positive, a chest X-ray is also required. All positive reactors will then be required to have an annual chest X-ray. These follow-up X-rays after admission will be done at the Student Health Service. The University also requires that all continuing students have a repeat of the skin test every two years. This will be performed by the Health Service.

STUDENT HEALTH SERVICE

The Student Health Service maintains a complete outpatient department and a 40-bed infirmary. The staff consists of three full-time physicians, including the director, a part-time psychiatrist, seven full-time registered nurses, a full-time registered laboratory technician and a full-time registered X-ray technician. 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.

The 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 equip

the staff better in protecting the student from illness and to serve as a guide for the care of preexisting medical problems. The health service also provides medical information as well as the indicated medical action: diagnostic, therapeutic and preventive.

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. 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 and health service staff for most illnesses and injuries occurring on the campus. There are certain things, however, that it does not include, such as fees for routine physical examinations for employment or transfer to another school and fees for outside physicians when called in for consultation, medical or surgical services performed away from the University or for accidents ocurring off the campus. The fee also covers medication for acute illness but not for chronic illness lasting over two weeks or for pre-existing illness. Although ambulance transportation to a general hospital for serious illness or injury occurring on campus will, of course, be arranged, the expense 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 right of the Director of the Student Health Service, with the approval of the proper university authority, to obtain any of these extra services in behalf of any student under his care, is hereby expressly reserved.

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.

HOUSING, FOOD SERVICE, AND COSTS

Dormitories

The University dormitories will accommodate 4,352, two students being assigned to a room. The University also has 271 individual units for married students.

Application for Dormitories and Advance Payment. An application for dormitory accommodations will be forwarded to those students who are accepted by the University for the fall semester. These applications are to be completed and returned with a $60 advance room payment to the Dormitory Manager's Office at the earliest practicable date.

Students who have made an advance payment and later decide not to enroll or to live in the dormitory may obtain a refund of the advance payment provided notification of intent and request for refund is received by the Dormitory Office prior to July 5. When such notification and refund request is not received by the deadline date, no refund of advance payment will be made.

Refund of the advance payment will not be made to students who apply for asignments after July 5.

Normally, dormitory accommodations are available to those students who enter the University at the beginning of the second semester; therefore, the advance payment is not now required of students entering at this time.

Assignment Preference. Graduate students will be assigned to sections reserved for them as long as space is available. Priority of room assignments is given to continuing students who file application and make advance payments during the priority periods established by the Dormitory Office.

Notification of Assignments. As soon as room assignments are made, students are advised of the assignment and furnished information regarding occupancy.

Assignment Changes. Students who desire to move from the assigned room may apply at the Dormitory Office to change rooms. A fee of $4 is charged for moving; charges will also be made for students moving from a lower- to a higher-rated room. Rental re-

funds are made to students moving from a higher- to a lower-rated room on a prorated basis.

Opening and Closing of Dormitories. The University dormitories officially open for students at 8 a.m., the day prior to matriculation date for new students and close at 8 p.m., the day scheduled for graduation exercises of the term or semester. Dormitory fees cover only the time between the day before matriculation and the scheduled date of graduation exercises or end of term when no graduation exercises are scheduled.

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.

Student Responsibility for Damages. The University holds resident students responsible for any damages other than normal wear that occur to their rooms and furnishings. Damages will be assessed by the University and the student will be billed for repairs or replacements. Students should inform University officials immediately upon occupancy of any conditions reflecting prior damages which have not been corrected.

Dormitories for Men. There are eleven dormitories available for housing 3,632 male students. The room rent varies from $125 to $160 per semester, depending upon the dormitory facilities.

At the present time 432 women students are housed in University dormitories. The room rent is $160 per semester.

STUDENT FOOD SERVICE

Dining Hall. The University Dining Hall offers a cafeteria-type meal to students. Six cafeteria lines provide timely service of quality foods. Completion of an additional dining facility on the East Campus is scheduled in 1968.

The University provides two food-service plans. One plan provides for the payment of all meals served in the dining hall on a fixed-fee semester basis. The other plan provides for cash payment at the end of the serving line for each item of food selected. After the initial selection of a food-service plan at the beginning

of a semester, only one change from one board plan to another will be allowed. No student will be allowed to change from the semester board plan without prior written approval of the student's parents or other individual responsible for the payment of University expenses.

Semester Plan Board Fee: $238 per Semester. This plan allows a selection of quality foods from well-balanced menus. The fee covers the cost of all meals served in the Student Dining Hall from the day of matriculation through the day of graduation exercises, holidays, excluded. These dates are listed in the University Calendar appearing in this catalogue.

Cash Cafeteria Service. Quality food may be obtained at reasonable prices by paying cash at the end of the serving line for each item of food selected.

Refunds. Refunds, when authorized, will be made on a daily prorata basis, holidays excepted.

Married Student Housing. Clemson provides comfortable and economical housing for married students. There are three housing areas consisting of 139 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 units and are equipped with stove and refrigerator. The Littlejohn apartments and Prefabs are not equipped with stoves and refrigerators.

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.

Booklets describing these facilities are available and will be furnished upon request to the Housing Office of the University. Monthly rental fees are: Prefabs, $30.00; Littlejohns, $45.00 for interior and $48.00 for end units; East Campus, $60.

EXPENSES

Full-Time Students. The 1967-1968 semester charges for regular full-time graduate students are shown below:

First Semester

Tuition	$ 75
Matriculation Fee (Non-Refundable)	5
Maintenance and Activities Fee	136
Library Fee	12
Medical Fee	15
Room Fee	120-150
Board	210
Total First Semester	$573-603

Tuition and fees for the full semester are payable in advance at the beginning of each semester. In addition, one-half of the semester's board and $60 of the semester's room rent are payable at the beginning of each semester. (For the fall semester, those students who have paid the $60 advance payment of room rent by July 15 have space reserved and no additional room rent is due at the beginning of the semester.) Payment of the remainder of first semester's room and board is due October 15. Payment of the remainder of the second semester's room and board is due March 10.

Second Semester

Charges for the second semester are the same as the first semester.

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.

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
Maintenance and Activities Fee (per semester hour)	10.00
Library Fee (per semester hour)	.75
Medical Fee (optional for non-dormitory students)	15.00

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

The University reserves the right to adjust charges to current costs.

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.

Graduate Assistants and Staff. Graduate assistants and staff members will pay total charges of $4.75 per semester hour during regular semesters and one-half the summer school rate during summer sessions. These charges are in lieu of tuition, matriculation, maintenance, activity and library fees. Graduate assistants receive medical treatment by paying the medical fee of $15. A graduate assistant is defined as a student with a baccalaureate degree from an approved institution who contracts to devote a minimum of ten working hours per week to the University for at least a full semester.

Reservation of Right to Change Fees and Regulations. The University reserves the right to make changes in its fees, charges, rules, and regulations.

THE GRADUATE SCHOOL

GRADUATE SCHOOL INFORMATION

REGULATIONS AND PROCEDURES

Every graduate student and every prospective graduate student is expected to make himself thoroughly familiar with the regulations of the Graduate School and the requirements for degrees. Failure to follow the regulations and requirements almost inevitably results in complications for which the Graduate School cannot assume responsibility.

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

A student who wishes to deviate from the normal graduate school regulations and procedures may present his problem in a letter addressed to the Graduate Council signed by himself, his major adviser and his department head. The Graduate Council will consider the petition at the first meeting following its receipt in proper form. Action taken on a petition will not be considered a precedent for any future action.

The University and its various colleges, schools and departments reserve the right to change the rules regulating the admission to, instruction in, and graduation from the University or its various divisions, and any other regulations affecting the student body. Such regulations become effective whenever the proper authorities may determine and will apply not only to prospective students but also to those who may at such time be matriculated in the University. The University also reserves the right to withdraw courses, to change instructors, or to change fees at any time.

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

GRADUATE DEGREES AND CURRICULUMS

Courses and Degrees. Courses are offered leading to the degree of Master of Science in the following fields: Agricultural Economics, Agricultural Engineering, Agronomy, Animal Science, Biochemistry. Bioengineering, Botany, Ceramic Engineering, Chemical Engineering, Chemistry, Civil Engineering, Dairy Science, Electrical Engineering, Engineering Mechanics, Entomology, Environmental Systems Engineering, Forestry, Horticulture, Industrial Management, Materials Engineering, Mathematics, Mechanical Engineering, Microbiology, Nutrition, Physics, Plant Pathology, Poultry Science, Textile Chemistry, Textile Science, Water Resources Engineering, Wildlife Biology, and Zoology.

The Master of Arts degree is offered in Economics, English, and History.

The degrees of Master of Agricultural Education and Master of Industrial Education are offered.

The Master of Education degree provides majors in the teaching areas of English, History, Mathematics and the sciences as well as in Personnel Services.

The degree of Master of Architecture is offered by the School of Architecture.

The degree of Doctor of Philosophy is offered in Agricultural Economics, Agricultural Engineering, Agronomy, Animal Physiology, Bioengineering, Chemical Engineering, Chemical Physics, Chemistry, Civil Engineering, Electrical Engineering, Engineering Management, Engineering Mechanics, Entomology, Environmental Systems Engineering, Materials Engineering, Mathematics, Mechanical Engineering, Nutrition, Physics, Plant Pathology, Plant Physiology, Water Resources Engineering, and Zoology.

A list of courses acceptable for graduate credit is found elsewhere in this Bulletin.

ADMISSION

For admission to the Graduate School a degree-seeking student must have the Bachelor's degree from an institution with a scholastic rating satisfactory to the University, must have made a satisfactory score on the Graduate Record Aptitude Tests, and must have the approval of the Head of the Department in which he plans to do his major work.

Admission is restricted to those students whose academic records clearly indicate that they are prepared to benefit from graduate study. Neither a transcript exceeding minimum requirements nor satisfactory scores on the Graduate Record Aptitude Test alone will assure a student's admission. Rather his total record must indicate the likehood of successful graduate study. Graduate students are admitted as follows: (a) the department head recommends admission on the basis of a general review of the student's record; (b) the recommendations receive final action in the Graduate School office.

An undergraduate student lacking less than a full semester of work to complete the requirements for his baccalaureate degree may apply for admission to the Graduate School and if admitted, be allowed to enroll in courses for graduate credit. These courses must be over and above those required for his Bachelor's degree and should not cause his total load of course work to exceed 15 semester hours.

Students with grade-point ratios of 3.0 or higher may enroll in graduate-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. The student must receive permission from the Graduate School to enroll in graduate-level courses.

Enrollment in any course is subject to approval by the department offering the course.

Normally a student who has both his Bachelor's and Master's degrees from Clemson will not be allowed to enter a doctoral program at Clemson.

Applicants accepted for graduate study may be admitted as graduate students in full standing or as graduate students not seeking a degree. Students in this latter category are primarily public school teachers who require graduate work for certification, or recertification. Only graduate students in full standing may become candidates for advanced degrees.

Credentials submitted for admission become the property of the University and are not returned.

An applicant for admission to the Graduate School must register for courses within twelve months after his application has been accepted; otherwise his admission will be withdrawn.

Students who have been admitted to the Master's program but subsequently desire to enroll in a Ph.D. program must apply for admission by submitting Graduate School Form 10.

Applications for admission must be submitted at least two weeks prior to the first date for matriculation listed in the general university catalog.

REQUIREMENTS FOR THE MASTER OF SCIENCE AND MASTER OF ARTS DEGREE

To receive the Master of Science degree a student must spend the equivalent of at least one academic semester in graduate residence at the University. No graduate credit will be allowed for any course completed in less than five weeks. All course work which is to be credited toward a Master of Science or Master of Arts degree must have been completed not more than six 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 the Graduate School, as many as six semester hours of course work completed outside the six-year limit of time may be validated by written re-examination. Such examination 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 limit of time at an institution other than Clemson University may not be transferred to Clemson for graduate credit.

The Student's Advisory Committee. As soon as possible after the student arrives on the campus he will, with the approval of the head of his major department, select a major adviser.

An advisory committee shall then be selected by the department head, the major adviser, and the student. The department head will then recommend formal appointment of this committee by the Dean of the Graduate School. This advisory committee will approve the student's preliminary study plans, supervise his grad-

uate program, administer his final examination, and initiate the recommendation for the awarding of the degree.

Course Work Required. In addition to such supplementary or supporting courses as may be required, the degree program will consist of a minimum of thirty semester hours, including six semester hours of research which will provide the basis for the thesis if a thesis is required. Of the remaining twenty-four semester hours, at least twelve hours must come from courses numbered 800 or above. A minimum of twelve hours must be in the student's major field and a minimum of six hours in one minor.

Final Examination. Each candidate for a Master's degree, after the completion of the thesis, if required, and at least two weeks before the degree is to be awarded, must pass such 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 research report. Included with those members of the faculty and staff invited to attend the examination will be the members of the Graduate Council and the Dean of the Graduate School. Immediately after the examination the examining committee will notify the Dean of the Graduate School of the findings. This notification will be made on Graduate School Form 7.

NON-THESIS DEGREE REQUIREMENTS

MASTER OF AGRICULTURAL EDUCATION

Course Work Required. In addition to such supplementary or supporting courses as may be required, the work for the Master of Agricultural Education degree will consist of a minimum of thirty semester hours distributed as follows:

1. Six to twelve hours in Education as a major.
2. Twelve to eighteen hours in technical agriculture or related fields. Six of these hours must be in the same field and will be considered a minor.
3. Three hours in research techniques.
4. Three hours in experimental statistics.

All other requirements of the Graduate School for the Master of Science Degree will be met with the exception of the foreign language proficiency and the thesis.

THE MASTER OF EDUCATION DEGREE IN SECONDARY EDUCATION

The Master of Education degree is offered only to experienced high school or junior college teachers in the subject areas of English, history and government, mathematics and the natural sciences.

Course Work Required. In addition to such supplementary or supporting courses as may be required, course work for the Master of Education degree will consist of a minimum of thirty semester hours, distributed as follows:

1. At least six and not more than twelve hours in education.
2. A minimum of eighteen hours in the subject area selected.

With the exception of the thesis and foreign language proficiency, all other regular requirements of the Graduate School for the Master of Science degree will be met.

In place of the usual final examination, a preliminary examination may be held by the student's committee after the student has completed at least twelve but not more than fifteen hours of course work. This examination will determine whether the student will be allowed to continue course work toward the M.Ed.

REQUIREMENTS FOR THE MASTER OF INDUSTRIAL EDUCATION DEGREE

This degree is offered only to experienced teachers of industrial education.

Course Work Required. In addition to such supplementary or supporting courses as may be required, course work for this degree will consist of a minimum of thirty semester hours, distributed as follows:

1. Six to twelve hours in education methods.

2. Eighteen to twenty-four hours in subjects that contribute to the student's technical ability.

With the exception of the thesis and foreign language proficiency, all other regular requirements of the Graduate School for the Master of Science degree will be met.

REQUIREMENTS FOR THE MASTER OF EDUCATION DEGREE IN PERSONNEL SERVICES

The Master of Education degree in Personnel Services is offered to teachers who have a valid teacher's certificate and at least two years of teaching experience 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), Guidance Counselor (Secondary School), Vocational Counselor, or Junior College Counselor, and Reading Consultant, or Reading Director.

Course Work Required. In addition to such supplementary or supporting courses as may be required, course work for the degree will consists of a minimum of thirty semester hours, distributed as follows:

1. A minimum of twenty-one hours in the area of specialization.
2. Three to six hours in field training at the level of specialization.
3. Three hours in statistics, research techniques or in a field related to the area of specialization.

With the exception of the thesis and foreign language proficiency, all other regular requirements of the Graduate School for the Master of Science degree will be met. The candidate's final examination may be oral and/or written.

REQUIREMENTS FOR DOCTOR OF PHILOSOPHY DEGREE

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 re-

search. 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.

Advisory Committee. Shortly after the time of his initial registration in a doctoral program the student shall designate in writing to his department head his selection of a major field and one or more minor fields of study. The heads of these departments in consultation with the student will recommend to the Graduate Dean for approval and formal appointment an advisory committee composed of at least four professors. One member of the committee will be designated as chairman and normally he will direct the student's dissertation. The advisory committee will aid the student in planning his course work to achieve the required competence. This planning will include the selection of specific courses, and their sequence. Work in the minor field or fields should normally consist of from 12 to 24 semester hours in courses carrying graduate credit. If the direction of the student's study or research interest should change as his work progresses, he may request the appointment of a new major adviser. The committee will also arrange for the student's preliminary and final comprehensive examinations and initiate the recommendations for the awarding of his degree.

Residence Requirements. Doctoral work, dealing with study and research as it does, requires an intense dedication and devotion to the subject of inquiry. The desired level of concentration and concern cannot be achieved where a student holds, throughout the period of his study, a full-time job not concerned with research in his field.

To receive the Doctor of Philosophy degree the student must complete two successive academic semesters of course work in the doctoral program given on the Clemson campus.

No credit toward graduate degrees may be obtained by correspondence or extension study. All transfer credits must be verified by an official transcript from the college at which the work was done.

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. A reading knowledge of both French and German is required of all candidates for the doctorate; other languages may be substituted in cases where it is demonstrated that they will be of more value in the particular specialty of the student. Such substitutions must be approved by the student's department head and by the Dean of the Graduate School. Normally a combination of two Romance languages will not be approved. 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 Dean of 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 two 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 office 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

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. Both are renewable. Stipends range from $1,900 to $4,200 and tuition is reduced. Application forms are obtainable from the Dean of 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. Among them are the following:

Alumni Fellowships ranging upward to $1,200, are awarded in all fields of study. These fellowships are made possible through gifts to the Alumni Loyalty Fund.

American Cyanamid Fellowship. A $500 award to a student in the School of Industrial Management and Textile Science.

American Zinc Institute Fellowship. An award of $2,400 to a student in Ceramic Engineering.

The Alexander P. and Lydia Anderson Fellowship. A $350 award for study in the biological sciences.

Army Corps of Engineers Graduate Fellowships. The U. S. Army Corps of Engineers has arranged with the Clemson University

Graduate School to employ graduate students who have completed their academic studies for a one-year period to work on their thesis or dissertation. The topics must concentrate on a subject of current analytical or informational need related to the mission of the Corps of Engineers. This will cover the full range of engineering and nonengineering professional disciplines involved in studies, special investigations, design and research in all phases of construction engineering including ways to enhance esthetic and living aspects of structures.

Belle W. Baruch Graduate Research Fellowships. Four $3,000 fellowships plus $1,000 for tuition and supplies for study in Forestry and Natural Resources Biology.

Stuart F. Brown Fellowship. A $1,000 award given by the Whitinsville Spinning Ring Company to a student in the School of Industrial Management and Textile Science.

Burlington Industries Fellowship. A $5,000 grant from the Burlington Industries Foundation to the School of Industrial Management and Textile Science, including a $3,000 award to a student in textiles, plus fees, and the remainder in support of his textile research program.

Clay Products Service Fellowships. A $1,500 award to a student in Ceramic Engineering.

Coker's Pedigreed Seed Company Award. A $2,400 award to a student in Agricultural Education.

Commercialores Fellowship. A $500 award to a student in Ceramic Engineering.

Eastman Kodak Fellowship. An award of $2,000 plus tuition and fees to a student in Chemical Engineering.

Environmental Health Traineeships. Traineeships are awarded for a three-year period by the University for doctoral study on behalf of the Public Health Service. Under special circumstances, an additional year of support may be awarded. These traineeships are specifically for students interested in a career involving some aspect of environmental health.

Foundation for Cotton Research and Education. A limited number of $2,500 awards, made to students in Agricultural Engineer-

ing, with concentration in Ginning Engineering. The recipients are selected by the Foundation (Box 9905, Memphis 12, Tenn.) with approval of the University.

Graduate School Research Assistantships. Assistantships for doctoral study in selected areas are awarded by the Graduate School. Stipends are paid from monies appropriated by the State of South Carolina.

Gregg-Graniteville Fellowship. A $5,000 grant from the Gregg-Graniteville Foundation to the School of Industrial Management and Textile Science, including a $3,000 award to a student in textiles, plus fees, and the remainder in support of his textile research program.

Hercules Powder Fellowship. A $2,000 award to a student in Textile Chemistry.

David Jennings Fellowships. An award varying from $1,000 to $2,500 per year to students in the School of Industrial Management and Textile Science.

Lead Industries Association Fellowship. A $2,400 award to a student in Ceramic Engineering.

E. C. McArthur Memorial Fellowship. A $2,500 award plus tuition and research materials given by the South Carolina Association of Soil Conservation District Supervisors to a student in Agricultural Engineering.

Monsanto Fellowship. A $1,000 award to a student in one of the sciences.

National Aeronautics and Space Administration Traineeship Grants. Fellowships for from one to three years study in space-related fields have been awarded annually by the University in behalf of the National Aeronautics an dSpace Administration. Announcement of the availability of these fellowships will be made during the fall semester. Inquiries should be addressed to the Graduate School.

National Defense Education Act Fellowships. Three-year fellowships for doctoral study in particular areas are awarded annually by the University on behalf of the Department of Health, Education, and Welfare. Announcement of the availability of these fellowships is made in early October. Inquiries should be addressed to the Graduate School.

National Science Foundation Traineeships. The Graduate School participates in the National Science Foundation Traineeship Program. Inquiry about these awards should be made early in the academic year and should be directed to the Dean of the Graduate School.

Edward Orton, Jr., Fellowship. A $1,350 award plus supplies, to a student in Ceramic Engineering.

Federal Water Pollution Control Administration and Public Health Service Fellowships and Traineeships. Awards are made by these agencies to students studying in the water pollution and health-related fields. Inquiries about these awards should be directed to the Graduate School.

The J. E. Sirrine Textile Foundation Fellowships. Fellowships of $1,000 to $3,000 per year (depending on student's needs) are awarded to encourage outstanding young men to undertake graduate work in one of the graduate programs administered by the School of Industrial Management and Textile Science.

Alan G. Stanford Fellowship. An award of $500 to a student in Electrical Engineering.

Textile Research Institute Research Fellowship. An award of up to $3,000 plus tuition and fees to a student in the sciences or engineering. The recipient's dissertation research will be conducted on a textile-oriented problem.

Warwick Chemical Foundation Fellowships. Income from a fund, donated in memory of Manfred Caranci, available annually for awards to students in Chemistry.

GRANTS-IN-AID to graduate students are sponsored by the Mead Corporation and the Clemson Alumni through the Alumni Loyalty Fund.

All fellowship awards are made by the heads of departments concerned. Information about grants-in-aid is obtainable from the Dean of 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.

SUPPLEMENTAL INFORMATION

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."

A minimum grade of "C" must be made on all course work to obtain graduate credit. Students must maintain an average of "B" on all work taken in the graduate school to remain in good standing. Failure to maintain a "B" average will place the student on probation, and after two consecutive semesters the student will not be permitted to continue a graduate program without written approval of the Dean of the Graduate School. Further, the presence of more than one grade below "B" will subject the student's record to careful re-evaluation. Grades on research and language courses are not considered in this average. Students will not be admitted to candidacy while on probation. No students shall receive both graduate and undergraduate credit for the same course.

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 can be dropped from the Graduate School at any time for failure to maintain an adequate academic status.

Continuous Enrollment. Graduate students, other than those involved in summer studies only, will be required to maintain a continuous enrollment in the Graduate School unless excused by the Dean of the Graduate School. All graduate students must enroll in the semester or session during which they expect to receive a degree. Registration for one credit hour per enrollment will satisfy these requirements.

A student who has completed his work prior to the beginning of a semester, and who does not plan to be on campus at all during the course of the semester, meets the continuous enrollment regulation by registering for "Continuous Enrollment for Graduation". No formal grade is given. The fee for this registration is $10.00.

Auditing by Graduate Students. A regularly enrolled student may audit one additional course a semester, provided approval is obtained from the professor offering the course, the head of the department, and dean of the school in which the course is offered. Forms for requesting such approval are available at the Office of Admissions and Registration. Graduate assistants, and those graduate students who enroll for at least six hours, will not be charged for auditing. Other part-time students will be charged (1) one-half tuition fee and one-half maintenance and activity fee or one-half summer school fee (where applicable), and (2) full library fee charged part-time 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 professor, 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. The credit requirements for advanced degrees must be satisfied through registrations at Clemson University, except that on the recommendation of the student's major adviser and the approval of the Dean of the Graduate School, a student may earn in some accredited institution other than Clemson 6 credits in campus courses toward one of the Master's degrees and as many as 48 credits toward a Doctor's degree.

Credit may be transferred for work completed at off-campus centers of accredited institutions provided such courses are accepted in degree programs at those institutions. Transfer credit will not be accepted for courses in which a grade lower than B, or its equivalent, has been received.

No credit toward graduate degrees may be obtained by correspondence or extension study. All transfer credits must be veri-

fied by an official transcript from the college at which the work was done.

Transcripts certifying to graduate courses completed at another institution must be received in the Graduate School Office prior to the date of filing application for the degree. The degree will not be conferred at the close of the term during which the student has been registered elsewhere.

Filing of Preliminary Study Plans. Preliminary study plans must be filed with the Graduate School office by those students who are in the Master's and Doctoral programs.

Those enrolled in Masters' programs must file a preliminary study plan (GS2) during the early part of their second academic semester.* Those enrolled in the Doctoral programs must file a preliminary study plan (GS2d) during the early part of their second academic year.* In either program the preliminary study plans may be filed at times earlier than those required. Programs may be revised at any time by re-submission of form GS2 or GS2d.

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 Dean of the Graduate School of a written request for admission to candidacy. This request (Graduate School Form #4) may be filed by the student as follows: for the Master's degree, after he has completed fifteen hours of course work; for the Doctoral degree, after he has completed a major share of his course work and has successfully completed his preliminary examinations.

Deadlines. Listed below are deadline dates for the following: filing for admission to candidacy for a degree, ordering a diploma, taking final oral and/or written examinations; and submitting theses or dissertations.

For those who expect to receive the Master's degree on May 4, 1968

Jan. 15, 1968 Last day for filing GS4, "Admission to Candidacy for a Degree"

*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.

Feb. 5	Last day to order a diploma
Apr. 19	Final day for oral and/or written examinations
Apr. 27	Final date for submitting thesis to the Graduate Office

For those who expect to receive the Master's degree on August 3, 1968

May 17, 1968	Last day for filing GS4, "Admission to Candidacy for a Degree"
May 27	Last day to order a diploma
July 20	Last day for oral and/or written examinations.
July 27	Final date for submitting thesis to the Graduate Office

For those who expect to receive the Master's degree on December 17, 1968

Aug. 30, 1968	Last day for filing GS4, "Admission to Candidacy for a Degree"
Sept. 20	Last day to order a diploma
Dec. 3	Last day for oral and/or written examinations
Dec. 10	Final date for submitting thesis to the Graduate Office.

For those who expect to receive the Master's degree on May 10, 1969

Jan. 20, 1969	Last day for filing GS4, "Admission to Candidacy for a Degree"
Feb. 5	Last day to order a diploma
Apr. 26	Last day for oral and/or written examinations
May 3	Final date for submitting thesis to the Graduate Office

For those who expect to receive the Doctor of Philosophy degree on May 4, 1968

Sept. 6, 1967	Last day for filing GS4, "Admission to Candidacy for a Degree"
Feb. 2, 1968	Last day to order a diploma

Apr. 6	Last day to present completed dissertation to student's advisory committee
Apr. 20	Last day for final oral examination
Apr. 27	Final day for submitting dissertation to the Graduate Office

For those who expect to receive the Doctor of Philosophy degree on August 3, 1968

Jan. 5, 1968	Last day for filing GS4, "Admission to Candidacy for a Degree"
May 27	Last day to order a diploma
June 29	Last day to present completed dissertation to student's advisory committee
July 20	Last day for final oral examination
July 27	Final date for submitting dissertation to the Graduate Office

For those who expect to receive the Doctor of Philosophy degree on December 17, 1968

Apr. 17, 1968	Last day for filing GS4, "Admission to Candidacy for a Degree"
Sept. 20	Last day to order a diploma
Nov. 19	Last day to present completed dissertation to student's advisory committee
Dec. 3	Last day for final oral examination
Dec. 10	Final date for submitting dissertation to the Graduate Office

For those who expect to receive the Doctor of Philosophy degree on May 10, 1969

Sept. 6, 1968	Last day for filing GS4, "Admission to Candidacy for a Degree"
Feb. 3, 1969	Last day to order a diploma
Apr. 12	Last day to present completed dissertation to student's advisory committee
Apr. 26	Last day for final oral examination
May 3	Final date for submitting dissertation to the Graduate Office

Theses and Dissertations. Each candidate for an advanced degree in each curriculum requiring a thesis must prepare this thesis under the direction of a major adviser. Six hours of credit are required for the research leading to the required Master of Science or Master of Arts thesis. Nine hours of credit are required for the Master of Architecture thesis. Eighteen 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 two 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 Dean of the Graduate School at least one week prior to the date on which the degree is conferred. A binding fee of $11.25 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 $3.75 a copy. The responsibility for placing the thesis in proper final form rests with the student and the chairman of his advisory committee. A statement of special procedures for writing a thesis or dissertation at Clemson University may be obtained from the Graduate School Office.

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

Doctoral students must pay a fee of $25 to the Bursar for publication in **Dissertation Abstracts.** An additional fee of $12.75 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 de-

posited 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 Dean of the Graduate School.

Language Examinations. All Doctor of Philosophy and Master of Arts degrees and certain Master of Science degrees require that the student demonstrate a reading knowledge of one or more foreign languages. Language examinations are scheduled February 3, March 23, June 8, July 13 and November 2, 1968; February 8 and March 29, 1969. The language examinations are taken from sources supplied by the student's major department to the Language Department.

Subject to the approval of the Dean of the Graduate School, a language examination may be waived if the student has completed twelve semester hours of course work in the language with an average grade of B and with no grade lower than C.

A student who takes the examination in a given language more than twice will be charged $10 for each examination after the second.

Application for a Diploma. A formal application for a diploma must be placed by the student with the Director of Admissions and Registration within 4 weeks following the opening of the final semester of enrollment or by May 27 for summer graduation. At this time the diploma fee of $3.25 (or $6.75 if a diploma case is desired) must be paid and arrangements should be made for cap and gown rental.

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 office of the Dean of the School of Education.

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.

CREDIT LOADS

University upper limits on graduate student loads per semester are:

Full-time staff	6 credits
Graduate assistants—halftime	10 credits
Full-time students	15 credits

In the event of scheduling difficulties the limits may be exceeded in a particular semester if the average number of credits for the year does not exceed the upper limits. Special permission from the Graduate Office is needed if the upper limits are to be exceeded. Such a request must first be approved by the head of the department in which the student registered.

Within the limits set forth above, reasonable credit loads may be worked out for conditions other than those specifically stated. Major deviations from these limits must receive approval from the Graduate Office.

Maximum load for Summer School is one credit hour per week of session. An employee working full time during the summer may carry no more than four semester hours during the two summer sessions and not more than three semester credits during either session.

Eligibility 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. However, 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.

The Extension Service uses classifications that vary somewhat from those used in the teaching faculty and the following rules apply to members of that Service.

1. All Extension staff members except specialist leaders, supervisors, and administrators may, if otherwise qualified, be admitted to a Master's degree program at Clemson.

2. All Extension staff members except assistant specialists, associate specialists, specialists, specialist leaders, and administrators may, if otherwise qualified, be admitted to a Doctoral program at Clemson.

3. County agents, associate and assistant agents may, if otherwise qualified, be admitted to either degree program.

COURSES OF STUDY

The Director of Admissions and Registration will not permit enrollment in courses of the 600 series or above until the student has been officially admitted to the Graduate School.

Enrollment in any course is subject to approval by the department offering the course.

Where courses are offered on a schedule, there is a designation F, S, or SS following the title of each course, indicating whether it is customarily offered in the Fall, Spring, or Summer School.

The courses listed in this Bulletin in the 600 and 700 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.

AGRICULTURAL ECONOMICS

W. J. Lanham, Department Head

The Department of Agricultural Economics offers the 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.

AgEc 702—ECONOMICS OF AGRICULTURAL PRODUCTION—3 cr. (3 and 0) F

AgEc 703—LAND ECONOMICS—3 cr. (3 and 0)

A study of the characteristics of land and of the physical, legal, social, and economic principles and problems relating to the control and use of land resources.

AgEc 751—AGRICULTURAL COOPERATION—2 cr. (2 and 0) F

AgEc 752—AGRICULTURAL POLICY—3 cr. (3 and 0) FS

AgEc 756—PRICES—3 cr. (3 and 0) FS

AgEc 760—AGRICULTURAL FINANCE—2 cr. (2 and 0) FS

AgEc 802—AGRICULTURAL PRODUCTION ECONOMICS PROBLEMS—3 cr. (3 and 0)

An advanced study of production theory and its quantitative application including consideration of factors promoting change in input and output combinations on farms and among areas; relationship of economic theory to analysis of production activity; alternative approaches to explanation of input-output relations. **Prerequisite:** Permission of instructor.

AgEc 804—WATER RESOURCE POLICIES—3 cr. (3 and 0)

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.

AgEc 806—ECONOMIC DEVELOPMENT IN AGRICULTURAL AREAS—3 cr. (3 and 0)

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 micro-economic aspects.

AgEc 807—MARKET STRUCTURE IN AGRICULTURAL INDUSTRIES—3 cr. (3 and 0)

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.

AgEc 808—APPLIED QUANTIFICATIONS IN AGRICULTURAL ECONOMICS—3 cr. (3 and 0)

A survey of the mathematical tools requisite for a concise description of the principles in the economics of agriculture. Models are formulated as media for empirical research. 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.

AgEc 814—CONTEMPORARY ECONOMIC PROBLEMS—3 cr. (3 and 0)

A critical review of the nature of contemporary economic problems, the background out of which they developed, the remedies which have been applied, and possible alternatives. Special emphasis will be given to problems relating to agriculture and rural life.

AgEc 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.)

AgEc 891—RESEARCH—Credits to be arranged.

AgEc 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:** Agricultural Economics 703 or 804

AgEc 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:** Agricultural Economics 806.

AgEc 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:** Agricultural Economics 807.

AgEc 991—DOCTORAL RESEARCH—Credit to be arranged.

(See also courses listed under Economics.)

AGRICULTURAL EDUCATION

L. H. Davis, Department Head

The Master of Agricultural Education degree is offered.

A student desiring to pursue graduate work with a major in the field of Agricultural Education is expected to have as prerequisite sufficient work in this field to qualify him for a Class III teacher's certificate under the rules of the State Board of Education.

Ag Ed 701—METHODS IN AGRICULTURAL EDUCATION—3 cr. (2 and 3)

Ag Ed 763—ADVANCED CONSERVATION EDUCATION—3 cr. (3 and 0)

Ag Ed 765—PROGRAM PLANNING IN AGRICULTURAL EDUCATION—3 cr. (3 and 0)

Ag Ed 767ADULT EDUCATION IN AGRICULTURE— 3 cr. (2 and 3)

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 educational 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 AGRICULTURAL 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 agricultural education. **Prerequisite:** Experience in agricultural education.

Ag Ed 815—ADVANCED METHODS OF TEACHING FARM MECHANICS —3 cr. (2 and 3)

Organization of teaching units, methods of determining the content of the course, securing and equipping the shop, teaching farm mechanics and other shop problems involved in teaching farm people are considered in this course.

Ag Ed 820—TEACHING YOUNG FARMERS—3 cr. (3 and 0)

Principles and practices appropriate to the solution of problems in developing 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 philosophy of teacher education; (2) analyzing the present teacher training program in South Carolina, to discover problem situations to be used as a basis for teacher-education programs; (3) determining the relative emphasis 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:** Experience in agricultural education and permission of the instructor.

Ag Ed 891—INTRODUCTION TO RESEARCH IN EDUCATION—Credit to be arranged.

AGRICULTURAL ENGINEERING

A. W. Snell, Department Head

The Department of Agricultural Engineering offers the Master of Science and Doctor of Philosophy degrees.

Student of agricultural engineering may also pursue the doctoral programs in Environmental Systems Engineering and Water Resources Engineering. Each of these inter-disciplinary programs relates closely to courses and research in agricultural engineering.

Additional course work for a major in Agricultural Engineering is usually taken in other departments such as Mathematics, Physics, Engineering Mechanics, Mechanical Engineering, and Civil Engineering. Courses for a minor are taken in other engineering departments, Agronomy and Soils, Mathematics, or Statistics.

AgE 652—FARM POWER—3 cr. (2 and 3) S

AgE 660—FARM AND HOME UTILITIES—3 cr. (2 and 3) S

AgE 716—AGRICULTURAL MACHINERY—3 cr. (2 and 3) S

AgE 722—SOIL AND WATER CONSERVATION ENGINEERING—4 cr. (3 and 3) S

AgE 731—AGRICULTURAL STRUCTURAL DESIGN— 3 cr. (2 and 3) F

AgE 742—AGRICULTURAL PROCESS ENGINEERING—3 cr. (2 and 3) S

AgE 765—ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS —3 cr. (2 and 3) S

AgE 801—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, (c) Farm Structures, or (d) Electric Power Processing.

AgE 804—ENGINEERING APPLICATIONS TO AGRICULTURAL PROCESSING—3 cr. (2 and 3) S

A course dealing with the unit operations involved in the processing of agricultural products. The application of engineering principles and instrumentation to size reduction, cleaning and grading, mixing, materials handling, work simplification, dehydrating and drying, refrigeration, storage, and related subjects.

AgE 806—INSTRUMENTATION IN AGRICULTURAL AND BIOLOGICAL 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.

AgE 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:** AgE 716 or equivalent.

AgE 822—WATER MOVEMENT IN SOILS—3 cr. (3 and 0) S

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:** AgE 722, or equivalent.

AgE 873—RADIOLOGICAL HEALTH—3 cr. (2 and 3)

Sources of ionizing radiation and radioisotopes in man's environment will be illustrated, and methods of protection from these sources will be discussed. The engineering aspects of detection, shielding, and disposal of radioactive materials will be studied. **Prerequisite:** Ch 491 or the equivalent.

AgE 874—RADIOLOGICAL HEALTH ENGINEERING—3 cr. (2 and 3)

This is a continuation of Radiological Health with a more detailed study of radiation protection from air, water, food, and solids through engineering procedures. This course is offered primarily for engineering students. **Prerequisite:** AgE 853 or the equivalent.

AgE 882—SYSTEMS ENGINEERING—3 cr. (2 and 3) F

An application of the systems approach to the processing of agricultural products from field to salable package. Emphasis is placed upon accepted methods of systems engineering including linear programming, probability considerations, and other operations research techniques. Specific engineering problems involved in cotton processing, e.g., pneumatic conveyance, feedback control systems, energy requirements, and the effect of various processes on the cotton fiber are considered.

AgE 891—RESEARCH—Credit to be arranged.

AGRONOMY

U. S. Jones, Department Head

The Department of Agronomy offers the 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, soil microbiology, 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, controlled environmental chambers, and graduate student laboratories in an air-conditioned building.

Some agronomists are trained as chemists; others have strong training in physics, geology and mathematics; some are plant physiologists, geneticists or microbiologists. An agronomist played a major role in the development of streptomycin and aureomycin.

Teaching in undergraduate courses is a departmental requirement of all graduate students in Agronomy.

Gen 602—GENETICS—3 (2 and 3) FS

Gen 751—GENETICS—3 cr. (3 and 0) F

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

A detailed study of the physical basis of genetic variation with emphasis on the co-relation of cytological and genetic concepts. Topics will include normal and abnormal chromosomal distribution, structural and numerical aberrations, interspecific hybridization, polyploidy and mutable genetic systems. **Prerequisite:** Gen. 302 or equivalent.

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

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

Agron 610—FORAGE AND PASTURE CROPS—3 cr. (3 and 0) S

Agron 612—FORAGE CROPS LABORATORY—1 cr. (0 and 3) S

Agron 703—SOIL CLASSIFICATION—2 cr. (1 and 3) F

Agron 705—PLANT BREEDING—3 cr. (2 and 3) S

Agron 707—PRINCIPLES OF WEED CONTROL—3 cr. (2 and 3) F

Agron 710—COTTON AND OTHER FIBER CROPS—2 cr. (2 and 0) S, odd numbered years.

Agron 711—GRAIN CROPS—2 cr. (2 and 0) F, even numbered years.

Agron 712—TOBACCO AND SPECIAL USE CROPS—2 cr. (2 and 0) S, even numbered years.

Agron 752—SOIL FERTILITY AND MANAGEMENT—2 cr. (2 and 0) S

Agron 755—SEMINAR—1 cr. (1 and 0) F

Agron 756—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—2 cr. (2 and 0) FS

Original investigation of special problems in Agronomy which are not related to a thesis but designed to provide experience and training in research.

Agron 807—SOIL PHYSICS—3 cr. (2 and 3) F, 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 SOILS AND WATER—3 cr. (3 and 0) S, odd numbered years.

Concepts concerning the behavior of important pesticides and their analogues in the dynamic soil system and in solution will be studied. Particular attention will be directed to transport, deposition, and reactions and interactions involving solids, liquids, and vapors. Demonstrations and applications will be included. **Prerequisite:** Graduate standing and permission of instructor.

Agron 825—SEMINAR—1 cr. (1 and 0) F

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, FS.

Agron 991—DOCTORAL RESEARCH—Credit to be arranged. FS.

ANIMAL PHYSIOLOGY

B. D. Barnett—Poultry Science—Chairman
J. H. Cochran—Entomology and Zoology
W. A. King—Dairy Science
R. F. Wheeler, Animal Science

The Doctor of Philosophy degree is offered.

The graduate program in Animal Physiology utilizes the faculties of the four departments listed above. Physiological processes of both verebrates 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.

AnPh 802—VERTEBRATE PHYSIOLOGY—3 cr. (2 and 3) F

A comparative physiology course dealing with all classes of mammals and fowl. Processes of ingestion, digestion, secretion, excretion, respiration, circulation and metabolism. Endocrinology and reproduction will be reviewed briefly. Rats, rabbits, chickens and humans are used as laboratory subjects.

AnPh 803—ANIMAL PHYSIOLOGY—4 cr. (3 and 3)

A comprehensive course in animal physiology covering circulation, respiration, digestion, excretion and metabolism. Endocrinology and reproduction will be reviewed briefly.

AnPh 804—ANIMAL PHYSIOLOGY—4 cr. (3 and 3)

A continuation of Animal Physiology 803 covering muscles, nerves, special senses, skin and bones.

AnPh 805—PHARMACOLOGY—3 cr. (2 and 3)

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.

AnPh 851—ANIMAL PHYSIOLOGY SEMINAR I—1 cr. (1 and 0)

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.

AnPh 852—ANIMAL PHYSIOLOGY SEMINAR II—1 cr. (1 and 0)

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

AnPh 991—DOCTORAL RESEARCH—Credit to be arranged.

Bact 805—PHYSIOLOGY OF BACTERIA—3 cr. (2 and 3)

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

Ch 826—CHEMISTRY OF ENZYMES—3 cr. (3 and 0)

DySc 753—ANIMAL REPRODUCTION—3 cr. (3 and 0)

DySc 755—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3)

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

DySc 804—ENDOCRINOLOGY—3 cr. (3 and 0)

PS 701—ANIMAL ENVIRONMENTAL TECHNOLOGY—3 cr. (and 0)

Zool 758—CELL PHYSIOLOGY—3 cr. (2 and 3)

Zool 760—GENERAL PHYSIOLOGY—3 cr. (2 and 3)

Zool 761—ANATOMY—3 cr. (3 and 0)

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

Zool 806—COMPARATIVE ANIMAL PHYSIOLOGY—3 cr. (3 and 0)

Zool 808—RADIOBIOLOGY—3 cr. (2 and 3)

Zool 809—TOXICOLOGY—3 cr. (2 and 3)

ANIMAL SCIENCE

R. F. Wheeler, Department Head

The Department of Animal Science offers the Master of Science degree.

The Department participates in Interdepartmental Ph.D. Programs in Animal Physiology and Nutrition.

An Sc 701—BEEF PRODUCTION—3 cr. (3 and 0)

An Sc 703—BEEF PRODUCTION LABORATORY—1 cr. (0 and 3)

An Sc 708—PORK PRODUCTION—3 cr. (3 and 0)

An Sc 710—PORK PRODUCTION LABORATORY—1 cr. (0 and 3)

An Sc 752—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 752.

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 nutrient requirements of meat animals with special emphasis on the properties and functions of nutrients. **Prerequisite:** Dy Sc 703.

An Sc 891—RESEARCH—Credit to be arranged.

ARCHITECTURE

H. E. McClure, Dean

The Master of Architecture degree is offered.

The School of Architecture administers a six-year professional program for the education of potential architectural practitioners. Students satisfactorily completing the first four years are awarded the Bachelor of Arts degree in pre-architecture; and, following two intensive, additional years

of professional training and the writing of a satisfactory thesis, the first professional degree, Master of Architecture, is awarded.

Arch 811—TOWN PLANNING THEORY—3 cr. (3 and 0)

Studies of urban planning including land use, circulation, urban economics, sociological factors in planning, urban design, governmental structure and the planning process; and zoning.

Arch 812—TOWN PLANNING THEORY—3 cr. (3 and 0)

A continuation of Arch 811. **Prerequisite:** Arch 811.

Arch 853—GRADUATE DESIGN—8 cr. (0 and 24)

City planning design and the development of complex building structures. **Prerequisite:** Arch 454.

Arch 854—GRADUATE DESIGN—8 cr. (0 and 24)

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

Arch 855—THESIS RESEARCH—2 cr. (0 and 6)

Systematic pre-thesis research and study; each student, working independently with tutorial assistance, will develop a graduate thesis program. **Prerequisite:** Arch 854.

Arch 857—GRADUATE DESIGN—10 cr. (4 and 18)

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

Arch 858—ARCHITECTURAL THESIS—17 cr. (5 and 36)

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.

Arch 861—ECONOMICS SEMINAR—3 cr. (3 and 0)

Studies in urban and building economics.

Arch 875—MECHANICAL PLANT—2 cr. (2 and 0)

The water supply, plumbing, heating and ventilating systems of present-day buildings.

Arch 876—MECHANICAL PLANT—2 cr. (2 and 0)

Air-conditioning, electrical systems, lighting, mechanical transportation, and acoustics as applied to contemporary buildings. **Prerequisite:** Arch 875.

Arch 881—OFFICE PRACTICE—2 cr. (2 and 0)

General consideration of architectural office procedure. Study of the professional relationship of the architect to client and contractor, including problems of ethics, law, and business.

Arch 882—OFFICE PRACTICE—2 cr. (2 and 0)

A continuation of Arch 881. **Prerequisite:** Arch 881.

Arch 891—ARCHITECTURAL STRUCTURAL SEMINAR—2 cr. (2 and 0)

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

Arch 892—ARCHITECTURAL STRUCTURAL SEMINAR—2 cr. (2 and 0)

Analysis of architectural structures with special emphasis on shells and space frames. **Prerequisite:** Arch 891.

Arch 893—ARCHITECTURAL STRUCTURAL SEMINAR—2 cr. (2 and 0)

The analysis of advance structural problems as related to concurrent graduate design problems. **Prerequisite:** Arch 892.

BACTERIOLOGY

W. M. Epps, Department Head

The Master of Science degree in Microbiology is offered.

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 or zoology), or chemistry, or in one of the agricultural sciences. Undergraduate work in bacteriology or microbiology is desirable but not necessary.

Bact 601—GENERAL BACTERIOLOGY—4 cr. (3 and 3) FS SS

Bact 612—FOOD MICROBIOLOGY—3 cr. (2 and 3) S, odd numbered years.

Bact 701—ADVANCED BACTERIOLOGY—4 cr. (2 and 6) F

Bact 702—DAIRY BACTERIOLOGY—3 cr. (2 and 3) S, even numbered years.

Bact 706—SANITARY BACTERIOLOGY—3 cr. (2 and 3) F, odd numbered years.

Bact 710—SOIL MICROBIOLOGY—3 cr. (2 and 3) S, even numbered years.

Bact 711—PATHOGENIC BACTERIOLOGY—3 cr. (2 and 3) S

Bact 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:** Bact 601, 701, and organic chemistry. May be taken concurrently with Bact 701.

Bact 802—BACTERIOLOGICAL TECHNIC— 4 cr. (2 and 6) F, even numbered years.

Methods of preparing special equipment for use in the bacteriological laboratory, sterilization by filtration, isolation of viruses, immunological procedures, and the experimental infection of animals. Designed to give students experience in more advanced methods of investigation. **Prerequisites:** Bact 601, 701, and organic chemistry.

Bact 803—SPECIAL PROBLEMS IN BACTERIOLOGY—2 cr.

Original research on special problems in bacteriology not related to the thesis.

Bact 805—PHYSIOLOGY OF BACTERIA—3 cr. (2 and 3) S, even numbered years.

A study of bacterial cytology, enzymes, growth curves, respiration, aerobiosis, anaerobiosis, nutrition of bacteria and degradation of proteins, carbohydrates, and fats. **Prerequisites:** Bact 601, 701.

Bact 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:** Bact 701 or 710.

Bact 891—RESEARCH—Credit to be arranged.

BIOCHEMISTRY

W. P. Williams, Chairman, Food Science and Biochemistry

H. G. Spencer, Chemistry and Geology

John F. Andrews, Environmental Systems Engineering

The Master of Science Degree is Offered.

Enrollment in the biochemistry graduate program is open to students possessing baccalaureate degrees in agricultural and biological sciences, chemistry, and in engineering. Students selecting biochemistry will be expected to have had courses in analytical, organic and physical chemistry. Students who have not completed these courses may be admitted to the program, but will be required to correct any deficiencies by registering for the appropriate courses.

Students pursuing graduate study in biochemistry will be assigned to the department in which the major advisor is a member.

Undergraduate teaching is an integral part of graduate work in biochemistry and is required of all graduate students.

Bioch 706—PHYSIOLOGICAL CHEMISTRY—4 cr. (3 and 3)

Ch 723—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 724—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 725—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 726—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Bioch 810—BIOCHEMICAL TECHNIQUES—3 cr. (1 and 6)

A discussion of techniques relating to the analyses of biological materials. Practice in the use of gas and liquid chromatography, Warburg apparatus, amino acid analyzer, spectrophotometers, radioisotopes, and other instruments employed in biochemical work will be stressed. **Prerequisite:** Ch 313 and 315 or 317.

Bioch 812—NUTRITIONAL BIOCHEMISTRY—3 cr. (3 and 0)

The biochemical aspects of nutrient function in nutrition. **Prerequisites:** Ch 723.

Bioch 814—LABORATORY METHODS IN NUTRITION—1 cr. (0 and 3)

A course to familiarize the student with experimental animal procedures, metabolism studies, nutritional diseases, and assay methods in biological materials. **Prerequisites:** Ch 313 and 315 or 317.

Bioch 815—LIPIDS—2 cr. (2 and 0)

Chemistry of plant and animal lipids, to include formation, function, metabolism, chemical reactions, and physical properties. Methods of analysis are discussed. **Prerequisites:** Ch 723.

Bioch 816—PROTEINS AND NUCLEIC ACIDS—3 cr. (3 and 0)

The chemical structure of proteins and nucleic acids to include theoretical correlations between structure and function will be discussed. Methods of analyses and characterization will be described. **Prerequisites:** Ch 723.

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

The isolation, assay, and chemistry of the various animal hormones are discussed. The hormonal control of metabolism and body function as well endocrinopathies of hormone imbalance are also studied. **Prerequisite:** Ch 723.

Bioch 818—VITAMINS AND MINERALS—3 cr. (3 and 0)

The chemistry of vitamins and the role of vitamins and minerals in metabolic function together with methods of assay and analysis are discussed. **Prerequisites:** Ch 723.

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

A descriptive consideration of the various chemical pathways of metabolism. **Prerequisite:** Ch 723.

Ch 826—CHEMISTRY OF ENZYMES—3 cr. (3 and 0)

Topics include a study of general enzyme kinetics, techniques of measurements and isolation, enzyme classification, specificity, biochemical mechanisms, cofactors and inhibitors, mechanism of biosynthesis of enzymes, its genetic control and regulation by induction, feed back inhibition and repression, enzyme structure, and enzyme biology. **Prerequisite:** Ch 723.

Ch 829—CHEMISTRY AND METABOLISM OF THE CARBOHYDRATES —2 cr. (2 and 0)

Chemistry and metabolism of carbohydrates. A study of the chemical properties of monosaccharides, and the structure of various polysaccharides. Study of the biochemical aspects of synthesis and degradation of polysaccharides including principles of glycolytic breakdown and aerobic carbohydrate metabolism. **Prerequisites:** Ch 723.

Bioch 851—BIOCHEMISTRY SEMINAR—1 cr. (1 and 0) F

A review of current topics in biochemistry by graduate students in biochemistry and interested staff members.

Biocch 852—BIOCHEMISTRY SEMINAR—1 ch. (1 and 0) S

Continuation of Bioch 851.

Bioch 891—RESEARCH—Credit to be arranged.

BIOENGINEERING

L. G. Rich, Chairman

Courses are offerend leading to the Master of Science and Doctor of Philosophy degrees.

The program in bioengineering is structured such that emphasis can be placed in either of two options; 1. studies relating to the fermentation field and the technology associated with artificial environments, or 2. studies of biomedical research problems as they relate to mamalian systems, primarily man.

In the first program referred to above, the application of engineering technology to the fermentation processes employed in the production of pharmaceuticals and industrial chemicals is studied. In addition, the technology associated with the design and maintenance of artificial environments for man has become an important part of the program. The establishment and control of such environments require the application of engineering principles to biological systems producing the physiological necessities of man. The educational preparation of the student entering this option must include, in addition to a strong background in the unit operations in process engineering, a firm foundation of principles of chemistry

and microbiology. Effective participation in the technology of artificial environments also requires a knowledge of environmental hygiene.

The second program in Bioengineering is concerned with the application of the technology of engineering science to problems in medical research. Mathematical modeling and computer simulation are used to study physiological systems. Biological signal processing, data, handling and the design of specialized instrumentation are topics covered. Specific examples drawn from these areas include electrical and mechanical properties of bone, fluid dynamics as applied to cardio-vascular systems, electrical information processing in neuro-muscular systems and man-machine communication.

Normally students enrolling in the second option will have a strong background in mathematics, computers and instrumentation. Course work in physiology, anatomy and physical chemistry is frequently part of the requirement for studies in this area.

In general the bioengineering program is open to students possessing degrees in engineering and to those with degrees in science who have credits for certain prescribed engineering courses.

Candidates for a degree in this field are allowed considerable flexibility in planning their program. Certain courses are, however, quite common in bioengineering programs. These are listed below. It is clear from the nature of the courses how they would fit into either of the bioengineering options.

Bact 601—GENERAL BACTERIOLOGY—4 cr. (3 and 3)

Bact 701—ADVANCED BACTERIOLOGY—4 cr. (2 and 6)

Bot 652—PLANT PHYSIOLOGY—4 cr. (3 and 3)

Ch 723—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 724—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 831—CHEMICAL THERMODYNAMICS—3 cr. (3 and 0)

Ch 832—STATES OF MATTER—3 cr. (3 and 0)

ME 704—PHYSICAL SYSTEMS ANALYSIS—3 cr. (3 and 0)

ME 860—DYNAMIC PROGRAMMING—3 cr. (3 and 0)

EE 870—BIOSYSTEMS ANALYSIS—3 cr. (3 and 0)

EE 710—CONTROL SYSTEMS—3 cr. (3 and 0)

EE 810—ANALYTICAL DESIGN OF LINEAR FEEDBACK CONTROL—3 cr. (3 and 0)

EE 806—NONLINEAR NETWORKS AND SYSTEMS—3 cr. (3 and 0)

EE 850—COMPUTATION AND SIMULATION—3 cr. (3 and 0)

Zool 760—GENERAL PHYSIOLOGY—3 cr. (2 and 3)

Zool 761—ANATOMY—3 cr. (3 and 0)

EE 815—RANDOM DATA MEASUREMENTS—3 cr. (3 and 0)

EE 827—INSTRUMENTATION AND MEASUREMENTS—3cr. (3 and 0)

Bioeng 846—ELEMENTS OF BIOENGINEERING I—3 cr. (3 and 0) S

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.

Bioeng 847—ELEMENTS OF BIOENGINEERING II—3 cr. (3 and 0) F

Cardiovascular system; 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.

Bioeng 991—DOCTORAL RESEARCH—Credit to be arranged.

BOTANY

W. M. Epps, Department Head

The Master of Science degree is offered in Botany and Plant Pathology.

The Doctor of Philosophy degree is offered in Plant Pathology and Plant Physiology.

Students who desire to pursue graduate work in botany or plant pathology 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. Undergraduate courses in plant pathology are desirable but not essential for plant pathology graduate majors.

Bot 652—PLANT PHYSIOLOGY—4 cr. (3 and 3) FS

Bot 656—TAXONOMY OF VASCULAR PLANTS—3 cr. (1 and 6) S

Bot 701—PLANT PATHOLOGY—3 cr. (2 and 3) FS

Bot 704—CYTOLOGY—4 cr. (3 and 3) F, odd numbered years.

Bot 705—FOREST PATHOLOGY—3 cr. (2 and 3) F

Bot 706—PLANT ANATOMY—3 cr. (2 and 3) F, even numbered years.

Bot 751—MORPHOLOGY OF THE FUNGI—3 cr. (2 and 3) F, even numbered years.

Bot 752—PLANT ECOLOGY—3 cr. (3 and 0) S, even numbered years.

Bot 755—PLANT MORPHOLOGY—4 cr. (2 and 6) S, odd numbered years.

Bot 756—PLANT VIROLOGY—3 cr. (3 and 0) S, even numbered years.

Bot 757—PHYCOLOGY—3 cr. (2 and 3) S, odd numbered years.

The taxonomy, morphology, and ecology of freshwater algae with emphasis on the local flora. **Prerequisite:** Bot 101 or permission of the instructor.

Bot 802—MYCOLOGY—4 cr. (3 and 3) S, odd numbered years.

Designed chiefly for students majoring in plant pathology and closely allied fields. A detailed study is made of specific groups of fungi, especially those of economic importance in this region. Emphasis is placed on field collection, identification, morphology, and cytology through lectures, student reports, and laboratory work. **Prerequisite:** Bot 751.

Bot 803—PLANT PATHOLOGY—4 cr. (3 and 3) S, odd numbered years.

An introduction to research on plant diseases with review and recording of literature; preparation of media; isolation of single-cells of organisms in pure culture; a class study of infection and epidemiology of selected plant diseases incited by fungi, bacteria, viruses, nematodes, and physiogenic factors; and an individual "problem" with preparation of a manuscript according to standards of a scientific journal. **Prerequisite:** Bot 701 or 705.

Bot 804—PHYSIOLOGY OF PARASITISM IN PLANTS—3 cr. (3 and 0) F odd numbered years

This course is designed to acquaint the student with the interaction of host and parasite in the development of plant diseases. Emphasis will be given to the factors that influence infection and the development of the parasite within the host. **Prerequisites:** Bot 652; Bot 701 or 705; organic chemistry.

Bot 805—SPECIAL PROBLEMS IN BOTANY—**

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

**Hours of credit to be arranged with instructor. Credit will be given under Bot 805 for special problems performed in connection with other graduate courses.

Bot 806—CONTROL OF PLANT DISEASES—3 cr. (3 and 0) S, even numbered years.

A theoretical and practical coverage of all aspects of plant disease control. Laboratory facilities are available for qualified students to conduct specialized investigations in plant disease control. **Prerequisites:** Bot 652, 701 or 705; organic chemistry.

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—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. **Prerequisites:** Bot 652, organic chemistry, or permission of instructor.

Bot 812—ORGANIC PLANT METABOLISM—3 cr. (3 and 0) S, 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 652, organic chemistry, or permission of instructor.

Bot 813—GROWTH AND DEVELOPMENT—3 cr. (3 and 0) F, 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 652, organic chemistry, or permission of instructor.

Bot 814—MICROBIAL PHYSIOLOGY—3 cr. (3 and 0) S, odd numbered years.

A detailed study of the growth of microorganisms and how they are affected by environment. Includes intermediary metabolism, enzyme kinetics, energy utilization, biological oxidation, adaptation, and biochemistry of amino acid transformations. The quantitative approach to research is emphasized. **Prerequisites:** organic chemistry, 1 year; biochemistry, 1 semester; Math 106; and Bact 401; or permission of instructor.

Bot 821—PLANT TAXONOMY I—4 cr. (2 and 6) F

Principles of plant classification and relationships and characteristics of the major groups of vascular plants. The collection and identification of the fall flora of the area. **Prerequisites:** Bot 101; Bot 356 or permission of instructor.

Bot 882—PLANT TAXONOMY II—4 cr. (2 and 6) S

A continuation of Bot 821 with emphasis on the collection and identification of the spring flora of the area. **Prerequisites:** Bot 101; Bot 821 or permission of instructor.

Bot 891—RESEARCH—Credit to be arranged.

Bot 991—DOCTORAL RESEARCH—Credit to be arranged.

CERAMIC ENGINEERING

G. C. Robinson, Department Head

Courses are offered leading to the degree of Master of Science.

CrE 702—SOLID STATE CERAMICS—3 cr. (3 and 0)

CrE 703—GLASSES—3 cr. (3 and 0)

CrE 704—SOLID STATE CERAMICS—3 cr. (3 and 0)

CrE 710—ANALYTICAL PROCESSES—3 cr. (3 and 0)

CrE 712—RAW MATERIAL PREPARATION—3 cr. (3 and 0)

CrE 716—ELECTRONIC CERAMICS—3 cr. (3 and 0)

CrE 718—PROCESS CONTROL—3 cr. (3 and 0)

CrE 719—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)

CrE 720—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)

CrE 807—SPECIALIZED CERAMICS—3 cr. (3 and 0)

An advanced study of one of the divisions of ceramics. The student may select either structural products, refractories, whitewares, abrasives, enamels, glass, cements, or raw materials processing.

CrE 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.

CrE 810—CERAMIC ENGINEERING THERMODYNAMICS—3 cr. (3 and 0)

The application of thermodynamics with special reference to physical and chemical changes in ceramic systems.

CrE 811—CERAMIC ENGINEERING KINETICS—3 cr. (3 and 0)

Theory and measurement of the rates and mechanisms of reactions in ceramic processes.

CrE 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.

CrE 813—NUCLEAR CERAMICS—3 cr. (3 and 0)

A study of the properties, selection, and uses of ceramic materials in nuclear reactors

CrE 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.

CrE 815—COLLOIDAL AND SURFACE SCIENCE—3 cr. (3 and 0)

The theory and application of colloidal and surface chemistry to ceramic materials and processes.

CrE 816—CONSTITUTION AND STRUCTURE OF GLASSES—3 cr. (3 and 0)

A study of modern concepts of glass structure and properties.

CrE 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.

CrE 822—ANALYTICAL PROCEDURES AND EQUIPMENT II—3 cr. (2 and 3)

A continuation of CrE 821.

CrE 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.

CrE 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.

CrE 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.

CrE 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.

CrE 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.

CrE 891—RESEARCH—Credit to be arranged.

CHEMICAL ENGINEERING

C. E. Littlejohn, Department Head

The Department of Chemical Engineering offers 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 may be taken in chemistry, physics, mathematics, life science, or other branches of engineering; however, a minor in mathematics is required for the M.S. degree. There is no language requirement for the Master's degree; however, a reading knowledge of two foreign languages is required for the Ph.D. degree

ChE 701—TRANSPORT PHENOMENA—3 cr. (3 and 0)

ChE 707—UNIT OPERATIONS LABORATORY II—2 cr. (0 and 6)

ChE 709—CHEMICAL ENGINEERING DESIGN II—2 cr. (0 and 6)

ChE 715—INTRODUCTION TO NUCLEAR ENGINEERING I—3 cr. (3 and 0)

ChE 716—INTRODUCTION TO NUCLEAR ENGINEERING II—3 cr. (3 and 0)

ChE 723—THEORY OF BIO-OXIDATION PROCESSES—2 cr. (2 and 0)

ChE 730—CHEMICAL ENGINEERING THERMODYNAMICS II—3 cr. (3 and 0)

ChE 750—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)

ChE 752—MOLECULAR AND TURBULENT TRANSPORT—3 cr. (3 and 0)

ChE 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:** ChE 307 and 453 and Math 306 or permission of the instructor.

ChE 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.

ChE 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.

ChE 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.

ChE 806—CHEMICAL ENGINEERING CALCULATIONS I—3 cr. (3 and 0)

Formulation and solution of basic chemical engineering problems using statistical and post-calculus techniques.

ChE 807—CHEMICAL ENGINEERING CALCULATIONS II—3 cr. (3 and 0)

A continuation of ChE 806. Emphasis is given to the formulation and solution of more complex problems in the area of steady and unsteady transport.

ChE 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.

ChE 809—WASTE TREATMENT—3 cr. (3 and 0)

Basic biochemical principles underlying bio-oxidation 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.

ChE 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.

ChE 820—FLUID MECHANICS—3 cr. (3 and 0)

See description of EM 851.

ChE 821—HEAT TRANSPORT— 3 cr. (3 and 0)

Advanced topics in heat transport by conduction, convection, and radiation.

ChE 822—MASS TRANSFER AND DIFFERENTIAL CONTACT OPERATIONS—3 cr. (3 and 0)

Topics include diffusion theory in binary and multicomponent gas and liquid systems, the HTU concept, and design considerations in absorption and extraction.

ChE 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.

ChE 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.

ChE 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.

ChE 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.

ChE 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.

ChE 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.

ChE 854—ENVIRONMENTAL INSTRUMENTATION AND MEASUREMENTS—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.

ChE 891—RESEARCH—Credit to be arranged.

ChE 902—PROCESS DYNAMICS AND CONTROL—3 cr. (3 and 0)

An extension of ChE 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:** ChE 802.

ChE 903—TRANSPORT PHENOMENA—3 cr. (3 and 0)

A consideration of problems in transport phenomena from the current literature. **Prerequisite:** ChE 803.

ChE 904—CHEMICAL ENGINEERING THERMODYNAMICS—3 cr. (3 and 0)

A continuation of ChE 804. Includes non-ideal behavior of mixtures, statistical thermodynamics and irreversible process. **Prerequisite:** ChE 804.

ChE 905—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)

A continuation of ChE 805. **Prerequisite:** ChE 805.

ChE 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 ChE 845-847.

ChE 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:** ChE 854.

ChE 991—DOCTORAL RESEARCH—Credit to be arranged.

CHEMICAL PHYSICS

H. G. Spencer, Chairman (Chemistry)

H. E. Vogel, Chairman (Physics)

Courses are offered leading to the Doctor of Philosphy degree.

Chemical physics is an interdisciplinary field utilizing particular courses in chemistry and physics. Where physical chemistry is concerned with the physical and thermodynamic properties of materials in bulk, chemical physics studies the involved spatial structures and properties of matter on the

atomic and molecular scale. The theoretical and experimental techniques of physics and physical chemistry are used in chemical physics.

Students may conduct their research with faculty members in either the Department of Physics or the Department of Chemistry, and joint projects may be arranged.

Course work required of the student in this field is drawn principally from the offerings in chemistry, physics, and mathematics.

CHEMISTRY

H. G. Spencer, Department Head

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

REQUIREMENTS FOR ADMISSION

An entering chemistry graduate student should have a record of sound academic accomplishment and a major in chemistry from a department approved by the American Chemical Society.

Although such an undergraduate program is obviously best, it is recognized that capable students sometimes acquire an interest in chemistry too late to complete the minimum A.C.S. requirements, or have attended institutions where the complete program is not available. The department will carefully evaluate the undergraduate records of such students and, if the possibility of their doing satisfactory graduate work seems good, they may be admitted on a provisional basis. These students must make up any undergraduate deficiencies upon entering the graduate program. It must be realized by an individual admitted under these conditions that it will take him somewhat longer to obtain his degree than if he had completed an A.C.S. approved program.

In addition to the requirements of the Graduate School, students who register for graduate work in chemistry must satisfy the following departmental requirements:

For the Master of Science degree. Each entering graduate student will be given placement examinations in four fields of chemistry — analytical, inorganic, organic and physical. These examinations are given during the week preceding the first semester of residence, and allow the department to arrange a program of study for the student so that any deficiency in undergraduate training may be rectified.

A reading knowledge of German is required. This requirement should be met as early in the student's program as is possible, and in no case later than the semester preceding the one in which the degree is to be awarded.

For the Doctor of Philosophy degree. Placement examinations, as described above, are required.

Qualifying examinations are required in each of the four fields of chemistry. In lieu of these examinations, graduate credit in certain courses provides proof of competence in the field. A list of these courses may be obtained from faculty advisers.

A comprehensive examination will be given in the major field. In the fields of analytical, inorganic and physical chemistry, this examination will consist of a written examination, followed by an oral examination—both examinations to be held within a period of two weeks. In the field of organic chemistry, the examination is of the cumulative type consisting of a series of one-hour, written examinations given monthly.

No student may take the comprehensive examination prior to completion of the language requirement.

Teaching in undergraduate courses is an integral part of graduate work in chemistry and is required of all graduate students.

The Ph.D. in Chemistry with Major in Textile Chemistry. The student in this program must meet the basic requirements of the chemistry department as set forth in the Graduate Bulletin. One exception is that students majoring in textile chemistry may omit qualification in analytical or inorganic chemistry, substituting textile chemistry for either of these.

The examination policy is the same, regardless of the areas of the student's major, and the comprehensive examination for the textile chemistry major will be written jointly by the two departments.

The minor for textile chemistry majors would normally be organic or physical chemistry.

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 631—PHYSICAL CHEMISTRY—3 cr. (3 and 0)

Ch 632—PHYSICAL CHEMISTRY—3 cr. (3 and 0)

Ch 639—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 640—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 702—INORGANIC CHEMISTRY—3 cr. (3 and 0)

Ch 711—INSTRUMENTAL ANALYSIS—4 cr. (2 and 6)

Ch 721—QUALITATIVE ORGANIC ANALYSIS—4 cr. (2 and 6)

Ch 723—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 724—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)

Ch 725—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 726—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Ch 731—ATOMIC AND MOLECULAR STRUCTURES—3 cr. (3 and 0)

Ch 754—INORGANIC SYNTHESIS—2 cr. (0 and 6)

Ch 772—ORGANIC SYNTHESIS—4 cr. (2 and 6)

Ch 791—INTRODUCTION TO RADIOCHEMISTRY—3 cr. (2 and 3)

Ch 805—THEORETICAL INORGANIC CHEMISTRY—3 cr. (3 and 0)

The applications of modern theory to inorganic chemistry. **Prerequisites:** Ch 702 and Ch 731, or permission of the instructor.

Ch 806—SPECIAL TOPICS IN INORGANIC CHEMISTRY—1-4 cr. (1-4 and 0)

Topics such as 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. Credit varies. (May be taken more than one semester.)

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. Modern molecular structor techniques and theories will be used to study these compounds. **Prerequisites:** Ch. 331, 332, 702 or their equivalent.

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 702.

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 821—ORGANIC CHEMISTRY I—3 cr. (3 and 0)

An intensive survey of modern organic chemistry with the emphasis on theoretical concepts and mechanisms.

Ch 822—ORGANIC CHEMISTRY II—3 cr. (3 and 0)

A continuation of Ch 821 **Prerequisite:** Ch 821.

Ch 823—ORGANIC REACTION MECHANISMS—3 cr. (3 and 0)

The mechanisms of organic chemical reactions, both aliphatic and aromatic.

Ch 824—FUNDAMENTAL PRINCIPLES OF POLYMER CHEMISTRY—3 cr. (3 and 0)

The organic chemistry of natural and synthetic macromolecules.

Ch 825—CURRENT TOPICS IN ORGANIC CHEMISTRY—1 cr. (1 and 0)

A discussion by faculty and students of recent developments in the field or organic chemistry. (May be taken more than one semester)

Ch 826—CHEMISTRY OF ENZYMES—3 cr. (3 and 0)

An advanced course on the kinetics, mechanism of action, inhibition and general properties of enzymes. **Prerequisite:** Ch 723.

Ch 829—CHEMISTRY AND METABOLISM OF THE CARBOHYDRATES—2 cr. (2 and 0)

A study of modern chemical methods used in carbohydrate chemistry. Also details of intermediary metabolism are studied. **Prerequisite:** 723.

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 631 or its equivalent.

Ch 832—STATES OF MATTER—3 cr. (3 and 0)

Advanced topics in the kinetic theory of gases, crystals and the liquid state as well as solution theory and macromolecules are considered.

Ch 834—STATISTICAL THERMODYNMATICS—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 of rate processes, relation of reaction rates to mechanism, homogeneous and heterogeneous catalysis, experimental methods, chain reactions, diffusion, and the 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 students.

Ch 836—TOPICS IN COLLOID SCIENCE—3 cr. (3 and 0)

A detailed examination of selected applications of thermodynamics, kinetics and intermolecular force theory to colloid, surface and macromolecular phenomena.

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 the applications of this method to chemical problems.

Ch 841—MATHEMATICAL ASPECTS OF CHEMICAL SPECTROSCOPY —3 cr. (3 and 0)

A presentation of the elements of matrix algebra and group theory, and their application to the problems of molecular structure. Emphasis will be placed on the relation of the symmetry properties of molecules to selection rules and factoring of secular equations encountered in electronic, vibrational and NMR spectroscopy. **Prerequisite:** Ch 731.

Ch 851—SEMINAR—0, 1, or 2 cr. (May be taken more than one semester.)

Ch 891—RESEARCH—Credit to be arranged. (May be taken more than one semester.)

Ch 921—HETEROCYCLIC COMPOUNDS—3 cr. (3 and 0)

The organic chemistry of heterocyclic compounds.

Ch 922—STEREOCHEMISTRY—3 cr. (3 and 0)

A study of all phases of stereochemistry as applied to organic compounds.

Ch 923—CHEMISTRY OF NATURAL PRODUCTS—3 cr. (3 and 0)

The chemistry of the isolation, proof of structure and synthesis of naturally occurring organic compounds. **Prerequisite:** Ch 922 or permission of the instructor.

Ch 924—CHEMISTRY OF NATURAL PRODUCTS—3 cr. (3 and 0)

A continuation of Ch 923.

Ch 930—ADVANCED TOPICS IN PHYSICAL CHEMISTRY—3 cr. (3 and 0)

An advanced study of one or more topics selected from any area of physical chemistry. (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.)

CIVIL ENGINEERING

A. E. Schwartz, Department Head

The Department of Civil Engineering offers the Master of Science and Doctor of Philosophy degrees.

Programs of study may be followed which have majors in structures, transportation, materials and soil mechanics. Programs of study in the sanitary engineering area are included under the interdisciplinary curricula of Environmental Systems Engineering, or Water Resources Engineering.

CE 631—INTRODUCTORY SOIL MECHANICS—3 cr. (2 and 3) F, S

CE 699—SIMULATION TECHNIQUES—1 cr. (0 and 3)

CE 712—URBAN TRANSPORTATION PLANNING—3 cr. (3 and 0) F

CE 719—GENERAL PHOTOGRAMMETRY—3 cr. (2 and 3) S

CE 731—APPLIED SOIL MECHANICS—3 cr. (2 and 3) S

CE 734—CONSTRUCTION COSTS AND ESTIMATES—3 cr. (2 and 3) F

CE 735—ENGINEERING PROJECT ANALYSIS—3 cr. (2 and 3) S

CE 743—ENVIRONMENTAL ENGINEERING CHEM. I—2 cr. (2 and 0) S

CE 744—ENVIRONMENTAL ENGINEERING CHEM LAB I—2 cr. (0 and 6)

CE 753—ADVANCED STRUCTURAL ANALYSIS—3 cr. (3 and 0) F

CE 790—SPECIAL PROJECTS—1-3 cr. (1-3 and 0-0)

CE 801—STRUCTURAL ENGINEERING I—3 cr. (3 and 0) F

Analysis and design of tall buildings subjected to wind stresses; torsion of non-circular sections; analysis of space frames; analysis and design of continuous trusses using influence lines; secondary stresses in trusses; introduction to the elastic center method and the column analogy; introduction to the design of arches. **Prerequisite:** CE 453 or equivalent.

CE 802—STRUCTURAL ENGINEERING II—3 cr. (3 and 0) S

Design of concrete structures by ultimate strength theory; design of prestressed concrete structural members. Composite design with concrete and metals. **Prerequisite:** CE 309, CE 404.

CE 804—THEORY AND DESIGN OF THIN PLATES—3 cr. (3 and 0) F

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—THEORY AND DESIGN OF SHELLS—3 cr. (3 and 0) S

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 806—STRUCTURAL VIBRATION—3 cr. (3 and 0) S (odd)

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, earthquate analysis and design, and blast-resistant design. **Prerequisite:** Permission of the instructor.

CE 807—NUMERICAL AND APPROXIMATE METHODS OF STRUCTURAL ANALYSIS—3 cr. (3 and 0) F (even)

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.

CE 810—TRAFFIC ENGINEERING: OPERATIONS—3 cr. (3 and 0) S (odd)

Basic characteristics of motor-vehicle traffic; techniques for making traffic engineering investigations; design and application of traffic control devices; traffic design of parking facilities; traffic laws and ordinances; public relations. **Prerequisite:** CE 311.

CE 811—TRAFFIC ENGINEERING: GEOMETRIC DESIGN—3 cr. (2 and 3) S (even)

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 311.

CE 813—HIGHWAY AND AIRPORT PAVEMENT DESIGN—3 cr. (3 and 0) S (odd)

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; Westerguard analysis for rigid pavements; pavement evaluation methods. **Prerequisites:** CE 311, 331.

CE 819—HIGHWAY RESEARCH—2 to 4 cr.

Independent investigation of some problems in highway engineering.

CE 820—CEMENT AND CONCRETE—3 cr. (2 and 3) S (even)

Chemistry and properties of cements; properties of plastic and hardened concrete; mix design methods.

CE 821—BITUMINOUS PAVING MATERIALS—3 cr. (2 and 3) Summer (even)

Manufacture of asphalt cements, road oils, asphalt emulsions, cutback asphalts, and tars; theory, design and evaluation of asphalt-aggregate mixes. **Prerequisite:** CE 320.

CE 822—AGGREGATES AS CONSTRUCTION MATERIALS—3 cr. (2 and 3) F (even)

Identification and suitability of aggregates for embarkment, drainage, and roadbed structures, concrete mixes, and bituminous mixtures.

CE 823—INELASTIC BEHAVIOR OF ENGINEERING MATERIALS—3 cr. (3 and 0) F (odd)

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.

CE 831—FOUNDATION ENGINEERING—3 cr. (2 and 3) F

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.

CE 832—ADVANCED SOIL MECHANICS—3 cr. (3 and 0) F (even)

Stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, analysis of flexible retaining walls and bulkheads, solution of problems by elastic theory. **Prerequisite:** CE 331.

CE 833—PHYSICAL AND PHYSIO-CHEMICAL PROPERTIES OF SOILS —3 cr. (2 and 3) S (even)

Formation of soils, soil minerals, soil structure, permeability, swelling pressures, pore pressure theory as related to shear strength and consolidation, critical anaylsis of consolidation and shear strength tests, properties of compacted soils. **Prerequisite:** CE 331.

CE 834—AIR PHOTO INTERPRETATION OF SOILS—3 cr. (2 and 3) F (odd)

A brief review of the basic geometry of aerial photographs, characteristic geological and topographic features identifiable from aerial photographs, and site characteristics related to soil profile. Laboratory work includes soil mapping, economic selection of transportation routes and building sites, and location of soil deposits for engineering purposes.

CE 835—DESIGN OF EARTH STRUCTURES—3 cr. (3 and 0) S (odd)

Design and construction of earth and rock fill dams, appurtenances and embankment details, highway embankments, methods of soil stabilitation, compaction, and compaction control, drainage systems for seepage and pressure control. **Prerequisite:** CE 331.

CE 889 and 890—SPECIAL PROBLEMS I AND II—1-3 cr. F, S

Research design problems may be assigned from the fields of structures, soil mechanics, transportation, or materials engineering. Subject matter will vary with interests and experience of student and instructor.

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

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

DAIRY SCIENCE

W. A. King, Department Head

The Dairy Science Department offers the Master of Science degree. The Doctor of Philosophy degree is offered in Animal Physiology and in Nutrition on an interdepartmental basis.

The curriculum in dairy science emphasizes studies of a fundamental and technical nature superimposed upon a core of basic science courses. The student becomes familiar with the production of quality milk and its use as a raw material and its manufacture into many food products. The biological nature of foods makes a background in the chemical and biological sciences highly desirable for advanced study in this field.

Majors in biology, chemistry, chemical engineering, or food technology will find an M. S. degree in Dairy a logical supplement to their undergraduate work, giving them the specialist's training now required in most industries. Because of the basic nature of the curriculum, such a degree would lead to employment opportunities in most food fields. Minors may be taken in zoology, bacteriology, chemistry, industrial management, economics, statistics, physiology, nutrition, genetics, and food technology.

DySc 606—CHEMICAL AND PHYSICAL NATURE OF MILK—3 cr. (2 and 3) S

DySc 607—MARKET MILK—3 cr. (2 and 3) F, 1968 and alternate years.

DySc 702—DAIRY MANUFACTURES—4 cr. (3 and 3) S, 1968 and alternate years.

DySc 703—ANIMAL NUTRITION—3 cr. (3 and 0) F

DySc 704—DAIRY PLANT MANAGEMENT—3 cr. (2 and 3) S, 1969 and alternate years.

DySc 752—DAIRY CATTLE FEEDING AND MANAGEMENT— 3 cr. (2 and 3) S, 1969 and alternate years.

DySc 753—ANIMAL REPRODUCTION—3 cr. (3 and 0) F

DySc 755—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3 F, 1969 and alternate years.

DySc 801—TOPICAL PROBLEMS—1 and 3. cr. F, S, SS.

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

DySc 802—GENETICS OF DAIRY CATTLE IMPROVEMENT—3 cr. (3 and 0) S, 1968 and alternate years.

A study of the inheritance in dairy cattle, with emphasis on milk and butterfat production, methods used in proving sires and dams and in analyzing herds as aids to selection.

DySc 803—PHYSIOLOGY OF REPRODUCTION AND MILK SECRETION —3 cr. (3 and 0) S, 1968 and alternate years.

The influence of the endocrine glands on reproduction and on milk secretion.

DySc 804—ENDOCRINOLOGY—3 cr. (3 and 0) S, 1969 and alternate years.

Includes a study of the anatomy and physiology of the glands of internal secretion. The chemistry of the hormones is considered. Emphasis is placed on the relationship of the endocrine glands to growth, reproduction, and lactation.

DySc 805—NEWER KNOWLEDGE OF DAIRY NUTRITION—3 cr. (3 and 0) F, 1969 and alternate years.

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

DySc 807—FERMENTED DAIRY PRODUCTS—3 cr. (2 and 3) S, 1967 and alternate years.

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

DySc 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.

DySc 809—RUMEN METABOLISM—3 cr. (2 and 3) F, 1968 and alternate years.

Biochemical physiological and microbiological functions in the rumen. Consideration is given to ontogeny and structural anatomy. The laboratory emphasizes in vitro methodology used in studying the microbial metabolism of dietary constituents.

DySc 891—RESEARCH—Credit to be arranged, F, S, SS

ECONOMICS

H. J. Wheeler, Chairman

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 including a course in intermediate price theory, a reading knowledge of a modern foreign language, and a comprehension of statistics. The statistics requirement may be met by satisfactory grades in undergraduate courses in statistics, by a special examination, or by graduate courses in statistics taken as part of the student's degree program.

Certain courses in agricultural economics, experimental statistics, and industrial management may be taken as part of the major.

Econ 703—DEVELOPMENT OF ECONOMIC THOUGHT—3 cr. (3 and 0) FS

Econ 704—COMPARATIVE ECONOMIC SYSTEMS—3 cr. (3 and 0)

Econ 707—NATIONAL INCOME AND EMPLOYMENT ANALYSIS—3 cr. (3 and 0) FS

Econ 710—ECONOMIC DEVELOPMENT—3 cr. (3 and 0) S

Econ 712—INTERNATIONAL TRADE—3 cr. (3 and 0)

Econ 716—DEVELOPMENT OF THE MODERN ECONOMY—3 cr. (3 and 0)

Econ 720—ECONOMICS OF TAXATION—3 cr. (3 and 0) S

Econ 722—MONETARY ECONOMIC AND POLICY—3 cr. (3 and 0)

Econ 800—ADVANCED ECONOMIC ANALYSIS—3 cr. (3 and 0)

Econ 810—SEMINAR IN ECONOMIC ANALYSIS— 3 cr. (3 and 0)

Topics chosen to give the students experience in the analysis of actual economic problems and to develop the student's proficiency in economic analysis, research, and writing.

Econ 811—SEMINAR IN LABOR ECONOMICS—3 cr. (3 and 0)

Econ 812—SEMINAR IN THE DEVELOPMENT OF ECONOMIC THOUGHT—3 cr. (3 and 0)

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 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 891—RESEARCH—Credit to be arranged.

Econ 900—SEMINAR IN ADVANCED ECONOMIC THEORY—3 cr. (3 and 0)

EDUCATION

H. F. Landrith, Dean of Education
H. M. Cox, English Adviser
R. S. Lambert, History and Government Adviser
J. L. Flatt, Mathematics Adviser
J. H. Hobson, Science Adviser

The School of Education offers the Master of Education degree with subject specialties in English, history and government, mathematics, the natural sciences, or personnel services.

Students seeking admission to the M. Ed. program should have:

a. A valid teacher's certificate; or

b. At least twelve hours in professional education.

Ed 701—THE COMMUNITY COLLEGE—3 cr. (3 and 0)

Ed 705—PRINCIPLES OF GUIDANCE—3 cr. (3 and 0)

Principles, procedures, and policies of the guidance services. For all personnel workers.

Ed 706—HISTORY AND PHILOSOPHY OF EDUCATION—3 cr. (3 and 0)

Ed 760—CURRICULUM DEVELOPMENT IN THE ELEMENTARY SCHOOL—3 cr. (3 and 0)

Ed 771—THE EXCEPTIONAL CHILD—3 cr. (3 and 0) F

Survey of areas of exceptionality including handicapped and gifted children; nature, cause, and treatment of difficulties; educational problems.

Ed 772—PSYCHOLOGY OF MENTAL RETARDATION—3 cr. (3 and 0) F

Psychological aspects of mental retardation; learning, motivation, personality development.

Ed 773—TEACHING THE MENTALLY RETARDED—3 cr. (3 and 0) F

Study, selection, and preparation of suitable curricular materials; methods of teaching retarded children within the pre-adolescent and adolescent range. **Prerequisite:** Ed 772 or equivalent.

Ed 794—SCHOOL AND COMMUNITY RELATIONSHIPS—3 cr. (3 and 0)

Ed 797—AUDIO VISUAL AIDS IN EDUCATION—3 cr. (3 and 0)

Ed 798—TEACHING SECONDARY SCHOOL READING—3 cr. (3 and 0)

Ed 801—SEMINAR IN HUMAN GROWTH AND DEVELOPMENT—3 cr. (3 and 0) S

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 IN TEACHING—3 cr. (3 and 0) F

The principles and practices involved in promoting effective learning.

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.

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.). **Prerequisites:** Ed 705.

Ed 811—PUBLIC SCHOOL ADMINISTRATION (FINANCE)—3 cr. (3 and 0)

A study of sound principles and suitable procedures relating to school administration and finance.

Ed 813—EDUCATIONAL AND VOCATIONAL INFORMATIONAL SERVICE AND PLACEMENT—3 cr. (3 and 0)

Gathering, interpreting 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.

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.

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.

Ed 817—CLINICAL STUDIES IN COUNSELING AND GUIDANCE— 1 to 3 cr.

Intensive case studies of those with psychological and educational difficulties. May be taken more than one semester.

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 evaluation 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 861—ORGANIZATION AND SUPERVISION OF READING—3 cr. (3 and 0) F

Detailed study of supervisory problems concerned with the planning of reading programs, analysis of methods and materials of teaching, and evaluation of reading programs.

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.

Ed 863—PRACTICUM IN READING—3 cr. (2 and 2)

Supervised practicum emphasizing diagnostic and remedial work with readers in the public schools.

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 in Science Teaching.

Biol 750—BIOLOGY FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Biol 800—PRINCIPLES OF BIOLOGY—3 cr. (2 and 3)

Expressly designed for high school teachers. Lectures, demonstrations, and practical laboratory exercises are presented on an advanced level. Particular attention is given to the Vertebrata and the higher plant Phyla.

Ch 750—REVIEW OF GENERAL CHEMISTRY I—3 cr. (3 and 0)

Ch 850—REVIEW OF GENERAL CHEMISTRY II—3 cr. (2 and 3)

Geol 800—EARTH SCIENCE I—3 cr. (2 and 3)

A study of the physics and chemistry of the earth and earth processes. The petrochemical cycle forms the nucleus about which the course is built. Theoretical considerations of the association of minerals and rocks which compose the earth's crust, their origins and transformations are emphasized, along with geological processes by which changes are produced on or in the earth. Common minerals and rocks are studied in the laboratory, and geomorphic features are interpreted in terms of geological processes from topographic maps and during field trips.

Geol 850—EARTH SCIENCE II—3 cr. (2 and 3)

A study of the earth, its origin and subsequent developments. The evolution of continents and ocean basins as well as the beginnings and development of life on earth in all its forms are considered. Laboratory instruction in the recognition of plants and animals which have left their record as fossils in the rocks of the earth's crust is planned. Emphasis in the laboratory is also placed upon geologic structures and the interpretation of geologic maps, and these principles demonstrated through numerous field excursions.

Courses applicable to the Master of Education degree in English, history, and mathematics are found under these headings.

ELECTRICAL ENGINEERING

Lyle C. Wilcox, Department Head

The Department of Electrical Engineering offers the Master of Science and Doctor of Philosophy degrees.

Graduate students in Electrical Engineering can direct their program towards several areas. The traditional fields of networks, controls, communications, 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. Other courses in these areas can be found under Bioengineering or Mechanical Engineering listings.

EE 703—ENERGY CONVERSION—3 cr. (3 and 0)

EE 709—ELECTRICAL ENGINEERING LABORATORY V—1 cr. (0 and 2)

EE 710—FEEDBACK CONTROL SYSTEMS—3 cr. (3 and 0)

EE 719—ELECTRICAL MACHINERY LABORATORY—1 cr. (0 and 2)

EE 720—POWER SYSTEM ANALYSIS—3 cr. (3 and 0)

EE 721—ELECTRICAL MACHINERY—3 cr. (3 and 0)

EE 725—INTRODUCTION TO THEORY AND DESIGN OF DIGITAL SYSTEMS—3 cr. (3 and 0)

EE 728—COMMUNICATIONS THEORY—3 cr. (3 and 0)

EE 731—ELECTRONICS III—3 cr. (3 and 0)

EE 733—ELECTRONICS III LABORATORY—1 cr. (0 and 2)

EE 736—RADIATION AND WAVE PROPAGATION—3 cr. (3 and 0)

EE 750—ANALOG, DIGITAL, AND HYBRID COMPUTATION—3 cr. (3 and 0)

EE 801—ANALYSIS OF LINEAR SYSTEMS I—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.

EE 802—ANALYSIS OF LINEAR SYSTEMS II—3 cr. (3 and 0)

An extension of the topics of EE 801. The study of multi-terminal 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:** EE 801.

EE 803—SEMINAR—1 cr. (1 and 0)

Student presentations and group discussions dealing with current research activities.

EE 804—NETWORK SYNTHESIS I—3 cr. (3 and 0)

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:** EE 801.

EE 805—NETWORK SYNTESIS II—3 cr. (3 and 0)

Continuation of EE 804. Realization of two-port transfer function with an emphasis on LC and RC networks. The approximation problem. Extensions to active network synthesis. **Prerequisite:** EE 804.

EE 806—NONLINEAR NETWORKS AND SYSTEMS I—3 cr. (3 and 0)

Theoretical coverage of analytical methods used to solve complex nonlinear problems arising in engineering.

EE 807—POWER SYSTEM STABILITY—3 cr. (3 and 0)

Problems related to the interconnection of power systems. Division of load, maximum feasible lengths of interconnecting lines, synchronization and related topics.

EE 810—MODERN CONTROL THEORY I—3 cr. (3 and 0)

A detailed treatment of time domain (state space) analysis and design methods. Lyapunov's methods, discrete-time systems. Introduction to nonlinear problems. Computers frequently used to solve practical problems.

EE 811—MODERN CONTROL THEORY II—3 cr. (3 and 0)

Concept of observability. Optimum control theory; the calculus of variations, principle of optimality. Hamilton-Jacob's equation and Pontryagin's principle. The computations of optimal control with gradient methods and dynamic programming.

EE 812—SAMPLED DATA SYSTEMS—3 cr. (3 and 0)

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 augument modern control theory methods. Stability, compensation, and performance are considered.

EE 814—NONLINEAR AUTOMATIC 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. Statistical design principles and sampled data systems are studied. Both graphical and analytical procedures are used; these include the describing function, the method of harmonic balance, and the phase plane. The phase plane is used in giving insight to Lyapunov's second method of stability analysis.

EE 815—RANDOM DATA MEASUREMENTS AND ANALYSIS—3 cr. (3 and 0)

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.

EE 820—COMMUNICATIONS I—3 cr. (3 and 0)

A study of modern communications systems with emphasis on modulation and methods of taking into account the effects of noise on various systems.

EE 821—COMMUNICATIONS II—3 cr. (3 and 0)

Continuation of EE 820.

EE 822—INFORMATION THEORY—3 cr. (3 and 0)

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 can be applied to communications.

EE 823—ELECTRONIC CIRCUITS—3 cr. (3 and 0)

Applications of recently developed electronic elements in amplifiers, switching circuits and other modern devices.

EE 824—ELECTRONIC CIRCUITS LABORATORY—1 cr. (0 and 2)

A laboratory course designed to accompany EE 823.

EE 825—SOLID-STATE ELECTRONICS—3 cr. (3 and 0)

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 amplifiers; e.g., the traveling-wave tube, tunnel diode, masers, and parametric amplifiers.

EE 826—INTEGRATED CIRCUIT DESIGN—3 cr. (3 and 0)

The analysis and synthesis methods for integrated and active networks are studied. Stress is placed upon the fundamental and state-of-the-art limitations on their capabilities and upon the nature of the design compromises that are required.

EE 827—INSTRUMENTATION AND MEASUREMENTS—3 cr. (3 and 0)

Instrumentation capable of measuring physical parameters, including spectrophotometry, spectroscopy, mass spectrometry, gas chromatography, NMR and EPR, will be considered. Electronic components such as detectors, pulse height analyzers, and data processing and telemetry equipment will also be covered.

EE 828—PULSE TECHNIQUES—3 cr. (3 and 0)

Analysis of basic circuits applicable to pulse-modulation communication systems, high-speed time measurements and cathode-ray instrumentation. Principles involved in electronic instruments for nuclear measurements, nuclear reactor control and other applications involving pulsed electrical energy are considered.

EE 829—PULSE TECHNIQUES LABORATORY—1 cr. (0 and 2)

A laboratory course designed to accompany EE 828.

EE 830—ELECTROMAGNETICS I—3 cr. (3 and 0)

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:** Approval of department.

EE 831—ELECTROMAGNETICS II—3 cr. (3 and 0)

Time dependent fields, plane waves, guided transmission systems, resonators, radiation, antennas, and interaction of charged particles with fields. **Prerequisite:** EE 830.

EE 832—ANTENNA THEORY I— 3 cr. (3 and 0)

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:** EE 831.

EE 833—ANTENNA THEORY II—3 cr. (3 and 0)

Continuation of EE 832 with emphasis on microwave antennas, slot antennas, slot antenna arrays, horn antennas, and antenna pattern theory. **Prerequisite:** EE 832.

EE 834—MICROWAVE ELECTRONICS—3 cr. (3 and 0)

Interaction of charged particles with electromagnetic fields, fundamental principles of microwave devices, including klystrons, magnetrons, traveling wave tubes and paticle accelerators. Semiconductor devices at microwave frequencies. **Prerequisite:** EE 831.

EE 836—OPTICAL ELECTROMAGNETICS AND QUANTUM ELECTRONICS—3 cr. (3 and 0)

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.

EE 850—COMPUTATION AND SIMULATION—3 cr. (3 and 0)

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.

EE 851—THEORY AND DESIGN OF DIGITAL-ANALOG MACHINES—3 cr. (3 and 0)

Theory and design of general purposes, special purpose, hybrid and sequential machines. Particular emphasis is placed on practical applications.

EE 852—DIGITAL COMPUTERS AND INFORMATION PROCESSING—3 cr. (3 and 0)

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:** A student is expected to have a prior knowledge of programming.

EE 860—ENGINEERING APPLICATIONS OF OPTIMIZATION—3 cr. (3 and 0)

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.

EE 861—FOUNDATIONS AND METHODOLOGY OF SYSTEMS ENGINEERING—3 cr. (3 and 0)

Definition of Systems Engineering, fundamental concepts of Systems Engineering. (Subsystems, environments for systems, microscopic aspects of systems.) Problem definitions (technical and economic environment). Theory of value and needs. Decision making.

EE 863—ADVANCED PHYSICAL SYSTEMS ANALYSIS I—3 cr. (3 and 0)

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. Same course as ME 863.

EE 864—ADVANCED PHYSICAL SYSTEMS ANALYSIS II—3 cr. (3 and 0)

Digital and analog computer solutions to linear and nonlinear systems, continuous and discrete. Systems with discrete and continuous subsystems. Optimizing processes; separable programming, and dynamic programing. Adaptive systems. Same course as ME 864.

EE 870—BIOSYSTEMS ANALYSIS—3 cr. (3 and 0)

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.

EE 890—SELECTED TOPICS IN ELECTRICAL ENGINERING—3 cr. (3 and 0)

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 the 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.

EE 891—RESEARCH—Credit to be arranged.

BioEngr 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.

BioEngr 847—ELEMENTS OF BIOENGINEERING II—3 cr. (3 and 0)

Cardiovascular system; physiology of blood, the heart, vascular bed and organ blood flow. Hemodynamics, properties of blood as a fluid, fluid flow equations, turbulence, pulse propogation. Electrocardiography, pacemakers, blood pressure and flow instrumentation. Respiration; dynamics of breathing, gas exchange, regulation. Digestive system and temperature regulation.

ENGINEERING MANAGEMENT

C. H. Whitehurst, Jr., Chairman

Courses are offered leading to the Doctor of Philisophy degree.

The Department of Industrial Management offers the Ph.D. in engineering management in cooperation with the College of Engineering.

Although entering students are accepted from diverse undergraduate backgrounds, each is required as a prerequisite to full graduate standing to have completed or to schedule in his first semester, basic courses in economics, accounting, statistics and calculus. In addition, students must have completed or schedule during the first year of enrollment, one or more courses in engineering communication and design.

The purpose of this degree is to develop a high level "manager-scholar" capable of applying the most advanced concepts and methods of management science, administrative theory and research techniques to engineering and scientific projects and enterprises. The curriculum also provides an unexcelled background for those interested in pursuing a university teaching career in the fields of industrial and engineering management.

EMgt 910—SEMINAR IN PRODUCTION MANAGEMENT—2 cr. (2 and 0) S

A seminar covering selected topics associated with current developments in areas relating to production management through readings, case studies and field trips. **Prerequisite:** Permission of instructor.

EMgt 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.

EMgt 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:** IM 802 and permission of instructor.

EMgt 913—SYSTEMS-ANALYSIS—3 cr. (3 and 0)

The basic premise of systems analysis is that meaningful similarities exist in the way physical systems and business systems function. Specifically considered is the logical arrangement of a business into an integrated system of subsystems. Extensively treated are fundamentals of system design, the utilization of electronic computers and the evaluation of specific equipment systems.

EMgt 991—DOCTORAL RESEARCH—Credit to be arranged.

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.

ENGINEERING MECHANICS

R. W. Moorman, Department Head

The Department of Engineering Mechanics offers 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 selection 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 720—HYDRAULIC ENGINEERING—3 cr. (3 and 0)

EM 750—MECHANICAL VIBRATIONS—3 cr. (3 and 0)

EM 770—EXPERIMENTAL STRESS ANALYSIS—3 cr. (2 and 3)

EM 801—EXPERIMENTAL STRESS ANALYSIS—3 cr. (2 and 3)

Experimental analysis of stress fields and determination of maximum principal stresses in deformable bodies. Emphasis is on the theoretical consideration in the reduction of data as well as the obtaining of data. Methods studied include photoelasticity, electrical resistance strain gauges, brittle lacquer, and birefringent coatings. Also required is the conduct of an individual investigation and the preparation of a report of findings. **Prerequisite:** 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:** EM 201, 202, 304; Math 208 or 306.

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 phenomena. **Prerequisites:** consent of instructor.

EM 825—ADVANCED MECHANICS OF MATERIALS—3 cr. (3 and 0)

Covers the general state of stress and strain, theories of failure, shear center, unsymmetrical bending, curved flexural members, and other selected topics, such as torsion of non-circular sections, stress concentrations, thick cylinders, contact stresses, energy methods, flat plates, elastic stability. **Prerequisite:** EM 304.

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 or 306 and consent of instructor.

EM 829—ENERGY METHODS AND VARIATIONAL PRINCIPLES—3 cr. (3 and 0)

Theory of variational energy principles including the principal 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 non-linear elastic frames, general elasticity theory, theories of plates and shells, and the theories of buckling and vibrations. **Prerequisites:** EM 831 and consent of instructor.

EM 831—THEORY OF ELASTICITY I—3 cr. (3 and 0)

The linear theory of homogeneous, isotropic, elastic media. Analysis of stress and strain. Tensor-development of stress-strain laws and basic equations. Two-dimensional problems. Energy and variational methods. **Prerequisites:** EM 304, Math 208 or 306.

EM 832—THEORY OF ELASTICITY II—3 cr. (3 and 0)

Continuation of Theory of Elasticity I. Complex variable methods of solutions. Three-dimensional problems including torsion, bending stress concentration, thermal stress, stress wave propagation. Approximate solutions of elasticity problems. **Prerequisite:** EM 831.

EM 834—THEORY OF ELASTIC STABILITY—3 cr. (3 and 0)

Theoretical analysis of the elastic stability of various important components in engineering design. Emphasis is placed on determining critical loads causing elastic buckling of beam-columns, rings, arches, curved bars, plates and shells. Special attention is given to torsional buckling of thin-walled members, lateral buckling of beams and inelastic buckling of bars. **Prerequisite:** EM 831, or consent of instructor.

EM 845—INTERMEDIATE DYNAMICS—3 cr. (3 and 0)

Kinematics and dynamics of particles and rigid bodies. Lagrange and Hamilton's formulations 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. **Prerequisite:** EM 202 or consent of instructor.

EM 851—FLUID DYNAMICS—3 Credits (3 and 0)

The basic equations for multi-dimensional flowfields are rigorously derived. Analytical techniques are developed for solving some of the more advanced problems of ideal and viscous flow involving both the steady and unsteady state. **Prerequisite:** Consent of instructor.

EM 852—THEORY OF IDEAL FLUID FLOW—3 cr. (3 and 0)

A study of the principles of fluid dynamics with primary emphasis on the fundamentals of inviscid fluid flow problems. Discussion of the kinematics of fluid flow; the equations of motion, continuity, and state; and the significance of compressibility. Concepts of the velocity potential, stream function, and irrotationality. Practical solutions of two and three dimensional flow. **Prerequisite:** EM 320, or consent of instructor.

EM 853—THEORY OF VISCOUS FLUID FLOW—3 cr. (3 and 0)

A continuation of EM 852. The differential equations of motion, continuity, and state of real fluids. Some exact and approximate solutions of these equations. Discussion of laminar and turbulent flow and the theories of turbulence. **Prerequisite:** EM 852.

EM 856—FLOW IN OPEN CHANNELS—3 cr. (3 and 0)

Consideration of open channel problems; uniform and varied flow, the hydraulic jump, design criteria for prismatic channels and transitions, and special methods of flood routing. **Prerequisite:** EM 320.

EM 889, 890—SEMINAR—0 or 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)

A general theory of the inelastic behavior of materials is developed. Specific topics included are: stress-strain relations under plastic conditions, the prediction of initial yielding and rupture, the ideal plastic, and work hardening. The theoretical findings are correlated with experimental data. **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. (May be taken more than one semester.)

ENGLISH

H. M. Cox, Department Head

The English Department offers the Master of Arts degree.

A student desiring to pursue graduate study with a major in English should present at least twelve hours of undergraduate credit in English above the sophomore level, including a course each in the English language, Shakespeare, and American literature. A student seeking the Master of Education degree with emphasis in English must present at least six hours of undergraduate credit in English above the sophomore level. A student who does not meet these requirements may seek admission as a provisional graduate student.

In addition to the requirements of the Graduate School, candidates for the Master of Arts degree in English must satisfy the following departmental requirements:

1. A reading knowledge of an approved foreign language.
2. Demonstrated proficiency in composition.
3. Completion of Engl 890 (Introduction to Research)

Engl 702—THE ENGLISH LANGUAGE—3 cr. (3 and 0) F, S

Engl 705—SHAKESPEARE—3 cr. (3 and 0) F

Engl 706—SHAKESPEARE—3 cr. (3 and 0) S

Engl 709—CHAUCER—3 cr. (3 and 0) S

Engl 715—INTRODUCTION TO DRAMA—3 cr. (3 and 0) F

Engl 716—INTRODUCTION TO DRAMA—3 cr. (3 and 0) S

Engl 723—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0) F

Engl 724—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0) S

Engl 725—THE ROMANTIC REVIVAL—3 cr. (3 and 0) F

Engl 727—VICTORIAN POETRY AND PROSE—3 cr. (3 and 0) S

Engl 731—THE RESTORATION AND EIGHTEENTH CENTURY—3 cr. (3 and 0) S

Engl 735—SOUTHERN LITERATURE—3 cr. (3 and 0) F

Engl 736—MILTON AND HIS AGE—3 cr. (3 and 0) S

Engl 737—THE ENGLISH NOVEL—3 cr. (3 and 0) F

Engl 738—CONTEMPORARY POETRY—3 cr. (3 and 0) F

Engl 739—CONTEMPORARY FICTION—3 cr. (3 and 0) S

Engl 740—LITERARY CRITICISM—3 cr. (3 and 0) S

Engl 741—WORLD LITERATURE—3 cr. (3 and 0) F

Engl 742—WORLD LITERATURE—3 cr. (3 and 0) S

Engl 743—17th CENTURY POETRY AND PROSE—3 cr. (3 and 0)

Substitute for the present English 803 and 805 the following:

Engl 803—SEMINAR—3 cr. (3 and 0). Subject area changes each semester.

Engl 805—SEMINAR—3 cr. (3 and 0). Subject area changes each semester.

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.

ENTOMOLOGY

J. H. Cochran, Department Head

The Master of Science and Doctor of Philosophy degrees are offered.

Ent 605—ECONOMIC ENTOMOLOGY—3 cr. (2 and 3) F '67 and alternate years.

Ent 606—ECONOMIC ENTOMOLOGY—3 cr. (2 and 3) S '68 and alternate years.

Ent 705—INSECT MORPHOLOGY—4 cr. (3 and 3) F

Ent 708—GENERAL AND TAXONOMIC ENTOMOLOGY—5 cr. (3 and 6) S '67 and alternate years.

Ent 755—MEDICAL AND VETERINARY ENTOMOLOGY—3 cr. (2 and 3) S

Ent 761—SEMINAR—1 cr. (1 and 0) F

Ent 762—SEMINAR 1 cr. (1 and 0) S

Ent 768—INTRODUCTION TO RESEARCH—2 cr. (1 and 3) S

Ent 808—TAXONOMY OF IMMATURE INSECTS—3 cr. (1 and 6) F '67 and alternate years.

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

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

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

Ent 860—PRINCIPLES OF INSECT CONTROL—3 cr. (3 and 0) F '68 and alternate years.

The mechanical, physical, cultural, biological, chemical and legal aspects of insect control.

Ent 861—INSECT TOXICOLOGY—3 cr. (2 and 3) S '67 and alternate years.

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

Ent 862—INSECT PHYSIOLOGY—3 cr. (2 and3) F '68 and alternate years.

The physiology of nutrition, digestion, respiration, excretion, nervous and hormonal systems. **Prerequisite:** Organic Chemistry.

Ent 863—SPECIAL PROBLEMS IN ENTOMOLOGY—3-6 cr. F, S,S S

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 890—RESEARCH TECHNIQUES IN AGRICULTURE—3 cr. (2 and 3)

Designed to give the student a comprehensive understanding of research procedures and techniques in solving problems in the various fields of

agriculture. Special attention will be given to the design of experiments, interpretation of results and report writing. The student will be expected to prepare a written report on a selected problem.

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

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

ENVIRONMENTAL HEALTH

Degrees are not awarded in Environmental Health. 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 and Zoology, Nutrition, Physiology, and Water Resources Engineering.

EnH 871—ENVIRONMENTAL HEALTH—3 cr. (3 and 0)

The interactions of man with his environment will be surveyed. Detrimental health factors such as pathogens, insect pests, ionizing radiation, and toxic chemical residues acting through air, water, food, and solids will be emphasized. Methods of detection and control of these health hazards will be included. **Prerequisite:** Graduate standing.

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

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

EnH 894—ENVIRONMENTAL HEALTH SEMINAR II—1 cr. (1 and 0)

A continuation of EnH 893. **Prerequisite:** Graduate standing.

ExSt 804—SAMPLING—3 cr. (3 and 0) S

The principles of scientific sampling; finite population sampling; simple random, stratified, multistage, and systematic sampling; optimum allocation; methods of obtaining and reporting survey information. Sampling as related to environment and natural resources as well as economic and social problems will be considered. **Prerequisite:** ExSt 801.

ENVIRONMENTAL SYSTEMS ENGINEERING

J. F. Andrews, Program Director

The Master of Science and Doctor of Philosophy degrees are offered.

Environmental Systems Engineering is an interdisciplinary field concerned with the engineering aspects of the understanding, prediction, and control of the environment of living organisms, both plant and animal.

Mathematics and the physical sciences, in which engineers have strong undergraduate backgrounds, provide the basic tools with which to describe quantitatively environmental systems. Certain biological competencies are also required in order to properly apply engineering to environments of living systems. Enrollment is open to students having degrees in engineering or science. With the approval of his adviser, a Master's candidate in certain specialized areas may select a non-thesis option.

The M.S. and Ph.D. programs of study will be planned to augment the student's previous engineering or science background. The M.S. student may select a minor in the basic sciences or in another field of engineering. The Ph.D. student will select at least one minor from the fields of mathematics, chemistry, physics, or biology. Generally, a student with a science background will take a number of engineering courses, and a student with an engineering background will take several science courses. The major field of study will be interdisciplinary in nature, consisting of existing courses in engineering and the basic sciences. Core courses in air, water, and plant and animal environments are also available.

CE 743—ENVIRONMENTAL ENGR. CHEM. I—2 cr. (2 and 0)

Theory and control of the chemical processes employed in treatment of waste water. The principles of analytical and physical chemistry are applied to problems in environmental engineering.

CE 744—ENVIRONMENTAL ENGR. CHEM. LAB. I—2 cr. (0 and 6)

Theoretical relationships considered in CE 443 are applied to actual problems in analysis and control of water and waste treatment processes. **Prequisite or concurrent:** CE 443.

ESE 842—SANITARY ENGINEERING PROCESSES—3 cr. (3 and 0) S

Theory and design of chemical and biological processes employed in sanitary engineering. (CE 842)

ESE 843—UNIT OPERATIONS OF SANITARY ENGINEERING—3 cr. (3 and 0) F

Theory and design of unit operations employed in sanitary engineering treatment processes. (CE 843)

ESE 846—POLLUTION OF THE AQUATIC ENVIRONMENT—3 cr. (2 and 3) S

A study of the effects of pollution resulting from domestic and industrial wastes upon the physical, chemical, and biological characteristics of natural waters. (CE 843)

ESE 848—ENVIRONMENTAL ENGINEERING CHEM. II—2 cr. (2 and 0)

Application of the principles of organic and biochemistry to the problems of environmental control. **Prerequisite:** CE 443 or permission of the instructor. (CE 848)

ESE 849—ENVIRONMENTAL ENGR. CHEM. LAB. II—2 cr. (1 and 3)

Theoretical principles developed in ESE 848 are applied to laboratory measurement and control of environmental engineering systems. Instrumental analysis and advanced analytical techniques are stressed. **Prerequisite:** ESE 848 or permission of the instructor. (CE 849)

ESE 850—ENVIRONMENTAL ENGR. MICROBIOLOGY—3 cr. (2 and 3)

The application of principles of microbial physiology to environmental engineering systems. Advanced techniques will be stressed in the laboratory. **Prerequisite:** Bact 301. (CE 850)

ESE 851—UNIT OPERATIONS & PROCESSES LABORATORY—2 cr. (1 and 3)

Laboratory exercises in solids-liquids separations, ion-exchange, electrogialysis, and biological processes. Stress will be placed on the relation between theory and experimental results. (CE 851)

ESE 852—WATER AND WASTE TREATMENT SYSTEMS—2 cr. (1 and 3) SS

Integration of the unit operations and processes involved in water and waste treatment into treatment systems. Emphasis will be placed on funcional and hydraulic design using analog and digital computers.

ESE 853—ADVANCED UNIT OPERATIONS AND PROCESSES—3 cr. (2 and 3) S

An advanced treatment of several unit operations and processes employed in water and waste treatment. The course is designed to give the student more depth in such areas as mixing, thickening, flotation, drying, combustion, water stabilization, electrodianalysis, ion exchange, composting, and dynamics of biological processes.

ESE 854—WATER AND WASTE TRANSPORT SYSTEMS—3 cr. (3 and 0) F

Theory and design of both continuous and discrete transport systems for fluids and solids. Application of systems analysis and operations research techniques will be stressed.

ESE 855—SOLID WASTES—3 cr. (3 and 0) F

Study of the extent and characteristics of the solid wastes problem, the general state of the art, and environmental interfaces and effects.

ESE 861—ENVIRONMENTAL SYSTEMS ENGINEERING SEMINAR—0 cr. (1 and 0) S

A discussion of current advances and research developments in the area of Environmental Systems Engineering. Off-campus speakers, students, and faculty will participate.

ESE 873—RADIOLOGICAL HEALTH—3 cr. (2 and 3)

Sources of ionizing radiation and radioisotopes in man's environment will be illustrated, and methods of protection from these sources will be

discussed. The engineering aspects of detection, shielding, and disposal of radioactive materials will be studied. **Prerequisite:** Ch 491 or the equivalent.

ESE 874—RADIOLOGICAL HEALTH ENGINEERING—3 cr. (2 and 3)

This is a continuation of Radiological Health with a more detailed study of radiation protection from air, water, food, and solids through engineering procedures. This course is offered primarily for engineering students **Prerequisite:** ESE 873 or the equivalent.

ESE 881—SPECIAL PROBLEMS—1-4 cr. FS

Problems are selected in the field of Environmental Eystems Engineering to meet the interests and experience of student and instructor. (CE 889) **Prerequisite:** AgE 873 or the equivalent.

ESE 883—SELECTED TOPICS I—3 cr. (3 and 0) S

A comprehensive study of any topic in the field of Environmental Engineering that is not covered in other courses. Emphasis will be placed on current developments in Environmental Engineering. The topics covered are expected to vary from year to year to keep pace with current developments.

ESE 884—SELECTED TOPICS II—3 cr. (3 and 0) S

A comprehensive study of any topic in the field of Environmental Engineering that is not covered in other courses. Emphasis will be placed on current developments in Environmental Engineering. The topics covered are expected to vary from year to year to keep pace with current developments.

ESE 891—RESEARCH—1-6 cr.

May be taken more than one semester. (CE 891)

ESE 991—DOCTORAL RESEARCH—1-18 cr.

May be taken more than one semester. (CE 991)

EXPERIMENTAL STATISTICS

W. P. Byrd, Chairman

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.

ExSt 701—INTRODUCTORY STATISTICS—3 cr. (2 and 3) FS

ExSt 762—STATISTICS APPLIED TO ECONOMICS—3 cr. (3 and 0) S

ExSt 801—STATISTICAL METHODS—4 cr. (3 and 3) FS

Role of statistics in research. Statistical inference, concepts, estimation, test of significance, principles of scientific investigation, analysis of variance including multiple comparison techniques, basic designs, simple and multiple linear regression and correlation, mean square expectations, and variance components analysis. **Prerequisite:** Permission of instructor.

ExSt 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:** ExSt 801.

ExSt 805—DESIGN AND ANALYSIS OF EXPERIMENTS—3 cr. (3 and 0) S

Principles of design and analysis of experiments, review of basic designs; individual degrees of freedom, orthogonality and responses in the analysis of variance; covariance analysis; factorials, split-plot arrangements, confounding incomplete block designs; transformations; non-parametric procedures; introduction to least squares methods for analysis of experiments, and response surface methodology. **Prerequisite:** ExSt 801.

FOOD SCIENCE

W. P. Williams, Department Head

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 603—ELEMENTS OF FOOD SCIENCE—3 cr. (3 and 0) F, '69 and alternate years.

Fd Sc 604—FOOD PROCESSING—3 cr. (1 and 6) S, '68 and alternate years.

Fd Sc 701—ELEMENTS OF FOOD SCIENCE—3 cr. (3 and 0) F, '68 and alternate years.

Fd Sc 703—BIOCHEMISTRY OF FOODS—3 cr. (2 and 3) F, '69 and alternate years.

Fd Sc 704—FOOD PROCESSING—3 cr. (1 and 6) S, '69 and alternate years.

FORESTRY

K. Lehotsky, Department Head

The Department of Forestry offers the Master of Science Degree.

The candidate for a Master of Science Degree in Forestry should hold a Bachelor of Forestry Degree from a forestry school accredited by the Society of American Foresters. Without such a degree additional course work may be required of the candidate by his departmental advisors and graduate committee to insure adequate preparation in his specialty field.

For 602—DENDROMETRY—3 cr. (2 and 3) S

For 604—FOREST ECONOMICS—3 cr. (3 and 0) S

For 606—WOOD AND WOOD FIBER IDENTIFICATION—1 cr. (0 and 3) S

For 607—ELEMENTS OF FORESTRY—3 cr. (2 and 3) F, S

For 608—AERIAL PHOTOGRAPHS IN FORESTRY—3 cr. (2 and 3) S

For 610—SILVICULTURE—4 cr. (3 and 3) S

For 701—LOGGING AND MILLING—4 cr. (2 and 6) F

For 704—MANAGEMENT PLANS—1 cr. (0 and 3) S

For 706—FOREST POLICY AND ADMINISTRATION—2 cr. (2 and 0) S

For 707—FOREST REGULATION—4 cr. (3 and 3) F

For 708—FOREST VALUATION—3 cr. (3 and 0) S

For 710—FOREST PRODUCTS—3 cr. (2 and 3) S

For 712—FOREST PROTECTION—2 cr. (2 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—DENDROMETRY—3 cr. (2 and 3) S

A continuation of For 302 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:** ExSt 701, For 302 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:** ExSt 401, For 302 or permission of instructor.

For 804—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, 708, or permission of instructor.

For 805—COST STUDIES IN HARVESTING AND PROCESSING—3 cr. (2 and 3) F

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. **Prerequisites:** For 701, or permission of instructor.

For 806—MULTIPLE USE MANAGEMENT—3 cr. (3 and 0) F

A study of the interplay of economics, public relations and political expediency and forest ecosystem in deciding the order of preference of various possible land uses, particularly with reference to privately owned forest land. **Prerequisites:** For 707, 708, or permission of instructor.

For 807—SPECIAL PROBLEMS IN FORESTRY— (Credit to be arranged) F, S, SS

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

GEOLOGY

P. K. Birkhead, Chairman

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

Geol 606—MINERALOGY—3 cr. (2 and 3)

Geol 607—OPTICAL MINERALOGY—3 cr. (2 and 3)

Geol 609—PETROLOGY—3 cr. (2 and 3)

Geol 611—STRATIGRAPHY AND SEDIMENTATION—3 cr. (3 and 0)

Geol 702—STRUCTURAL GEOLOGY—3 cr. (3 and 0)

Geol 703—INVERTEBRATE PALEONTOLOGY—3 cr. (2 and 3)

Geol 704—ECONOMIC GEOLOGY—3 cr. (3 and 0)

Geol 800—EARTH SCIENCE I—3 cr. (2 and 3)

Geol 850—EARTH SCIENCE II—3 cr. (2 and 3)

GENETICS

Advanced degrees are not awarded in Genetics. Courses are offered as a minor for students majoring in other areas. See Agronomy for a listing of available courses.

HISTORY AND POLITICAL SCIENCE

R. S. Lambert, Department Head

The Department of Social Sciences offers the Master of Arts degree.

A student who wishes to pursue graduate study toward a Master of Arts degree in history must meet the following departmental requirements.

1. Twenty-four undergraduate credits in history on which a grade point ratio of 3.0 was achieved.

2. An overall grade point ratio of 2.5 on his undergraduate work.

3. A reading knowledge of French or German.

4. Thesis research in primary materials beyond those in the Clemson library.

A student who seeks the Master of Education degree with a concentration in History must have a satisfactory record on History 101-102 and 203-204 or their equivalents.

Hist 702—MEDIEVAL HISTORY—3 cr. (3 and 0) F

Hist 704—HISTORY OF THE RENAISSANCE AND REFORMATION—3 cr. (3 and 0) F

Hist 708—INTERNATIONAL RELATIONS SINCE 1914—3 cr. (3 and 0) S

Hist 710—HISTORY OF COLONIAL AMERICA—3 cr. (3 and 0) F

Hist 711—UNITED STATES, 1783-1850—3 cr. (3 and 0) S

Hist 712—UNITED STATES, 1850-1900—3 cr. (3 and 0) F

Hist 713—UNITED STATES SINCE 1900—3 cr. (3 and 0) S

Hist 807—UNITED STATES DIPLOMATIC HISTORY SINCE 1877—3 cr. (3 and 0) S

The course will emphasize the factors influencing American diplomacy since 1877, and students will be given some acquaintance with source materials and documents.

Hist 808—INTERNATIONAL RELATIONS SINCE 1914—3 cr. (3 and 0) Not open to students who took History 708.

Hist 811—INTRODUCTION TO HISTORICAL RESEARCH—3 cr. (3 and 0)

Hist 812—UNITED STATES HISTORIOGRAPHY—3 cr. (3 and 0)

Hist 824—SEMINAR IN THE AMERICAN SOUTH—3 cr. (3 and 0)

Hist 825—SEMINAR IN CIVIL WAR AND RECONSTRUCTION—3 cr. (3 and 0)

Hist 891—RESEARCH—Credit to be arranged.

PolSci 732—AMERICAN CONSTITUTIONAL LAW—3 cr. (3 and 0) F

PolSci 762—INTERNATIONAL ORGANIZATIONS—3 cr. (3 and 0) S

HORTICULTURE

T. L. Senn, Department Head

The Department of Horticulture offers the Master of Science degree.

Graduate study in horticulture is designed to acquaint the student with the important biological principles underlying the production and post-harvest 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, and post-harvest handling. 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.

Students enrolling in the graduate program in horticulture beginning the first semester, 1967-68 will not receive graduate credits for Horticultural courses numbered below 700.

Hort 608—LANDSCAPE DESIGN—3 cr. (2 and 3) S

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

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

Hort 705—NUT TREE CULTURE—2 cr. (2 and 0) F, even numbered years.

Hort 706—NURSERY TECHNOLOGY—3 cr. (2 and 3) S

Hort 707—LANDSCAPE DESIGN—3 cr. (2 and 3) F

Hort 712—TURF MANAGEMENT—3 cr. (2 and 3) F

Hort 751—SMALL FRUIT CULTURE—3 cr. (2 and 3) S

Hort 756—TRUCK CROPS—3 cr. (3 and 0) S, even numbered years

Hort 760—LANDSCAPE DESIGN—5 cr. (3 and 6) F

Hort 764—FOOD PRESERVATION—3 cr. (2 and 3) F

Hort 768—INTRODUCTION TO RESEARCH—2 cr. (1 and 3) S

Hort 801—PROBLEMS IN SMALL FRUIT PRODUCTION—3 cr. (3 and 0) F, 67-68 and alternate 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. **Prerequisite:** Ch 220 or Ch 323, 327.

Hort 803—EXPERIMENTAL OLERICULTURE—3 cr. (3 and 0) F, 67-68 and alternate years.

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

Hort 804—SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICULTURE—3 cr. (3 and 0) S, 68-69 and alternate years.

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

Hort 805—PHYSICOCHEMICAL PROCEDURES FOR DETERMINING QUALITY IN HORTICULTURAL CROPS—3 cr. (2 and 3) F, 68-69 and alternate years.

Subject matter will include the study of special titrations, organoleptic evaluations, refractory, succulometers and tenderometers, colorimetry, and the effect of acids, sugars, salts, and other chemical constituents on quality.

Hort 806—POST-HARVEST PHYSIOLOGY AND HANDLING OF HORTICULTURAL CROPS—3 cr. (3 and 0) F

Principles, developments, and application of research findings dealing with 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.

Hort 807—POMOLOGY—3 cr. (3 and 0) S, 68-69 and alternate 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 Hort 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 891—RESEARCH—Credit to be arranged. F, S, SS.

INDUSTRIAL EDUCATION

A. F. Newton, Department Head

The Master of Industrial Education degree is offered.

InEd 701—INDUSTRIAL EDUCATION LABORATORY—3 cr. (1 and 6) F

InEd 705—TESTS AND MEASUREMENTS IN INDUSTRIAL EDUCATION—3 cr. (3 and 0) F

InEd 716—DESIGN AND OPERATION OF INDUSTRIAL EDUCATION LABORATORIES—3 cr. (2 and 3) FS

InEd 722—VOCATIONAL EDUCATIONAL PROGRAMS—3 cr. (3 and 0) S

InEd 725—TEACHING INDUSTRIAL SUBJECTS—2 cr. (3 and 0) FS

InEd 732—ADVANCED WOODWORKING—2 cr. (1 and 3) SS

InEd 735—ADVANCED WELDING—2 cr. (1 and 3) SS

InEd 736—ADVANCED MATERIAL FORMING—2 cr. (1 and 3) SS

InEd 738—ADVANCED MACHINING—2 cr. (1 and 3) SS

In Ed 741—COMPREHENSIVE GENERAL SHOP PRACTICES—2 cr. (1 and 3) F, SS

InEd 796—PUBLIC AND INDUSTRIAL RELATIONS FOR VOCATIONAL TEACHERS AND SUPERVISORS—3 cr. (3 and 0) SS

InEd 815—SEMINAR—1 cr. (1 and 0) SS

A joint study and discussion by graduate students and members of the faculty of new technological and professional advances.

InEd 820—RECENT PROCESS DEVELOPMENTS—3 cr. (3 and 0) S, SS

Consideration of new developments in production processes including ultrasonic and electrical discharge machining, high energy rate forming, precision casting methods, and recent joining techniques.

InEd 840—SCHOOL SHOP DESIGN—3 cr. (3 and 0) SS

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.

InEd 845—CURRICULUM DEVELOPMENT IN INDUSTRIAL EDUCATION—3 cr. (3 and 0) F, SS

Major consideration is given to curriculum construction, departmental coordination 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.

InEd 860—CURRICULUM PLANNING AND DEVELOPMENT IN INDUSTRIAL ARTS—3 cr. (3 and 0) SS

Philosophical, psychological, and sociological foundations of Industrial Arts education provides the basis on which curriculum planning and development techniques are acquired. An extensive study is made of contemporary and emerging curriculum patterns in Industrial Arts education.

InEd 865—AMERICAN INDUSTRIES—3 cr. (3 and 0) SS

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.

InEd 861—ADMINISTRATION AND SUPERVISION OF VOCATIONAL EDUCATION—3 cr. (3 and 0) SS

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.

InEd 891—RESEARCH—Credit to be arranged

InEd 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 student.

InEd 896—SPECIAL PROBLEMS II—3 cr. (3 and 0)
Continuation of InEd 895.

INDUSTRIAL ENGINEERING

Everett Laitala, Department Head

Advanced degrees are not awarded in Industrial Engineering. Courses are offered to provide a minor for students majoring in other fields.

IE 704—ENGINEERING ECONOMIC ANALYSIS—3 cr. (3 and 0) FS

IE 707—INDUSTRIAL APPLICATIONS OF STATICS—3 cr. (3 and 0) S

IE 710—ENGINEERING AND ORGANIZATION—3 cr. (3 and 0) FS

IE 711—WORK FLOW SYSTEMS AND CONTROL—3 cr. (3 and 0) S

IE 716—PROJECT SCHEDULING—3 cr. (3 and 0) S

INDUSTRIAL MANAGEMENT

C. H. Whitehurst, Department Head

Courses are offered leading to the Master of Science degree. The Department also administers the program leading to the Doctor of Philosophy Degree in Engineering Management.

Although entering graduate students are accepted from diverse undergraduate backgrounds, each is required as a prerequisite to full graduate standing to have completed, or to schedule in his first semester, basic courses in economics, accounting, statistics, and calculus.

All students enrolled in the industrial management curriculum must take the core courses IM 800, 801, 802, 803, or 717 and Econ 811 or IM 816.

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. It must be deemed satisfactory by the graduate faculty of the Department of Industrial Management.

Prior to the end of their second semester of graduate work, all students must complete an audit of the computer operation and programming course offered to the faculty and graduate students by the Computer Center.

The Department of Industrial Management periodically schedules a number of its regular graduate courses in the late afternoons and evenings. Thus, while no night degree program is offered as such, a **route** toward

the Masters degree is available for the industrial manager/engineer who is employed on a full time basis.

Mgt Sc 611—INTRODUCTION TO ECONOMETRICS—2 cr. (3 and 0)

IM 701—MARKETING ANALYSIS I—3 cr. (3 and 0) FS

IM 702—PRODUCTION AND PLANNING CONTROL—3 cr. (3 and 0) FS

IM 704—MANAGERIAL ECONOMICS—3 cr. (3 and 0) FS

IM 705—ECONOMICS OF TRANSPORTATION—3 cr. (3 and 0) F

IM 706—THEORY OF INDUSTRIAL LOCATION—3 cr. (3 and 0) S

IM 708—WORK SIMPLIFICATION AND STANDARDIZATION—3 cr. (2 and 3) FS

Acct 710—EXECUTIVE BUDGETING AND CONTROL—3 cr. (3 and 0) FS

IM 712—MARKETING ANALYSIS II—3 cr. (3 and 0) S

Mgt Sc 713—MANAGEMENT SCIENCE I—3 cr. (3 and 0) F

Mgt Sc 714—STATISTICAL ANALYSIS—3 cr. (3 and 0) F

IM 715—MANAGEMENT DECISION MAKING—3 cr. (3 and 0)

IM 716—MANAGEMENT OF HUMAN RESOURCES—3 cr. (3 and 0) F

IM 717—MANUFACTURING LOGISTICS—3 cr. (3 and 0) F

IM 800—ADVANCED MANAGEMENT SIMULATION—1 cr. (0 and 3) FS

A simulation of a competitive industry. Students are given the responsponsibility for major managerial decisions in a number of different firms. Within a firm students determine functional responsibilities with assignments being based upon an individual's backgdound and experience. The purpose of this simulation is to provide guided experience in management decision making under conditions of uncertainty.

IM 801—QUANTITATIVE ECONOMIC ANALYSIS—3 cr. (3 and 0) S

A systematic exposition of economic theory in terms of quantitative tools including both mathematics and statistics, and applications of economic theory to the tools of operations research and to business analysis. Emphasis is placed in analytical ideas and rigorous tools in economic theory by use of quantitative techniques. Included are mathematical formulations of economic theory, economic applications of differential and integral calculus, statistical inference, econometric models, linear and nonlinear programming, input-output models, and game theory. **Prerequisite:** Mgt Sc 311 (611) or permission of instructor.

IM 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.

IM 803—PRODUCTION MANAGEMENT—3 cr. (3 and 0) S

An analysis of the problems facing an industrial enterprise in planning, organizing, directing, and controlling its production activities and a study of the literature of the scientific management movement. **Prerequisite:** IM 402 or permission of instructor.

IM 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.

IM 805—QUALITY CONTROL—3 cr. (3 and 0) S

The organization and management of the quality control function in industry. Included are some advanced techniques in quality control. **Prerequisite:** IM 304 or permission of instructor.

Mgt Sc 806—LOCATION OF ECONOMIC ACTIVITY—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 organization, 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) F

Principal statistical problems in analysis of economic phenomena including least squares bias, problems in specification, aggregation identification, multicolinearity and auto correlation; single and multi-equation models and estimation. **Prerequisites:** Math 405, 411 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. **Prequisite:** Mgt Sc 807.

IM 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 401 or permission of instructor.

Mgt Sc 812—MANAGEMENT SCIENCE II—3 cr. (3 and 0) S

An application of scientific techniques—both econometric and theoretical—to decision making in business. A continuation of Management Science I, IM 413. **Prerequisite:** IM 412 or permission of instructor.

IM 816—MANAGEMENT OF HUMAN RESOURCES II—3 cr. (3 and 0) S

A more advanced consideration of the topics covered in IM 716. **Prerequisite:** IM 416 (716)or permission of instructor.

IM 891—THESIS RESEARCH—Credit to be arranged.

MATERIALS ENGINEERING

G. C. Robinson, Chairman

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

The program in Materials Engineering is an interdisciplinary program which permits students to concentrate in courses directed towards the analysis and synthesis of material components of engineering systems. The student is expected to achieve a balance in course work between three major classifications of courses. The first classification is concerned with the atomic, molecular and microstructures of materials. The second group of courses consists of studies of the relationship between the structure and composition of materials to the mechanical thermal, electrical, optical and chemical properties of materials. The third classification is concerned with the selection, application, design and development of material components to solve specific problems.

The courses included in the curriculum are drawn primarily from four disciplines; chemistry, physics, ceramic engineering and metallurgical engineering. Additional supporting courses are available from programs in electrical engineering, engineering mechanics and mathematics. Over sixty-five courses are available to the materials engineering programs from these disciplines.

Students are accepted in the materials engineering program possessing degrees in engineering, chemistry or physics. An individual program is designed for each student by his advisory committee to coordinate with his previous education and to suit the particular educational goals of the student.

MatE 991—DOCTORAL RESEARCH—Credit to be arranged.

MATHEMATICS

C. V. Aucoin, Department Head

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 a non-thesis option. Work for the non-thesis master's degree will consist of a minimum of thirty-one semester hours.

Math 605—FOUNDATIONS OF ANALYSIS—3 cr. (3 and 0)

Math 606—ORDINARY DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)

Math 608—COLLEGE GEOMETRY—3 cr. (3 and 0)

Comp Sci 610—INTRODUCTION TO ALGORITHMIC PROCESSES—3 cr. (2 and 3)

Comp Sci 611—COMPUTER ORGANIZATION & PROGRAMMING—3 cr. (2 and 3)

Comp Sci 612—NUMERICAL ALGORITHMS FOR ENGINEERS—3 cr. (3 and 0)

Math 613—STATISTICAL THEORY AND METHODS I—3 cr. (3 and 0)

Math 702—THEORY OF PROBABILITY—3 cr. (3 and 0)

Math 703—STATISTICAL INFERENCE—3 cr. (3 and 0)

Math 704—INTRODUCTION TO STOCHASTIC PROCESSES—3 cr. (3 and 0)

Math 705—STATISTICAL THEORY & METHODS II—3 cr. (3 and 0)

Math 707—PARTIAL DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)

Math 708—TOPICS IN GEOMETRY—3 cr. (3 and 0)

Math 709—NUMERICAL METHODS FOR COMPUTERS—3 cr. (3 and 0)

Math 711—LINEAR ALGEBRA—3 cr. (3 and 0)

Math 712—INTRODUCTION TO MODERN ALGEBRA I—3 cr. (3 and 0)

Math 713—INTRODUCTION TO MODERN ALGEBRA II—3 cr. (3 and 0)

Math 715—INTRODUCTION TO TOPOLOGY—3 cr. (3 and 0)

Math 717—MATHEMATICS PROGRAMS—3 cr. (3 and 0)

Comp Sci 727—COMPUTER PRINCIPLES—3 cr. (3 and 0)

Comp Sci 728—ALGORITHMIC LANGUAGES & COMPILERS—3 cr. (3 and 0)

Math 729—INTRODUCTION TO NUMERICAL ANALYSIS—3 cr. (3 and 0)

Math 751—VECTOR ANALYSIS—3 cr. (3 and 0)

Math 752—LINEAR PROGRAMMING—3 cr. (3 and 0)

Math 753—ADVANCED CALCULUS I—3 cr. (3 and 0)

Math 754—ADVANCED CALCULUS II—3 cr. (3 and 0)

Math 755—LAPLACE TRANSFORMS—3 cr. (3 and 0)

Math 757—APPLIED MATHEMATICS I—3 cr. (3 and 0)

Math 758—APPLIED MATHEMATICS—3 cr. (3 and 0)

Math 763—MATHEMATICAL ANALYSIS I—3 cr. (3 and 0)

Math 764—MATHEMATICAL ANALYSIS II—3 cr. (3 and 0)

Math 801—GENERAL LINEAR HYPOTHESIS I— 3 cr. (3 and 0)

Topics include: Least-square estimates, Gauss-Markoff 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 703 and 711.

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 704.

Math 804—STOCHASTIC PROCESSES II—3 cr. (3 and 0)

A continuation of Math 803.

Math 805—ADVANCED METHODS IN PROBABILITY AND STATISTICS—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 705 and 711.

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 764.

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-engineer majors. **Prerequisite:** Math 764.

Math 824—COMPLEX ANALYSIS II—3 cr. (3 and 0)

A continuation of Complex Analysis I 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 parameters, linear differential equations, self adjoint eigenvalue problems, oscillation and comparison theorems. **Prerequisites:** Math 754 and 711 or 764.

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 Legandre polynominals, with applications. **Prerequisites:** Math 845 or 764.

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 754.

Math 835—COMPLEX VARIABLES—3 cr. (3 and 0)

Elementary functions. Differentation and integration of analytic functions. Taylor and Laurent series. Contour integration and residue theory. Conformal mapping and residue theory. Schwartz-Christoffel transformation. **Prerequisite:** Math 753.

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 764 or 754.

Math 839—INTEGRAL EQUATIONS—3 cr. (3 and 0)

Basic theory. Relationships to linear differential initial value problems. Freedholm theory. Linear Freedholm integral equations of the first and second kind. Hilbert-Schmidt theory. Voteira equation. **Prerequisite:** Math 764.

Math 851—ABSTRACT ALGEBRA I—3 cr. (3 and 0)

A review of fundamental theory of Math 712-713 plus a development of many algebraic systems through the unified approach of a group with operators; chain conditions; Fittings Lemma; Shcreier, Krull-Scmidt, and

Jordan-Holder theorems in a general setting; elements of Noetherian rings; introduction to Galois Theory.

Math 852—ABSTRACT ALGEBRA II—3 cr. (3 and 0)

Continuation of 851.

Math 853—ADVANCED LINEAR ALGEBRA—3 cr. (3 and 0)

Properties of finite dimensional cevtor spaces: bases, dimention, transformations, projections and orthogonality. **Prerequisites:** Math 711 and Math 712.

Math 855—COMBINATORIAL ANALYSIS—3 cr. (3 and 0)

A study of basic counting procedures, combinations, permutations, generating functions, recurrence relations, principle of inclusion and exclusion, permanents, zero-one matrices and other selected topics. Included are discussions of some of the classical problems such as "le probleme des recontres" and the "probleme des menages." **Prerequisite:** Math 711.

Math 857—GROUP THEORY—3 cr. (3 and 0)

Elements of group theory, symmetry groups, group representations, irreducible representation, physical applications, symmetric group, continuous group.

Math 861—NUMERICAL ANALYSIS—3 cr. (3 and 0)

A continuation of Math 429. A study of least squares, Chebyshev polynominals, rational functions, Fourier approximation, nonperiodic functions, linear filters, smoothing and differentiating, exponential approximation, inversion of matrices, eigenvalues.

Math 863—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 754.

Math 871—GENERAL TOPOLOGY I—3 cr. (3 and 0)

R. L. Moore's Axioms for point set topology; consequences of these axioms. **Prerequisite:** Math 754.

Math 872—GENERAL TOPOLOGY II—3 cr. (3 and 0)

Continuation of Math 871 with an introduction to algebraic topology.

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:** Math 206.

Math 883—THEORY OF NUMBERS—3 cr. (3 and 0)

A study of the properties of the integers with theorems on divisibility congruences, numbers, theoretical functions, and continued fractions.

Math 885—PROJECTIVE GEOMETRY—3 cr. (3 and 0)

Introductory concepts relating to elements, axioms, primitive forms, and central projections; the principal of duality as applied to simple and complete figures; perspectivity and Desargues theorem; harmonic sets; metric properties and double ratio; projectively related primitive forms; conics and cones; Pascole theorem and Brianchon's theorem; theory of the pole and the polar; metric properties of conics; ruled surfaces; extended theory of projectivity; incolution and metric considerations; complex elements; planar collineations. **Prerequisite:** Math 708 or consent of the instructor.

Math 891—RESEARCH—Credit to be arranged.

Math 901—PROBABILITY THEORY I—3 cr. (3 and 0)

Axiomatic 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 infinitely many measurable spaces, Daniel-Kolmogoroff theorem, 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 702 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 903—ADVANCED STOCHASTIC PROCESSES—3 cr. (3 and 0)

Markov Process, martingales, stationary processes, Linear least squares prediction-stationary (wide sense) processes. **Prerequisites:** Math 704 and 901.

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 hypothesis, uniformly most powerful tests, methods of deriving tests. **Prerequisites:** Math 703 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 hypothesis on vector means and covariance matrices. **Prerequisites:** 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 Bauch Algebra L^1 (R) and Ideals in L^1. **Prerequisites:** Math 822 and 824.

Math 921—ABSTRACT HARMONIC ANALYSIS I—3 cr. (3 and 0)

Prerequisites: Real and Complex Variables (Math 722 and 724), Algebra (Math 413), Topology (Math 415).

Topics include: Elements of the theory of topological groups, integration on locally compact spaces, the Haar integral, convolutions, the basic theorems of Fourier Analysis, functions of Fourier transforms and Fourier Analysis on Ordered Groups. **Prerequisites:** Math 413, 415, 822, 824.

Math 922—ABSTRACT HARMONIC ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 921.

Math 923—INTRODUCTION TO THE THEORY OF DISTRIBUTIONS I—3 cr. (3 and 0)

Topics include: Linear topological spaces, generalized fuctions, support of distributions, distributions, convolutions of distributions, Fourier transfroms of distributions, and Connection with Analytic Functions. **Prerequisites:** Real and Complex Variables (Math 722 and 724)

Math 924—INTRODUCTION TO THE THEORY OF DISTRIBUTIONS II—3 cr. (3 and 0)

A continuation of Math 923.

Math 925—TOPICS IN NON-LINEAR DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)

The subject matter to be chosen from current research problems of interest: e.g. fixed point methods for obtaining periodic and almost periodic solutions in dissipative and conservative systems, methods of averaging and the related study of integral manifolds, general theory of dynamical systems, etc.; and the applications of the above to such classical problems as the three body problem. **Prerequisite:** Math 826.

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 929—FUNCTIONAL ANALYSIS III—3 cr. (3 and 0)

A continuation of Math 827-28; special topics, including survey of current literature and open questions in the field.

Math 930—FUNCTIONAL ANALYSIS IV—3 cr. (3 and 0)

A continuation of Math 929.

Math 941—APPLIED MATHEMATICS I—3 cr. (3 and 0)

Linear Spaces, Spectral Theory of Operators. Greens function. Eigenvalue problems of ordinary differential equations. Partial differential equations. **Prerequisites:** Math 764 and 853.

Math 942—APPLIED MATHEMATICS II—3 cr. (3 and 0)

A continuation of 941.

Math 975—CONVEXITY I—3 cr. (3 and 0)

Hyperplanes and separation theorems, characterizations of convex sets, local convexity, Helly-type theorems, convex functions. **Prerequisite:** Math 928.

Math 976—CONVEXITY II—3 cr. (3 and 0)

Continuation of Math 975—Survey of current literature and discussion of open questions.

Math 980—SPECIAL TOPICS IN PROBABILITY—3 cr. (3 and 0)

Math 981—SPECIAL TOPICS IN MATHEMATICAL STATISTICS—3 cr. (3 and 0)

Math 982—SPECIAL TOPICS IN ANALYSIS—3 cr. (3 and 0)

Math 983—SPECIAL TOPICS IN FUNCTIONAL ANALYSIS—3 cr. (3 and 0)

Math 984—SPECIAL TOPICS IN APPLIED MATHEMATICS—3 cr. (3 and 0)

Math 985—SPECIAL TOPICS IN ALGEBRA—3 cr. (3 and 0)

Math 986—SPECIAL TOPICS IN CONVEXITY—3 cr. (3 and 0)

Math 991—DOCTORAL RESEARCH—Credit to be arranged.

MECHANICAL ENGINEERING

T. C. Hardin, Department Head

The Department of Mechanical Engineering offers the Master of Science and Doctor of Philosophy degrees.

Programs of study may be followed which have majors in mechanical design, thermal sciences, automatic control, systems engineering, and operations research.

ME 701—PRINCIPLES OF MECHANICAL ENGINEERING DESIGN—3 cr. (3 and 0) FS

ME 702—MECHANICAL ENGINEERING ANALYSIS AND DESIGN—3 cr. (1 and 6)

ME 703—FLUID DYNAMICS—3 (3 and 0) S

ME 704—PHYSICAL SYSTEMS ANALYSIS—3 cr. (3 and 0)

ME 707—HEAT TRANSFER II—3 cr. (3 and 0) F

ME 711—GAS POWER—3 cr. (3 and 0) F

ME 721—PROPULSION SYSTEMS I—3 cr. (3 and 0) S

ME 722—PRINCIPLE OF TURBOMACHINERY—3 cr. (2 and 3) S

ME 723—PROPULSION SYSTEM ANALYSIS—1 cr. (3 and 0) S

ME 729—AIR CONDITIONING DESIGN—1 cr. (0 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 808—FLUID MECHANICS—3 cr. (3 and 0)

The basic equations for multi-dimensional flowfields are rigorously derived. Analytical techniques are developed for solving some of the more advanced problems of ideal and viscous flow involving both the steady and unsteady state. **Prerequisite:** Consent of instructor.

ME 809—AERODYNAMICS—3 cr. (3 and 0) F

The flow of incompressible inviscid fluids in two dimensions. The vector flow field, Gauss's Theorem, Stoke's Theorem, the velocity potential and stream function. Euler's Equation applied to incompressible fluids, super-position of flows. Method of conformal mapping and non-steady incompressible flow problems. **Prerequisites**: ME 312, EM 320.

ME 810—ADVANCED THERMODYNAMICS—3 cr. (3 and 0) F

A critical review of the first and second laws, entropy, and general thermodynamic relations. The relations of entropy to probability and communication theory. Non-steady flow processes. Selected topics. **Prerequisite:** One year of thermodynamics.

ME 811—GAS DYNAMICS II—3 cr. (3 and 0) S

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. **Prerequisites:** ME 703, ME 809.

ME 812—BOUNDARY LAYER THEORY I—3 cr. ((3 and 0) F

Derivation of Navier-Stokes Equation. Exact solutions of one-dimensional non-steady cases. Boundary layer approximations and similar solutions in laminar flow. Karman Integral form of equation of motion and approximate solutions. Mangler transformation. Turbulent boundary layer, derivation of energy equation and solutions. Compressible laminar boundary layer and related transformations. Boundary layer control. **Prerequisites:** Math 454, ME 809.

ME 813—ADVANCED GAS DYNAMICS III—3 cr. (3 and 0) F

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 814—HYPERSONICS—3 cr. (3 and 0) S

General features of hypersonic flow. The role played by the ratio of specific heats. Normal, oblique and curved shock relation; vorticity and shock curvature. Irrotational small-disturbance similitude. Boundary layer hypersonic flow interaction. The principle of equivalence. Blast wave theory. **Prerequisite:** ME 811, Math 454.

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 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 III—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, Math 208.

ME 831—HEAT AND MASS TRANSFER IV—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, Math 208.

ME 840—KINEMATICS II—3 cr. (3 and 0)

Space mechanisms. Computer mechanisms. Analysis and synthesis of

linkages. Coupler curves. Inflection circle curvature. Euler-Savary equation. Polode curvature. Finite displacements. **Prerequisite:** ME 315.

ME 842—ADVANCED MECH. ENGR. DESIGN I—3 cr. (3 and 0)

Principles of mechanical sciences applied to the analysis of machines, devices and mechanical systems. Analysis of state of stress, state of strain, elasticity, plasticity, working stresses, lubrication and contact stress. Applications to the design of machine frames, shafts, bearings, springs, gears and other machine elements. **Prerequisite:** ME 701.

ME 843—ADVANCED MECH. ENGR. DESIGN II—3 cr. (3 and 0)

Continuation of ME 842. **Prerequisite:** ME 842.

ME 844—DYNAMICS OF ELASTIC MECHANICAL SYSTEMS—3 cr (3 and 0)

Dynamics of elastic mechanisms. Vibration analysis of elastic systems and components. Dynamic stress analysis, shock and fatigue of system components. Synthesis and design of elastic systems. Analog simulation and digital computer solutions of problems in dynamic analysis.

ME 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, and adaptive control. **Prerequisite:** Consent of Instructor.

ME 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:** Consent of instructor.

ME 862—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:** Consent of Instructor.

ME 863—ADVANCED PHYSICAL SYSTEMS ANALYSIS I—3 cr. (3 and 0)

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.

ME 864—ADVANCED PHYSICAL SYSTEMS ANALYSIS II—3 cr. (3 and 0)

Digital and analog computer solutions to linear and nonlinear systems, continuous and discrete. Systems with discrete and continuous subsystems. Optimizing processes; separable programming, and dynamic programming. Adaptive systems.

ME 865—MODERN CONTROL THEORY I—3 cr. (3 and 0) F

A detailed treatment of time domain (state space) analysis and design methods. Lyapunov's methods, discrete-time systems. Introduction to nonlinear problems. Computers frequently used to solve practical problems. Same course as EE 810.

ME 866—NONLINEAR AUTOMATIC CONTROLS—3 cr. (3 and 0) S

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. Statistical design principles and sampled data systems are studied. Both graphical and analytical procedures are used; these include the describing function, the method of harmonic balance, and the phase plane. The phase plane is used in giving insight to Lyapunov's second method of stability analysis. Same course as EE 814.

ME 867—CONTROL SYSTEM COMPONENTS—3 cr. (3 and 0) F

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 868—CONTROL OF AEROSPACE SYSTEMS—3 cr. (3 and 0) S

Derivation of mathematical models of aerospace vehicles and systems. Vector equations based in inertial and body-axis reference frames. Euler equations. Guidance and control techniques and their application to the design of closed-loop control for aerospace systems. **Prerequisite:** ME 404 or EE 410 or equivalent.

ME 870—BIOSYSTEMS ANALYSIS—3 cr. (3 and 0)

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.

ME 880—METHODS OF OPERATIONS RESEARCH—3 cr. (3 and 0)

Application and theory of selected topics from Operations Research such as linear programming, network analysis, game theory and simulation. **Prerequisites:** ME 299 and Math 313 or equivalent.

ME 881—ADVANCED METHODS OF OPERATIONS RESEARCH II—3 cr. (3 and 0)

A continuation of ME 880. Topics included are nonlinear programming,

dynamic programming, queuing theory, and stochastic processes. **Prerequisite:** ME 880.

ME 882—RELIABILITY ENGINEERING—3 cr. (3 and 0)

The statistical study of reliability and life testing. The reliability of series, parallel, and non-serial systems are analyzed. **Prerequisite:** Math 613 or equivalent and consent of instructor.

ME 883—OPERATIONS SYSTEM SIMULATION I— 3 cr. (3 and 0) F

An introduction to feedback type simulation models and their use in analyzing business, governmental, and military problems. The concept of Industrial Dynamics is stressed along with the simulation language FORDYN.

ME 884—OPERATIONS SYSTEM SIMULATION II—3 cr. (3 and 0) S

Continuation of ME 883 with emphasis on Monte Carlo type simulation models. The simulation languages GPSS and GASP are used.

ME 886—OPERATIONS RESEARCH IN PRODUCTION CONTROL—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.

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.

ME 912—BOUNDARY LAYER THEORY II—3 cr. (3 and 0) S

Continuation of turbulent and compressible boundary layer theories Boundary layer stability study and boundary layer control. **Prerequisite:** ME 812.

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. **Prerequisite:** Phys 541 or EE 521.

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 from instructor.

ME 930—CONDUCTION HEAT TRANSFER—3 cr. (3 and 0) S

Physical properties; steady conduction in one and two-dimensional sys-

tems; 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 THE 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. (May be taken more than one semester.)

METALLURGICAL ENGINEERING

G. C. Robinson, Department Head

Advanced degrees are not awarded in metallurgical engineering. Courses are offered to provide a minor and to supplement majors in other areas.

MetE 802—RESEARCH TECHNIQUES IN PHYSICAL METALLURGY—3 cr. (2 and 3)

A study of advanced x-ray diffraction, field ion microscope, electron microscope, 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 structures.

MetE 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 defects, dislocations, anelasticity, solid state transformations, martensitic transformations, structure sensitive and insensitive properties, liquid to solid solidification.

MetE 806—PHYSICAL METALLURGY II—3 cr. (3 and 0)
A continuation of MetE 805.

MetE 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:** MetE 304 or equivalent.

MetE 821—STRENGTHENING 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 composite will also be studied. **Prerequisite:** MetE 820.

MICROBIOLOGY

W. M. Epps, Department Head

The Master of Science degree is offered. See Botany, Bacteriology, and Zoology for a listing of courses available.

NUTRITION

W. A. King, Dairy Science, Chairman
B. D. Barnett, Poultry Science
R. F. Wheeler, Animal Science
W. P. Williams, Food Science and Biochemistry

The Master of Science and Doctor of Philosophy degrees are offered.

Graduate work in Nutrition encompasses four departments from which a student may select courses and his area of study. A core of basic courses in biochemistry and nutrition will be required for all students and additional course work will be taken in areas of special interest. The latter includes nutrition of humans, poultry, and dairy and meat animals. Minors are available in animal physiology, biochemistry, and similar programs.

Students enrolling for a degree in Nutrition will choose from those listed below and from others deemed appropriate by the advisory committee.

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

Bioch 706—PHYSIOLOGICAL CHEMISTRY—4 cr. (3 and 3)

Bioch 810—BIOCHEMICAL TECHNIQUES—3 cr. (1 and 6)

Bioch 812—NUTRITIONAL BIOCHEMISTRY—3 cr. (3 and 0)

Bioch 814—LABORATORY METHODS IN NUTRITION—1 cr. (0 and 3)

Bioch 815—LIPIDS—2 cr. (2 and 0)

Bioch 816—PROTEINS AND NUCLEIC ACIDS—3 cr. (3 and 0)

Bioch 817—CHEMISTRY AND METABOLISM OF HORMONES—2 cr. (2 and 3)

Bioch 818—VITAMINS AND MINERALS—3 cr. (3 and 0)

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

Ch 826—CHEMISTRY OF ENZYMES—3 cr. (3 and 0)

Ch 829—CHEMISTRY AND METABOLISHM OF THE CARBOHYDRATES—2 cr. (2 and 0)

Dy Sc 703—ANIMAL NUTRITION—3 cr. (3 and 0)

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

Dy Sc 809—RUMEN METABOLISM—3 cr. (2 and 3)

PS 751—POULTRY NUTRITION—3 cr. (2 and 3)

PS 801—POULTRY NUTRITION AND METABOLISM—3 cr. (2 and 3)

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. Some discussion of the history and men of nutrition will also be included.

Nutr 852—NUTRITION SEMINAR II—1 cr. (1 and 0) S

Nutr 891—RESEARCH—Credit to be arranged. (May be taken more than one semester). FS, SS

Nutr 991—DOCTORAL RESEARCH—Credit to be arranged. (Maye be taken more than one semester). FS, SS

PHYSICS

H. E. Vogel, Department Head

The Physics Department offers the Master of Science and Doctor of Philosophy degrees.

All entering graduate students will take a placement examination at the beginning of their semester of attendance. This examination is administered by the graduate adviser to assist him in the scheduling of their courses.

For the Master of Science degree:

1. A student must have a reading knowledge of one foreign language.

2. 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.

3. A final oral examination on the subject matter of the major and minor fields and on the thesis. This examination will be given at least two weeks before the date on which the degree is to be granted.

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 two weeks prior to the convocation on 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.

Phys 621—MECHANICS I—3 cr. (3 and 0)

Phys 622—MECHANICS II—3 cr. (3 and 0)

Phys 625—EXPERIMENTAL PHYSICS—4 cr. (2 and 6)

Phys 626—EXPERIMENTAL PHYSICS—4 cr. (2 and 6)

Phys 641—ELECTRICITY AND MAGNETISM—3 cr. (3 and 0)

Phys 651—INTRODUCTION TO MODERN PHYSICS—3 cr. (3 and 0)

Phys 704—ASTRODYNAMICS—3 cr. (3 and 0)

Phys 732—PHYSICAL OPTICS AND INTRODUCTION TO SPECTROSCOPY—3 cr. (3 and 0)

Phys 741—ELECTRICITY AND MAGNETISM—3 cr. (3 and 0)

Phys 746—SOLID STATE PHYSICS—3 cr. (3 and 0)

Phys 752—INTRODUCTORY NUCLEAR PHYSICS—3 cr. (3 and 0)

Phys 755—MODERN PHYSICS II—3 cr. (3 and 0)

Phys 760—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Phys 765—THERMODYNAMICS AND STATISTICAL MECHANICS—3 cr. (3 and 0)

Phys 771—ELECTRON MICROSCOPY—3 cr. (2 and 3)

Phys 773—X-RAY CRYSTALLOGRAPHY—3 cr. (2 and 3)

Phys 760—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Phys 801—PHYSICS FOR HIGH SCHOOL TEACHERS I—3 cr. (3 and 0)

An elementary treatment of mechanics, heat and sound from a mature viewpoint. Material will be chosen to show the growth of ideas and the development of the general laws. Applications to atomic Physics as well as to large scale problems will be studied.

Phys 802—PHYSICS FOR HIGH SCHOOL TEACHERS II—3 cr. (3 and 0)

A continuation of Physics 801 covering electricity and magnetism, optics, and an introduction to atomic and nuclear physics.

Phys 804—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 descriptive astronomy and the phenomena associated with the seasons, time systems, and current interests. Fundamental physical principles necessary to proper explanations will be introduced. The new Spitz planetarium at the University and night observations of the heavens will be used to supplement the lectures.

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) (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—THERMODYNAMICS AND STATISTICAL MECHANICS—3 cr.

Classical statistical mechanics and the derivation of the laws of thermodynamics. Statistical treatment of the thermodynamics of irreversible processes.

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 formulations 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 application 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 introduction to the theory of electrons and microscopic phenomena is given.

Phys 845—SOLID STATE 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 II—3 cr. (3 and 0)

A continuation of Physics 545, but includes the electronic properties of solids. The topics treated are band theory of solids, rectifiers and transistors, 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.

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 or 2 or 3 cr. (1 or 2 or 3 and 0)

A joint study by graduate students and interested members of the faculty of some area of physics which is currently being extensively investigated.

Phys 885—COLLOQUIUM—1 cr. 1 and 0)

Selected topics. Required of all Physics graduate students each semester in residence.

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 physics 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 Physics 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 AND DISSERTATION— Credit to be arranged.

May be taken more than one semester.

PLANT PATHOLOGY

W. M. Epps, Chairman

The Master of Science and Doctor of Philosophy degrees are offered. See Botany for a listing of courses available.

PLANT PHYSIOLOGY

W. M. Epps, Botany, Chairman
U. S. Jones, Agronomy
T. L. Senn, Horticulture

The Doctor of Philosophy degree is offered.

Graduate work in Plant Physiology encompasses three departments from which a student may select courses and his major area of study.

POULTRY SCIENCE

B. D. Barnett, Department Head

The Poultry Science Department offers the Master of Science degree. 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 and Biochemistry.

PS 654—POULTRY BREEDING—3 cr. (2 and 3)

PS 655—POULTRY PRODUCTS GRADING AND TECHNOLOGY—3 cr. (2 and 3)

PS 656—INCUBATION AND BROODING—3 cr. (2 and 3)

PS 701—ENVIRONMENT TECHNOLOGY—3 cr. (2 and 3)

PS 751—POULTRY NUTRITION—3 cr. (2 and 3)

PS 758—AVIAN MICROBIOLOGY AND PARASITOLOGY—4 cr. (3 and 3)

PS 760—SEMINAR—2 cr. (2 and 0)

PS 801—POULTRY NUTRITION AND METABOLISM—3 cr. (2 and 3) F

A study of dietary requirements as they result from the biochemistry of animals. Poultry will be emphasized, but mammals and other animals will be discussed and comparisons made between species. Term papers will be required on specified areas of nutrition or biochemistry. Laboratory material will include development of nutritional imbalances with poultry and other appropriate species. Chemical and biological assays of nutrients will be performed using acceptable methods and species.

PS 804—POULTRY PATHOLOGY—3 cr. (1 and 6) S

A study of the causes, prevention and treatment of poultry diseases. The laboratory material will include exercises in bacteriology, virology, protozoology, and serology, applied as diagnostic procedures and in studies of disease producing agents.

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.

SOCIOLOGY

W. J. Lanham, Chairman, Rural Sociology
R. S. Lambert, Chairman, General Sociology

Advanced degrees are not awarded in Sociology. Courses are offered to provide a minor for students majoring in other fields.

RS 659—THE COMMUNITY—3 cr. (3 and 0)

RS 761—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 the instructor.

Soc 711—HISTORY OF SOCIAL THOUGHT—3 cr. (3 and 0)

Soc 721—SOCIOLOGICAL THEORY—3 cr. (3 and 0)

Soc 731—COMPLEX ORGANIZATIONS—3 cr. (3 and 0)

Soc 741—SOCIAL STRATIFICATION—3 cr. (3 and 0)

Soc 751—SOCIOLOGY OF MEDICINE—3 cr. (3 and 0)

TEXTILE CHEMISTRY

T. A. Campbell, Jr., Chairman

The Master of Science degree is offered. For Ph.D. requirements see Ph.D. in Chemistry with major in Textile Chemistry.

Graduate students will be accepted with backgrounds in other areas of study provided that they have taken sufficient course work in mathematics, chemistry and physics. Minors normally will be taken in chemistry, physics or mathematics.

TC 615—THE CHEMISTRY OF FIBERS—3 cr. (3 and 0)

TC 616—CHEMISTRY OF SCOURING, BLEACHING AND SURFACE ACTIVE AGENTS—3 cr. (2 and 3)

TC 617—SYNTHETIC FIBERS LABORATORY—1 cr. (0 and 3)

TC 757—DYEING AND FINISHING I— 1 cr. (0 and 3)

TC 759—DYEING AND FINISHING LABORATORY—1 cr. (0 and 3)

TC 766—TEXTILE UNIT OPERATIONS—3 cr. (3 and 0)

TC 775—CELLULOSE CHEMISTRY—2 cr. (2 and 0)

TC 811—THE THEORY OF FIBER-FORMING HIGH POLYMERS I—3 cr. (3 and 0)

Structure and properties of fibers; thermodynamic and statistical treatments of polymer solutions; molecular weight determination; flow properties. The application of these concepts to current polymers in use in the textile industry.

TC 812—THE THEORY OF FIBER-FORMING HIGH POLYMERS II—3 cr. (3 and 0)

Emulsion polymerization; polymer degradation; preparation, theory and utilization of synthetic resinous materials. The use of different polymerization techniques in synthetic fiber production. **Prerequisite:** TC 811.

TC 821—ADVANCED CELLULOSE CHEMISTRY—3 cr. (3 and 0)

The chemistry of cellulose and closely related polysaccharides, through a systemic study of the extensive volume of research which has been completed on these substances.

TC 831—THE 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. The theory of color and its use in dyeing operations. **Prerequisite:** TC 457.

TC 891—RESEARCH—Credit to be arranged.

TEXTILES

T. A. Campbell, Department Head

The Master of Science degree is offered.

Enrollment in this program is open to students possessing a baccalaureate degree in Textiles, Textile Chemistry, Physics, Chemistry, and Engineering. Graduates from other scientific disciplines will be considered. The program is designed to allow the student with a textile background to do advanced study and research in the area of textiles and to also allow the student with a scientific background other than textiles to pursue graduate study in textiles, while building upon his baccalaureate area through the selection of his minor fields of study.

The student is expected to select his course work to provide a major area and one or two minor areas. The major area, which will be in Textiles, should emphasize one of the technical topics, fiber physics or textile technology. The student's minor area(s) will be selected in conjunction with his faculty advisor to complement his background and research interest and may consist of course work from several areas of science and engineering.

Text 603—FIBER PROCESSING III—3 cr. (2 and 3)

Text 604—FIBER PROCESSING 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 711—FABRIC DEVELOPMENT III—4 cr. (3 and 3)

Text 712—FABRIC DEVELOPMENT IV—4 cr. (3 and 3)

Text 726—INSTRUMENTATION—3 cr. (3 and 0)

Text 760—TEXTILE PROCESSES—3 cr. (3 and 0)

Text 830—TEXTILE PHYSICS—3 cr. (3 and 0)

Mechanics of Twisted Yarn: kinematics and geometry of twist, theory of migration, effect of twist on the physical properties of yarns.

Fabric geometry: Effect of fabric and geometry on its physical and mechanical properties.

Text 840—SPECTROPHOTOMETRY—3 cr. (3 and 0)

The application of spectral transmittance and spectral transmittance and spectral reflectance measurements to the color of dye-stuffs, textiles, and other related materials. The identification and specification of these materials in the visible, ultraviolent, and infrared spectra. **(Prerequisite:** Text 440 or consent of instructor.)

Text 870—ADVANCES IN TEXTILE MANUFACTURING—3 cr. (3 and 0)

Studies of recent problems widely discussed in textile literature and of particular interest to textile science and industry, e.g., fiber hooks, spinnability, fiber length distribution, effect of processing on fiber properties, etc.

Text 880—SELECTED TOPICS—3 cr. (3 and 0)

A comprehensive study of selected topics not covered in other courses in Textiles or Textile Chemistry.

Text 891—RESEARCH—To be arranged.

WATER RESOURCES ENGINEERING

L. G. Rich, Chairman

The Master of Science and Doctor of Philosophy degrees are offered.

Water Resources Engineering is an interdisciplinary curriculum encompassing several departments within the University. The emphasis is on the engineering aspects of the occurrence, circulation, distribution, conservation, and use of water throughout its history on the earth. The program is designed to provide training in the basic sciences of mathematics, mechanics, meteorology, hydrology, and geology as applied to precipitation, storage, surface and sub-surface flow, and evapotranspiration of water.

The Ph.D. and M.S. curricula in Water Resources Engineering are designed to enhance the student's previous engineering or science background in one or more specialized areas. The program is directed by a core faculty from Departments of Agricultural Engineering, Engineering Mechanics, and Environmental Systems Engineering. The major and minor work can be made up of course from the above departments as well as supporting departments such as Agricultural Economics, Agronomy, Mathematics, Physics, Chemistry, Experimental Statistics, Biology, Economics and Forestry.

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:** Consent 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 822—WATER MOVEMENT IN SOILS—3 cr. (3 and 0)

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:** Permission of instructor.

WRE 861—HYDROLOGY—3 cr. (3 and 0)

The principles concerning the occurrence of natural water and engineering practices in dealing with it in the design of facilities for water supply, flood control, power development and other purposes. **Prerequisite:** Permission of the instructor.

WRE 862—ADVANCED HYDROLOGY—3 cr. (3 and 0)

Special work to strengthen the student's background in modern methods. Emphasis is laid on evaporation, infiltration and the synthetic hydrograph. **Prerequisite:** WRE 861.

WRE 864—GROUND-WATER HYDROLOGY—3 cr. (3 and 0)

A study of the occurrence and movement of water beneath the earth's surface, with emphasis on development and management of ground-water as part of the total resource. **Prerequisite:** Permission of the instructor.

WRE 881, 981, 982—SPECIAL TOPICS IN WATER RESOURCES— 3 cr. (3 and 0)

WRE 891—RESEARCH—Credit to be arranged.

WRE 991—DOCTORAL RESEARCH—Credit to be arranged.

ZOOLOGY

J. H. Cochran, Department Head

The Master of Science and the Doctor of Philosophy degrees are offered.

Zool 602—VERTEBRATE EMBRYOLOGY—3 cr. (2 and 3) F, S, S S

Zool 604—ANIMAL ECOLOGY—3 cr. (2 and 3) F

Zool 612—WILDLIFE MANAGEMENT—3 cr. (2 and 3) FS

Zool 703—PROTOZOOLOGY—3 cr. (2 and 3) S

zool 704—ANIMAL PATHOLOGY—3 cr. (2 and 3) S

Zool 705—ANIMAL HISTOLOGY—3 cr. (2 and 3) F

Zool 710—LIMNOLOGY—3 cr. (2 and 3) F

Zool 756—PARASITOLOGY—3 cr. (2 and 3) F

Zool 758—CELL PHYSIOLOGY—3 cr. (2 and 3) S

Zool 760—GENERAL PHYSIOLOGY—3 cr. (2 and 3)

Zool 761—ANATOMY—3 cr. (2 and 3)

Zool 762—ADVANCED HERPETOLOGY AND ICHTHYOLOGY—4 cr. (3 and 3) F

Zool 801—ANIMAL HISTOLOGY—3 cr. (2 and 3) F '68 and alternate 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) S S '67 and alternate years.

The fixing, staining, sectioning, and identification of all tissues, glands and organs of animals. **Prerequisites:** Zool 101, 103.

Zool 803—ANIMAL ECOLOGY—4 cr. (2 and 6) S '68 and alternate years.

A study of animals in relation to their natural environment. Typical animal habitats are visited to study the animal life and the ocean, shore, lakes, streams, cultivated fields, woodlands, and mountains.

Zool 804—ORNITHOLOGY—4 cr. (2 and 6) S '68 and alternate years.

The identification, life history and ecology of birds. Field trips, work with bird specimens and correlated reading will give the student a working knowledge of at least 100 species of the common birds.

Zool 805—ANIMAL PATHOLOGY—3 cr. (3 and 0) S '67 and alternate years.

Designed to acquaint the student with the cause, prevention, and treatment of pathogenic diseases.

Zool 806—COMPARATIVE ANIMAL PHYSIOLOGY—3 cr. (3 and 0) F '68 and alternate years.

An advanced level study of the physiological principles as they occur throughout the animal kingdom. The course is organized on a function-system rather than on a taxonomic basis. **Prerequisite:** Zool 758 or permission of the instructor.

Zool 807—USE OF RADIOSOTOPES IN BIOLOGICAL RESEARCH—3 cr. (2 and 3) S '67 and alternate years.

The types of radioisotopes useful in biological research will be studied, including methods of detection and measurement in biological systems. **Prerequisites:** Graduate standing and permission of instructor.

Zool 808—RADIOBIOLOGY—3 cr. (2 and 3) F '68 and alternate years.

A study of the effects of various types or radiation upon cells, tissues, and organs of animals. Various methods of evaluation and quantitation of effects will be employed in the laboratory. **Prerequisite:** Permission of the instructor.

Zool 809—TOXICOLOGY— 3 cr. (2 and 3) F '67 and alternate years.

Toxicologic methods, modes of action, signs and symptoms of poison, and antidotes will be studied. Special emphasis will be given deleterious effects from commonly used chemicals. Quantitative aspects of toxicology will be demonstrated in the laboratory. **Prerequisite:** Permission of instructor.

Zool 810—MAMMALOGY—3 cr. (2 and 3) S '67 and alternate years.

A study of the taxonomy, distribution, ecology and economic importance of mammals with emphasis on South Carolina and North American forms. **Prerequisites:** Zool 101, 103, and 301 or permission of instructor.

Zool 811—RECENT ADVANCES IN ZOOLOGY AND ENTOMOLOGY I—1 cr. (1 and 0)

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

Zool 812—RECENT ADVANCES IN ZOOLOGY AND ENTOMOLOGY II—1 cr. (1 and 0)

A continuation of Zool 811.

Zool 813—EVOLUTION—3 cr. (3 and 0) F '67 and alternate 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—PRINCIPLES OF WILDLIFE BIOLOGY—3 cr. (2 and 3) F

Theories and principles applicable to wildlife biology. Emphasis will be placed on upland game species. **Prerequisite:** Permission of instructor.

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

Techniques and practices involved in the management of wildlife species with special reference to upland game. **Prerequisite:** Permission of instructor.

Zool 852—PRINCIPLES AND METHODS OF SYSTEMATIC ZOOLOGY—2 cr. (2 and 0) F '68 and alternate years.

Presents the problems which confront the taxonomist in the zoological sciences and the conventional practices which have been developed to handle them.

Zool 856—ECONOMIC ZOOLOGY—3 cr. (2 and 3)

A study of all phylla (exclusive of class insecta) to include those animals either beneficial or destructive to man. **Prerequisites:** Zool 101, 103.

Zool 863—SPECIAL PROBLEMS—(1-4 cr.) F, S, S S

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

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