1965

Clemson Graduate School Catalog, 1965-1966

Clemson University

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Clemson University

Record

Announcements of
The Graduate School

For

1965-1966
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228878
Clemson University Library
CHECK LIST ON GRADUATE SCHOOL PROCEDURES

In obtaining admission to the Graduate School, the following procedure is followed:

1. The prospective student sends a letter of inquiry to the Graduate School or Department Head.

2. The Graduate School mails information and forms to the student.

3. Completed application forms, transcript, and Graduate Record Aptitude Test scores must be received in the Graduate School Office.

4. Application information is sent to the Department Head for study.

5. The Department Head and Dean of Graduate School act on the student’s application and the Dean notifies the student.

After admission 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 page 35)
2. Submit Plan for Graduate Study (G. S. Form 2) (See page 32.)

3. If necessary, submit request for changes in Plan for Graduate Study. (See page 32.)

4. Satisfy any prescribed foreign language examination and other qualifying examinations prerequisite to admission to candidacy. (See page 34.)

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 page 32.)

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 June 15 for summer graduation. (See page 34.)

7. Submit completed thesis to advisory committee chairman and arrange for final examination by the advisory committee. (See page 33.)

8. Pay binding fee to the Bursar and submit approved copies of thesis to the Dean of the Graduate School. Doctoral candidates pay for abstract publication in Dissertation Abstracts. (See page 33.)

The final responsibility for following Graduate School procedures rests with the graduate student. Special problems should be referred to the Graduate School office, Room 17, Tillman Hall.
UNIVERSITY CALENDAR

SESSION 1965-1966

Matriculation, new students .......................... August 20
Matriculation, current students ...................... August 21
Registration, new students .......................... August 23
Registration, current students ...................... August 23, 24
Late registration fee .................................. August 25
Classes begin, abbreviated schedule ................. August 25
Last day for matriculation ......................... August 31
Graduate School foreign language examination .. September 4
Last day to add a subject ............................ September 7
Last day to drop a subject without record of drop .. September 21
Last day to order diploma for mid-year graduation .. September 21
Preliminary reports due ............................. October 11
Last day to drop a subject ............................ November 13
Last day to withdraw from college without
having grades recorded .............................. November 13
Clemson-Carolina Game—classes suspended .......... November 20
Thanksgiving Holidays* ............................. November 25-27
Graduate School foreign language examination .. December 4
Last day for thesis and oral examination .......... December 4
Examinations begin .................................. December 9

*Follow Thursday, Friday, Saturday schedule Monday, Tuesday, Wednesday, November 22, 23, 24.
Faculty meeting to consider candidates for graduation December 17

Mid-year graduation December 18

Matriculation, new students January 10

Registration, all students January 12, 13

Late registration fee applies January 14

Classes begin, abbreviated schedule January 14

Last day for matriculation January 20

Graduate School foreign language examination January 22

Last day to add a subject January 27

Last day to order diploma for June graduation February 10

Preliminary reports due February 28

Last day to drop a subject April 7

Last day to withdraw from college without having grades recorded April 7

Easter Holidays begin at 1 p.m. April 7

Classes resume April 13

Honors and Awards Day—classes suspended at 12 noon April 20

Graduate School foreign language examination April 30

Last day for thesis and oral examination April 30

Examinations begin May 4

Faculty meeting to consider candidates for graduation May 13

Commencement May 14
CLEMSON UNIVERSITY BOARD OF TRUSTEES

Life Members

R. M. Cooper, President of the Board                      Wisacky
Edgar A. Brown                                             Barnwell
James F. Byrnes                                           Columbia
Frank J. Jervey                                           Clemson
Winchester Smith                                          Williston
Robert R. Coker                                           Hartsville
James C. Self                                              Greenwood

Term Expires 1966

A. M. Quattlebaum                                         Florence
L. D. Holmes                                               Johnston
E. Oswald Lightsey                                         Hampton

Term Expires 1968

Paul Quattlebaum, Jr.                                      Charleston
W. Gordon McCabe, Jr.                                      Greenville
T. Kenneth Cribb                                           Spartanburg

A. W. Rigsby, Secretary                                    Clemson
PERSONNEL

OFFICERS OF ADMINISTRATION

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

Jack Kenny Williams, Ph.D. ________ Vice-President for Academic Affairs

Walter Thompson Cox, B.S. ________________ Dean of Student Affairs

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

William Wright Bryan, B.S., Litt.D., LL.D. ________________ Vice-President for Development

William Henry Wiley, Ph.D. ________________ Dean, College of Agriculture and Biological Sciences

Jess Willard Jones, Ph.D. ________________ Director of Resident Instruction and Assistant to the Dean, College of Agriculture and Biological Sciences

Harlan Ewart McClure, M.Arch ____________ Dean, School of Architecture

Howard Louis Hunter, Ph.D. ____________ Dean, College of Arts and Sciences

Harold Fochone Landrith, Ed.D., ________________ Dean, School of Education

Linvil Gene Rich, Ph.D. ________________ Dean, College of Engineering

Wallace Dabney Trevillian, Ph.D. ________________ Dean, School of Industrial Management and Textile Science

Victor Hurst, Ph.D. ________________ Dean of the Graduate School

John Wallace Gordon Gourlay, A.M.L.S. ____________ Director of the Library

Kenneth Notley Vickery, B.S. _____ Director of Admissions and Registration

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THE GRADUATE COUNCIL

1965-66

Victor Hurst, Ph.D., Professor of Dairy Science and Dean of the Graduate School. Chairman ex officio.

Theodore Roosevelt Adkins, Jr., Ph.D., Associate Professor of Entomology and Zoology.

John F. Andrews, Ph.D., Associate Professor of Civil Engineering

Robert Frederic Borgman, D.V.M., Ph.D., Associate Professor of Food Science and Biochemistry.

Wilbert Preston Byrd, Ph.D., Associate Professor of Experimental Statistics.

Richard James Calhoun, Ph.D., Associate Professor of English.

James Harvey Hobson, Ph.D., Professor of Chemistry.

James Willis Kenelly, Jr., Ph.D., Associate Professor of Mathematics.

Jim Thomas Long, Ph.D., Associate Professor of Electrical Engineering.

Hugh Holleman Macaulay, Jr., Ph.D., Alumni Professor of Economics.

John Paul Uldrick, Ph.D., Associate Professor of Engineering Mechanics

Samuel Marsh Willis, Ph.D., Associate Professor of Industrial Management.

Jess Willard Jones, Ph.D., Professor of Agronomy and Director of Resident Instruction, and Assistant to the Dean, College of Agriculture and Biological Sciences. Ex officio.

Harlan Ewart McClure, M.Arch., Professor of Architecture and Dean, School of Architecture. Ex officio.

Howard Louis Hunter, Ph.D., Professor of Chemistry and Dean, College of Arts and Sciences. Ex officio.

Harold Fochone Landrith, Ed.D., Professor of History and Education and Dean, School of Education. Ex officio.

Linvil Gene Rich, Ph.D., Professor of Civil Engineering and Dean, College of Engineering. Ex officio.

Wallace Dabney Trevillian, Ph.D., Professor of Economics and Dean, School of Industrial Management and Textile Science. Ex officio.
GENERAL INFORMATION

INTRODUCTION

Clemson is the land-grant university of South Carolina, a state institution, and one of the A. and M. universities which emphasizes study in agriculture and mechanical industries. Clemson is fully accredited by the Southern Association of Colleges and Schools. The fifty-three graduate curriculums under the Colleges of Agriculture, 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.
EXPENSES

Full-Time Students. The 1965-1966 charges for regular full-time students are shown below:

First Semester

<table>
<thead>
<tr>
<th>South Carolina Student</th>
<th>Non-Resident Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tuition</td>
<td>$75</td>
</tr>
<tr>
<td>Matriculation Fee</td>
<td>$5</td>
</tr>
<tr>
<td>(Non-Refundable)</td>
<td></td>
</tr>
<tr>
<td>Maintenance and Activities Fee</td>
<td>136</td>
</tr>
<tr>
<td>Library Fee</td>
<td>$12</td>
</tr>
<tr>
<td>Medical Fee</td>
<td>$15</td>
</tr>
<tr>
<td>Room Fee</td>
<td>110-126</td>
</tr>
<tr>
<td>(See Dormitories, page 15)</td>
<td></td>
</tr>
<tr>
<td>Board</td>
<td>$190</td>
</tr>
<tr>
<td>Total First Semester</td>
<td>$543-559</td>
</tr>
</tbody>
</table>

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 $50 of the semester's room rent are payable at the beginning of each semester. (For the fall semester, those students who have paid the $50 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:

<table>
<thead>
<tr>
<th>Fee Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matriculation Fee (non-refundable)</td>
<td>$5.00</td>
</tr>
<tr>
<td>Tuition (per semester hour)</td>
<td>6.00</td>
</tr>
<tr>
<td>Maintenance and Activities Fee (per semester hour)</td>
<td>10.00</td>
</tr>
<tr>
<td>Library Fee (per semester hour)</td>
<td>.75</td>
</tr>
</tbody>
</table>

Part-time students taking six or more credits and graduate assistants are given the opportunity of receiving medical treatment on a semester basis by payment of a hospital fee of $15. Students who elect not to pay the hospital fee are responsible for arranging their own medical care.

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 only $4.75 per semester hour during regular semesters and one-half the summer school rate during summer sessions. These charges are in lieu of matriculation, tuition, maintenance, activity and library fees. A graduate assistant is defined as a graduate student devoting approximately half or more of his time to University duties for a full semester or more.

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

**Income Tax Deductions.** According to Treasury Decision 6291, under Section 162 of the 1954 Internal Revenue Code, income tax deductions are allowed in many instances for tuition and other educational expenses. Students are referred to the the federal ruling on income tax deductions for teachers and other professional people seeking to maintain or improve skills required in their employment.
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 periods of twelve months. 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 in the Graduate School. Recipients of assistantships are selected by the respective academic departments and will be notified on or before April 15.

GRADUATE FELLOWSHIPS and GRANTS-IN-AID are also available. Among them are the following:

Alumni Fellowships ranging from $200 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.

Stuart F. Brown Fellowship. A $1000 award given by the Whitinsville Spinning Ring Company to a student in the School of Industrial and Management and Textile Science.

Chemstrand Fellowship. An award of $2,000 to a student in Chemical Engineering.

Clay Products Service Fellowship. 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.

E. I. duPont Fellowship. An award of $1200 plus tuition to a teaching assistant in Chemistry.

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

Foundation for Cotton Research and Education. A limited number of $2,500 awards, made to students in Agricultural Engineering, with concentration in Ginning Engineering. The recipients are selected by the Foundation (Box 9905, Memphis 12, Tenn.) with approval of the University.

Hercules Powder Fellowship. A $2000 award to a student in Textile Chemistry.

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 $1000 award to a student in one of the sciences.

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

National Science Foundation Fellowships and Traineeships. The Graduate School participates in the National Science Foundation summer fellowship program for graduate teaching assistants and in the 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.

Public Health Service Traineeships and Fellowships. Awards are made by the Public Health Service to students studying in health-related fields. Inquiry about these awards should be directed to the Public Health Service, Bethesda 14, Maryland, or to the Graduate School.

Wade Stackhouse Loan Fund. Income from a fund donated by Dr. Wade Stackhouse in memory of his father is used to assist graduate students at Clemson and Clemson graduates who are accepted for graduate study.

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

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.

OTHERS 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 for further information.

COMPUTER CENTER

The Clemson University Computer Center operates an RPC 4000 digital computing system with an RPC 4600 auxiliary input/output unit and an RPC 4410 photoelectric reader. Input and output are through a typewriter-paper tape system with card capability provided by a K-177 card-to-tape converter. An IBM System/360 is on order, to be delivered about July 1, 1966. The Computer Center is available for graduate research on an open-shop basis. Instruction in programming and the use of the equipment is available.

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 235,000 bound volumes of books, periodicals, and government publications. Added to these are thousands of unbound federal and state documents, agricultural and engineering experiment station publications, and extension publications which are classified and available for use. In addition to the Main Library there are departmental libraries.

Forty newspapers and about 3,600 serial titles—periodicals, reports, bulletins and the like—are received regularly. Eight hundred of these are foreign publications. Microfilm and microcard readers are provided for consulting material that is in microtext.
Library service is maintained for 87 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 8 A.M. to 10 P.M.
Saturday 8 A.M. to 5 P.M.
Sunday 2 P.M. to 10 P.M.

Special study desks and carrels are available for graduate students doing thesis research and are assigned by the Library.

LIVING CONDITIONS AND COST

Dormitories

The University dormitories will accommodate 3,624, two students being assigned to a room. The University also has 397 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 $50 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 1. 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 assignments after July 1.

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 refunds 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 undergraduate 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.

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.
Responsibility for Student Possessions. Although every precaution is taken to maintain adequate security, the University cannot assume the responsibility for the loss of or damage to student possessions.

Refund of Dormitory Fees. Once a student occupies a dormitory room he is obligated for the first $50 of the semester's room rent. Refunds may be made on a pro rata basis except that no refund shall be made of the initial $50 advance payment. Further, no refund shall be made if the paid unused period is less than 15 consecutive days.

Extra Dormitory Charges. Extra charges are made to students who occupy dormitories before or after the dates established for a semester or term. Rates are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
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<tbody>
<tr>
<td>Less than 1 week</td>
<td>$1.00 per night</td>
<td>$1.00 per night</td>
</tr>
<tr>
<td>One week</td>
<td>$5.50 each</td>
<td>$6.00 each</td>
</tr>
<tr>
<td>One week and part</td>
<td>$5.50 for full week plus</td>
<td>$6.00 for full week plus</td>
</tr>
<tr>
<td>of another week</td>
<td>$1.00 per night for part</td>
<td>$1.00 per night for part</td>
</tr>
<tr>
<td></td>
<td>of week</td>
<td>of week</td>
</tr>
</tbody>
</table>

Students who are required by the University to be on campus prior to and after the scheduled term or semester may upon the approval of the Dean of Student Affairs be exempted from paying the extra dormitory charges.

Room Furnishings. The rooms for men are equipped with single-width beds, including bunk-type and single beds, built-in clothes locker, study tables, and chairs. The rooms for women are carpeted and equipped with twin beds, two desks and desk chairs, two chests, book shelves, study lamps and two closets. Students provide their own pillows, bed linens, blankets, towels, and wash cloths.

Reservation of Right to Change Fees and Regulations. The University reserves the right to make changes in its fees, charges, rules, and regulations.
Dormitories for Men. There are eight dormitories available for housing 3,188 male students. An additional 74-room dormitory is under construction and is scheduled for completion by the beginning of the 1965-1966 school year. The room rent varies from $110 to $118 per semester, depending upon the dormitory facilities.

Dormitories for Women. Women students are required to live in University dormitories. The only exceptions are married students, graduate students, those living with close relatives, and those who are 23 years of age or older and who have parental permission and a clear conduct record.

One dormitory for women has been completed and a second is scheduled for completion by the beginning of the 1965-1966 term. Each building is designed with 72 rooms accommodating 144 women. The room rent is $126 per semester.

Dining Hall. Cost per semester $190. The University Dining Hall offers a counter-service cafeteria-type meal to students. Six large counters provide timely service of quality foods.

The semester fee covers the time from day of matriculation through the day scheduled for graduation exercises. These dates are published in the University Calendar. An extra charge is made for meals eaten in the Student Dining Hall prior to the beginning or after the end of a semester or a term. The fee does not cover the cost of any meals a student may be required to eat off campus due to curricular requirements, unless the time exceeds 14 consecutive complete days.

Students who live in the dormitories will be required to pay the Dining Hall fee. Students who live outside the dormitories may take all meals in the Dining Hall if they pay for such meals on a semester or half-semester basis. Commuting students may purchase individual meal tickets at the rate of 65¢ for breakfast, 85¢ for lunch or dinner.

Refund of paid unused services is made on a daily pro rata basis, holidays excepted, provided the unused portion is more than 14 consecutive days.
Laundry—Dry Cleaning.

A new building with modern equipment is conveniently located on campus to service the laundry and dry cleaning requirements of students. Reasonable prices are charged for individual items on a cash-and-carry basis.

The University will not be liable for lost or damaged items unless reported within two days after delivery date, and then for not more than the actual depreciated value of such articles as have been lost or damaged.

Coin-operated washing machines and dryers are available in the laundry building and several of the dormitories.

Married Student Housing. Clemson provides comfortable and economical housing for its married students. There are three housing areas consisting of 247 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 October 20 for second semester housing; or before February 20 for summer session 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, $36.00 for interior and $39.00 for end units; East Campus, $48.00.

MEDICAL EXAMINATIONS

Medical examinations are required of every student entering Clemson University for the first time. These examinations must be administered by 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 (Medical Examination Report) provided for this purpose by the Director of Admissions and Registration. This form will be sent after the student is admitted.

The University requires that all new students have a current tetanus toxoid series or booster (within three years), a smallpox vaccination within three years and immunization against poliomyelitis with oral (Sabin) type vaccine. 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.

**STUDENT HEALTH SERVICE**

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

PLACEMENT SERVICE

An office of student placement is maintained in the Student Center. This office endeavors to assist all qualified students and former students in selecting suitable vocations, in arranging summer work, and in obtaining career employment.

GRADUATE SCHOOL INFORMATION

REGULATIONS AND PROCEDURES

Every graduate student and every prospective graduate student is expected to make himself thoroughly familiar with the regula-
tions 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 and his departmental adviser. 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, Ceramic Engineering, Chemical Engineering, Chemistry, Civil Engineering, Dairy Science, Electrical Engineering, Engineering Mechanics, Entomology, Environmental Systems Engineering, Forestry, Horti-

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

The degrees of Master of Agricultural Education, Master of Industrial Education, and Master of Education in the teaching areas of English, history, mathematics, and the sciences are offered.

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


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

**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.

**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.
ADMISSION

Before 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 include only those students whose academic records clearly indicate that they are prepared to profit from graduate study. In general, an applicant should have an average undergraduate grade of B or better in his major field and C or better in his remaining course work. Neither a transcript exceeding these 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 likelihood 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.

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 provisional graduate students. Only graduate students in full standing may become candidates for advanced degrees.

Students otherwise qualified for admission will be classified as provisional if they (1) do not plan to obtain a graduate degree from Clemson; or (2) have either general or specific deficiencies which require remedial work prior to admission to a degree program.
A provisionally admitted student may apply at any time to the Dean of the Graduate School for reclassification to full standing. An application for such reclassification should indicate that the student has successfully completed any required prerequisites, has maintained at least a B average for all courses taken as a graduate student, and desires a graduate degree from Clemson.

Appropriate graduate courses completed by a provisional student may be counted toward a degree program when the student has been reclassified.

Students desiring to enroll in the Graduate School must make application on Graduate School Form 1. This form may be obtained from the Dean of the Graduate School. The application, accompanied by transcripts of previous college work and by such written recommendations as are necessary in support of the application, is returned to the Graduate School office.

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 to the Graduate School in the Ph.D. program.

Graduate work of fragmentary character taken over a long period of years, or work completed many years before the student becomes a degree candidate will not be accepted as satisfying the requirements of residence. Students who find it necessary to interrupt their program of study for a period longer than a summer vacation should, before departure, leave with the Graduate Office a statement of the reason for interruption, mailing address, and expected date of return. Students who fail to do so may be dropped from the Graduate School.

**Graduate Record Examinations.** Applicants for admission to a degree program are required to submit their scores on the Aptitude Test of the Graduate Record Examinations.
This test is prepared and scored by the Educational Testing Service, Princeton, New Jersey. The Graduate Record Examinations are administered at many centers throughout the United States and several foreign countries five times each year, usually in January, March, April, July, and November. The test is expected to be given at Clemson November 13, 1965, April 23, 1966, and July 9, 1966.

Students desiring to take the test should request from the Graduate School a booklet of information concerning the Aptitude Test of the Graduate Record Examinations and an application blank. The completed application form, together with the examination fee, should reach the Educational Testing Service two weeks in advance of the actual test date.

On his application for the Aptitude Test, the prospective student should indicate that his test scores are to be sent to the Dean of the Graduate School, Clemson University, Clemson, South Carolina.

The Aptitude Test of the Graduate Record Examinations is an objective-type examination involving vocabulary, reading comprehension, and logical and mathematical reasoning. It yields two scores: Verbal Factor and Quantitative Factor. No special preparation in advance is necessary for it.

**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 in any semester 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 student 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 roll at any time for failure to maintain an adequate academic status.

**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. Additional information on faculty enrollment in the Graduate School may be found in the Faculty Manual.

**Maximum and Minimum Credit Loads.** The maximum load for students who are devoting all of their time to graduate work is fifteen credit hours per semester, or one credit hour per week during the Summer School. Persons who are employed by the University on a full-time basis may not carry more than six semester credits per semester. An employee actively 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.

The maximum graduate load for students devoting part-time to staff duties or research work will be determined by their total work load. The work load is the number of credit hours taken or taught multiplied by three plus the actual number of hours per week spent in performing other staff duties or research work. For students devoting part-time to graduate study, the total work load per week for the first semester of graduate enrollment must not exceed 48 hours. After the first semester, a part-time student whose work is superior may, with the approval of the head of his major department and the Dean of the Graduate School, schedule a work load in excess of 48 hours but not in excess of 60 hours.

In the event of scheduling difficulties, a part-time student may, with the approval of the persons named above, exceed the limits
specified by not more than three work load hours for any one semester, provided the average work load for the academic year does not exceed these limits.

A student who is not enrolled in formal courses during a given semester or summer session but who is working on the research required for his degree must enroll in one of the Master's or doctoral research courses.

**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 more than twelve 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 unless such is agreed to by the head of the department requiring the prerequisite. 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 Clem-
son 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.

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 Plan.** Each graduate student, with the help of his major professor, shall file with the Dean of the Graduate School a preliminary study plan soon after he begins his study at Clemson. The form for this plan (G. S. Form 2) may be obtained from the student's department head or from the Graduate School office. Changes in the student's preliminary plan of study may be requested at any time. Proposals for change should originate in consultation between the student and his major adviser, be approved in writing by the heads of the student's major and minor departments, and be forwarded in quintuplicate to the Dean of the Graduate School.

**Admission to Candidacy for a Graduate Degree.** Admission to the Graduate School does not qualify a student as a candidate for an advanced degree. Such candidacy depends on the acceptance by the Dean of the Graduate School of a written request for admission to candidacy. This request (G.S. Form 4) should be filed by the student once he has completed at least one-half his prescribed graduate residence and course work (research courses excepted), and has successfully undertaken whatever preliminary or qualifying examinations are required. This request for admission to candidacy must list each of the major and minor subjects to be offered for the degree and must contain the title of the proposed thesis or research report. The request should bear the signed approval of the student's major adviser and the head of his major department. A stu-
dent must be admitted to candidacy for a Master's degree at least one semester, and for a Doctor of Philosophy degree at least one academic year or eight months, before the date on which the degree is expected.

**The Thesis and Thesis Abstract.** 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 allowed for the research leading to the required Master of Science or Master of Arts thesis. Nine hours of credit are allowed for the Master of Architecture thesis.

Three typewritten copies* of the thesis (the original copy and the first and second carbons) 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 $9 must be paid to the Bursar and the Bursar's receipt submitted to the Graduate School Office at the time the thesis is submitted. If the student desires, he may have additional copies of his thesis bound for himself at a cost of $3 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 at Clemson University may be obtained from the Graduate School Office.

The student will prepare one additional copy of the abstract and title sheet of his thesis to be submitted with the thesis 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**.

*Multilith or Xerox copies are as a rule acceptable.*
Restriction on Use of Theses and Dissertations. Unpublished theses and dissertations submitted to the Graduate School in partial fulfillment of the requirements for graduate degrees and deposited in the University Library are, as a rule, open to the public for reference purposes. However, extended quotations or summaries may be published only with the permission of the author and the 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 for September 4, and December 4, 1965, and for April 30 and June 11, 1966. The language examinations are taken from sources supplied by the student's major department to the Language Department.

Subject to approval by the Dean of the Graduate School and the Head of the Department of English and Modern Languages, the language requirement may be met if the student has completed with a grade of B or better, (1) two years of course work in the language at Clemson or another university or (2) German 251—Scientific German, which is offered at Clemson.

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 June 15 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.

ADDITIONAL REQUIREMENTS FOR THE MASTER OF SCIENCE AND MASTER OF ARTS DEGREES

To receive the Master of Science degree a student must spend the equivalent of at least one academic year 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 the student's preliminary plan of study is filed and his objectives crystallized he will, with the approval of the head of his major department, select a major adviser. The major adviser in consultation with the student will recommend to the Dean of the Graduate School for approval and formal appointment at least two associate advisers, one of whom shall represent the student's minor field of study. These associate advisers, with the major adviser as chairman, will constitute the student's advisory committee which will supervise his graduate program, administer his final comprehensive examination, and initiate the recommendation for the awarding of his degree.

Course Work Required. In addition to such supplementary or supporting courses as may be required, the work will consist of a minimum of thirty semester hours, including six semester hours of research which will provide the basis for the required thesis. Of the remaining twenty-four semester hours, at least twelve hours must come from courses numbered 500 or above. A minimum of twelve hours must be in the student's major field and a minimum of six hours in one minor.

*An academic semester of residence is defined as a semester of enrollment in and the successful completion of a minimum of nine hours of course work or a combination of course work and research acceptable as its equivalent. Summer equivalents may be accumulated to count toward residence.
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 Dean of the Graduate School who will, in turn, notify members of the Graduate Council of the examination. Immediately after the examination the examining committee will notify the Dean of the Graduate School of its findings. This notification will be made on Graduate School Form 7.

REQUIREMENTS FOR THE MASTER OF AGRICULTURAL EDUCATION DEGREE

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 as a minor.

3. Three hours in research technique.

4. Three hours in experimental statistics.

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 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. The candidate's final examination may be oral and/or written.

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.

ADDITIONAL 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 research. The degree is not awarded solely on the basis of course work completed, residence, or other routine requirements. The
final basis for granting the degree will be the student's grasp of the
subject matter of a broad field of study, his competency to plan
and conduct research, and his ability to express himself adequately
and professionally in oral and written language.

Advisory Committee. Shortly after the time of his initial regis-
tration in a doctoral program the student shall designate in writing
to the Dean of the Graduate School his selection of a major field
and one or more minor fields of study. The heads of these depart-
ments 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 additional
member will be appointed by the Graduate School. 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, their number, 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 com-
mittee will also arrange for the student's preliminary and final
comprehensive examinations and initiate the recommendations for
the awarding of his degree.

Residence Requirements. Graduate 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 con-
cern 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
spend the equivalent of at least three academic years in residence
as a graduate student. At least one academic year after admission
to the Ph.D. program must be in continuous full-time resident
study at this institution. Up to one year of residence may be earn-
ed by the completion of eighteen hours of courses, or an equal
amount of courses and research, taken over a period longer than two semesters. The definition of an academic year in residence is found on page 35 of this Bulletin.

**Time Limit.** All work for a Doctor of Philosophy degree must be completed within a period of seven years. If the 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; except that 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 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 student's 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 shall recommend 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's being declared ineligible for the Doctor of Philosophy degree at Clemson University.
**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.

**COURSES OF STUDY**

A graduate student is defined as one who has been admitted to advanced study beyond the Bachelor's degree.

The branch of learning to which a graduate student devotes the greater part of his time and effort is termed his "major." Any subject of advanced nature selected with reference to its bearing upon the major or to the broadening of the student's training is known as the "minor." Other subjects taken by a graduate student to meet technical requirements or for any other reason are termed supporting subjects. The credits earned for supporting courses do not count toward the attainment of an advanced degree.

The courses listed below will carry graduate credit when properly approved by graduate advisers. Enrollment in courses of the 500 and 600 series is restricted to graduate students. Courses of the 300 and 400 series will enroll undergraduate and graduate students; however, the graduate students will normally be expected to complete such additional assignments as instructors may require.

The Director of Admissions and Registration will not permit enrollment in courses of the 500 or 600 series or enrollment for graduate credit in 300 or 400 series courses until the student has been officially admitted to the Graduate School.

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 must be approved by the department offering it.

Complete descriptions of the 300 and 400 series courses listed in this Bulletin may be found in the general University Catalog, obtainable from the Director of Admissions and Registration.

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.

**AGRICULTURAL ECONOMICS**

W. J. Lanham, Department Head

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

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.
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.

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.

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.

A critical examination of the theory of economic growth and development with emphasis on both its macro- and its microeconomic aspects.

A study of selected economic problems involved in marketing Southern foods and fibers and in conducting related marketing research. Students will undertake individual assignments in the field of their interest. **Prerequisite:** Ag Ec 309 or permission of instructor.

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.)

Ag Ec 591—THESIS RESEARCH—Credits to be arranged.

Ag Ec 610—RESEARCH PROBLEMS IN FARM MANAGEMENT—3 cr. (3 and 0)

Review of economic problems in operating and managing a farm; examination of related published materials and critical evaluation of methodology used; selection of specific management problems and preparation of outlines of applicable research procedures for their solution. (Open to Ph.D. candidates only.)

Ag Ec 611—RESEARCH PROBLEMS IN FARM MANAGEMENT—3 cr. (3 and 0)

Continuation and extension of Ag Ec 610.

Ag Ec 614—RESEARCH PROBLEMS IN ECONOMIC DEVELOPMENT—3 cr. (3 and 0)

Review of literature in the field of economic development, particularly as related to rural areas and to the broad concept of agriculture; critical examination of methodology and findings; selection of specific development problems and preparation of outlines of applicable research procedures for their solution.

Ag Ec 615—RESEARCH PROBLEMS IN ECONOMIC DEVELOPMENT—3 cr. (3 and 0).

Continuation and extension of Ag Ec 614.

Ag Ec 616—RESEARCH PROBLEMS IN MARKETING—3 cr. (3 and 0)

Review of literature in the field of marketing; critical examination of methodology and findings; and preparation of outlines, plan of work and procedures for specific marketing studies. (Open only to Ph.D. candidates.)

Ag Ec 617—RESEARCH PROBLEMS IN MARKETING—3 cr. (3 and 0)

Continuation and extension of Ag Ec 616.

Ag Ec 691—DOCTORAL RESEARCH—Credit to be arranged.

(See also courses listed under Economics.)

AGRICULTURAL EDUCATION

L. H. Davis, Department Head

Courses are offered leading to the Master of Agricultural Education degree.

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 401—METHODS IN AGRICULTURAL EDUCATION—3 cr. (2 and 3)
Ag Ed 463—ADVANCED CONSERVATION EDUCATION—3 cr. (3 and 0)
Ag Ed 465—PROGRAM PLANNING IN AGRICULTURAL EDUCATION—3 cr. (3 and 0)
Ag Ed 467—ADULT EDUCATION IN AGRICULTURE—3 cr. (2 and 3)
Ag Ed 503—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 504—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 505—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 515—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 520—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 525—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) supervised apprentice training. Prerequisite: Experience in agricultural education and permission of the instructor.
Ag Ed 591—INTRODUCTION TO RESEARCH IN EDUCATION—3 cr.
Ag Ed 592—RESEARCH IN AGRICULTURAL EDUCATION—3 cr.
Courses are offered leading to the Master of Science degree.

Students of agricultural engineering may find the doctoral programs in Environmental Systems and Water Resources Engineering of interest. Each of these inter-disciplinary programs draws heavily on courses and research in agricultural engineering.

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

*AgE 352—FARM POWER—3 cr. (2 and 3) S
*AgE 360—FARM AND HOME UTILITIES—3 cr. (2 and 3) S
AgE 416—AGRICULTURAL MACHINERY—3 cr. (2 and 3) S
AgE 422—SOIL AND WATER CONSERVATION ENGINEERING—4 cr. (3 and 3) S
AgE 431—AGRICULTURAL STRUCTURAL DESIGN—3 cr. (2 and 3) F
AgE 442—AGRICULTURAL PROCESS ENGINEERING—3 cr. (2 and 3) S
AgE 465—ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS—3 cr. (2 and 3) F
AgE 501—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 504—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 simplifications, dehydrating and drying, refrigeration, storage, and related subjects.

*May be used for graduate credit under special conditions only.
AgE 506—INSTRUMENTATION IN AGRICULTURAL 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 511—AGRICULTURAL POWER AND MACHINERY—3 cr. (3 and 0) F

A critical analysis is made of present problems and trends in the design and application of machines and machine systems for agriculture. Advanced methods of analysis and design, research methods, techniques, and instrumentation are covered along with other topics of current importance. Prerequisite: AgE 416 or equivalent.

AgE 522—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. Prerequisites: AgE 422, or equivalent.

AgE 582—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 591—RESEARCH—Credit to be arranged.

AGRONOMY

U. S. Jones, Department Head

Courses are offered leading to 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. Unusual facilities include radioscope equipment, a cytogenetics laboratory, controlled environment chambers, and graduate student laboratories in an air-conditioned building.

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

*Gen 302—GENETICS—3 (2 and 3) FS
Gen 451—GENETICS—3 cr. (3 and 0) F
Gen 453—GENETICS LABORATORY—1 cr. (0 and 3) F
Gen 501—CYTOGENETICS—3 cr. (2 and 3) S, even 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:** Bot 404 and a knowledge of basic genetics.

*Agron 306—FORAGE AND PASTURE CROPS—3 cr. (3 and 0) S
*Agron 308—PHYSICAL AND CHEMICAL EDAPHOLOGY—3 cr. (1 and 6) S
Agron 401—CROP AND SEED LABORATORY—1 cr. (0 and 3) F
Agron 403—SOIL CLASSIFICATION—2 cr. (1 and 3) F
Agron 405—PLANT BREEDING—3 cr. (2 and 3) S
Agron 407—PRINCIPLES OF WEED CONTROL—3 cr. (2 and 3) F
Agron 409—COTTON AND TOBACCO—3 cr. (3 and 0) F
Agron 452—SOIL FERTILITY AND MANAGEMENT—2 cr. (2 and 0) S
Agron 455—SEMINAR—1 cr. (1 and 0) F
Agron 456—SEMINAR—1 cr. (1 and 0) S
Agron 501—CROP PHYSIOLOGY AND NUTRITION—3 cr. (3 and 0) S, odd numbered years.

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

*Courses which may be used by students majoring in other fields.
Agron 502—PEDOLOGY AND SOIL CLASSIFICATION—3 cr. (3 and 0) S, odd numbered years.

Deals with the factors of soil formation 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 503—CROP PRODUCTION—3 cr. (3 and 0) F, 1965 and alternate years.

An advanced analysis of the factors affecting the growth and reproduction of crops. Special emphasis is given to important field crops.

Agron 504—THEORY AND METHODS OF PLANT BREEDING—3 cr. (3 and 0) F, 1965 and alternate 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 505—SOIL FERTILITY—3 cr. (3 and 0) S, 1966 and alternate 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 506—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 507—SOIL PHYSICS—3 cr. (2 and 3) F, 1966 and alternate years.

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

Agron 508—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 525—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 591—RESEARCH—Credit to be arranged, FS.

Agron 691—DOCTORAL RESEARCH—Credit to be arranged. FS.
Animal Physiology represents an interdisciplinary area of study, although the student will enroll in one of the departments listed above.

Inasmuch as there is considerable latitude under such a broad interdisciplinary program, it follows that no simple set of prerequisite courses can be listed. Such requirements will depend on the student’s choice of an area of concentration.

The student will organize his program of study from the courses listed below, those offered by the cooperating departments listed above, and those offered in supporting fields such as chemistry, bacteriology, and experimental statistics.

An Ph 502—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.

An Ph 503—ANIMAL PHYSIOLOGY—4 cr. (3 and 3)

A comprehensive course in animal physiology covering circulation, respiration, digestion, excretion and metabolism.

An Ph 504—ANIMAL PHYSIOLOGY—4 cr. (3 and 3)

A continuation of Animal Physiology 503 covering muscles, nerves, special senses, skin and bones.

An Ph 505—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. Prerequisite: An Ph 504

An Ph 551—ANIMAL PHYSIOLOGY SEMINAR I—1 cr. (1 and 0)

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

An Ph 552—ANIMAL PHYSIOLOGY SEMINAR II—1 cr. (1 and 0)
This course is a continuation of An Ph 551 and will include further discussion of current research and literature on topics selected by instructor and students.

An Ph 691—DOCTORAL RESEARCH—Credit to be arranged.

ANIMAL SCIENCE

R. F. Wheeler, Department Head

Courses are offered leading to the Master of Science degree.

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

An Sc 401—BEEF PRODUCTION—3 cr. (3 and 0)
An Sc 403—BEEF PRODUCTION LABORATORY—1 cr. (0 and 3)
An Sc 408—PORK PRODUCTION—3 cr. (3 and 0)
An Sc 410—PORK PRODUCTION LABORATORY—1 cr. (0 and 3)
An Sc 452—ANIMAL BREEDING—3 cr. (3 and 0)
An Sc 502—TOPICAL PROBLEMS—1-3 cr. (1-3 and 0)
A critical study of animal science experiments and interpretation of their results.
An Sc 503—MEAT TECHNOLOGY—3 cr. (3 and 0)
Biochemistry, histology and microbiology of fresh, frozen, cured, smoked and processed meats and by-products. Processing methods and techniques. Prerequisites: An Sc 353 and 355.
An Sc 504—METHODS IN ANIMAL BREEDING—3 cr. (3 and 0)
Gene and zygotic frequency; systems of mating; heritabilities; genetic consequences of selection; and criteria for evaluating improvement in beef cattle, swine, and sheep. Prerequisite: An Sc 452.
An Sc 505—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 403.
An Sc 591—RESEARCH—Credit to be arranged.
ARCHITECTURE
H. E. McClure, Dean

Courses are offered leading to the Master of Architecture degree.

Arch 511—HISTORY SEMINAR I—3 cr. (3 and 0)
Seminar discussion and creative writing concerning questions of function, structure and beauty in historic and contemporary architecture.

Arch 512—HISTORY SEMINAR II—3 cr. (3 and 0)
Continuation of Arch 511.

Arch 515—STRUCTURAL SEMINAR I—3 cr. (2 and 3)
An advanced comparative analytical study of contemporary structural systems and the materials utilized therein. Discussion and laboratory work.

Arch 516—STRUCTURAL SEMINAR II—3 cr. (2 and 3)
Continuation of Arch 515. A terminal report with adjunct studies will be required.

Arch 551—PLANNING & HOUSING SEMINAR I—3 cr. (2 and 3)
Discussion of problems of urban design and housing. Special research topics will be assigned.

Arch 552—PLANNING & HOUSING SEMINAR II—3 cr. (2 and 3)
Continuation of Arch 551, with the requirement of a final term paper of planning study.

Arch 561—GRADUATE ARCHITECTURAL DESIGN—9 cr. (3 and 18)
Project work oriented to the individual student in advanced areas of architectural design and arranged to develop the creative capacities of mature graduate students.

Arch 592—GRADUATE THESIS—9 cr. (3 and 18)
A thesis of the student's own choosing provides the terminal vehicle for comprehensive research in architectural, structural or planning design. A complete oral, written and visual presentation of the solution is normally required, although in special cases, the presentation may take one form.

BACTERIOLOGY
W. M. Epps, Department Head

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

Graduate work in Microbiology requires sound undergraduate training in the biological and physical sciences. This training may be received
in an undergraduate program in biology (botany or zoology), or chemistry, or in one of the agricultural sciences. Undergraduate work in bacteriology or microbiology is desirable but not necessary.

*Bact 312—FOOD MICROBIOLOGY—3 cr. (2 and 3) S, odd numbered years.

Bact 401—ADVANCED BACTERIOLOGY—4 cr. (2 and 6) F

Bact 402—DAIRY BACTERIOLOGY—3 cr. (2 and 3) S, even numbered years.

Bact 406 SANITARY BACTERIOLOGY—3 cr. (2 and 3) F, odd numbered years.

Bact 410—SOIL MICROBIOLOGY—3 cr. (2 and 3) S, even numbered years.

Bact 411—PATHOGENIC BACTERIOLOGY—3 cr. (2 and 3) S, odd numbered years.

Bact 501—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 301, 401, and organic chemistry.

Bact 502—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 301, 401, and organic chemistry.

Bact 503—SPECIAL PROBLEMS IN BACTERIOLOGY—2 cr.

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

Bact 505—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 301, 401.

*May be used for graduate credit under special conditions only.
Bact 510—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. Effect of soil microorganisms on plant growth. Relations of plant rhizospheres to nutritional groups of microorganisms. Prerequisite: Bact 410.

Bact 591—RESEARCH—Credit to be arranged.

BIOCHEMISTRY

F. I. Brownley, Jr., Chairman, Chemistry
W. P. Williams, Chairman, Food Science and Biochemistry

Advanced degrees are not awarded in biochemistry. Courses may be taken as a minor or to supplement a major in the biological sciences or chemistry.

Ch 423—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 424—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 425—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)
Ch 426—GENERAL BIOCHEMISTRY LABORATORY—1 cr. (0 and 3)

Bioch 503—INTERMEDIARY METABOLISM—4 cr. (3 and 3)
A discussion of the general metabolic pathways in the overall metabolism of living organisms. The metabolic pathways of carbohydrates, the hydrogen transport system, and the role of minerals, vitamins, and hormones in these pathways are emphasized. Laboratory exercises illustrate the role of enzymes in metabolic pathways and involve isolation of intermediates. Prerequisite: General biochemistry and quantitative analysis.

Bioch 504—INTERMEDIARY METABOLISM II—4 cr. (3 and 3)
A continuation of Bioch 503. Discussion of the metabolic pathways followed by proteins, lipids, and nucleic acids, and the role of these materials in the cell. Laboratory exercises illustrate the relationship of nutrients and other compounds in cellular metabolism. Prerequisite: Bioch 503.

Bioch 506—BIOCHEMISTRY OF NUTRITION—3 cr. (3 and 0)
Nutrition is discussed in relationship to the needs of men and animals for specific nutrients and the influence of environmental conditions on nutrient requirement. The biochemistry of nutrients during digestion and assimilation and factors influencing these processes are emphasized. Prerequisite: General Biochemistry and quantitative analysis.
Bioch 508—BIOCHEMISTRY OF NUTRITION LABORATORY—2 cr. 
(0 and 6)
Research methodology in nutrition investigations is explained and illustrated. Experiments with small animals as well as various chemical and biological methods for determining the nutritional value of foods and feedstuffs are emphasized. **Prerequisite:** Registration in Bioch 506.

Bioch 510—ADVANCED BIOCHEMICAL TECHNIQUES AND PREPARATIONS—3 cr. (1 and 6)
A discussion of methods and techniques relating to the isolation, purification, and analysis of biological materials. Practice in the use of gas chromatography, paper chromatography, column chromatography, Warburg respiration apparatus, amino acid analyzer, spectrophotometry, and radioisotopes in biochemical work will be emphasized. **Prerequisite:** General biochemistry and quantitative analysis.

Ch 526—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.

Ch 529—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.

**BIO-ENGINEERING**

L. G. Rich, Chairman

Courses are offered leading to the Doctor of Philosophy degree

The program in bio-engineering offers a concentration in either the fermentation field or the technology associated with artificial environments. Because of the interdisciplinary nature of the program, it is open to students possessing degrees in engineering and to those with degrees in science who have credits for certain prescribed courses in engineering.

The field of bio-engineering was formerly limited to the application of engineering technology to the fermentation processes employed in the production of pharmaceuticals and industrial chemicals. Now, however, use of the field has been broadened to include the technology associated with the design and maintenance of artificial environments for man. The estab-
lishment and control of such environments require the application of engineering to biological systems producing the physiological necessities of man. The educational preparation of a person entering the field of bioengineering must include, in addition to a strong background in the unit operations of process engineering, a firm foundation in the principles of chemistry and microbiology. Effective participation in the technology of artificial environments requires also a knowledge of environmental hygiene.

Candidates for a degree in this field may choose certain courses from those offered in bacteriology, botany, chemical engineering, chemistry, and civil engineering. Candidates for the Ph.D. degree must take or have taken the courses listed below.

Bact 301—GENERAL BACTERIOLOGY—4 cr. (3 and 3)
Bact 401—ADVANCED BACTERIOLOGY—4 cr. (2 and 6)
Bot 352—PLANT PHYSIOLOGY—4 cr. (3 and 3)
Ch 323—ORGANIC CHEMISTRY—3 cr. (3 and 0)
Ch 324—ORGANIC CHEMISTRY—3 cr. (3 and 0)
Ch 423—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 424—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 531—CHEMICAL THERMODYNAMICS—3 cr. (3 and 0)
Ch 532—STATES OF MATTER—3 cr. (3 and 0)

**BOTANY**

W. M. Epps, Department Head

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

Students who desire to pursue graduate work in plant pathology or plant physiology should have sound undergraduate training in 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 or plant physiology are desirable but not necessary.

*Bot 352—PLANT PHYSIOLOGY—4 cr. (3 and 3) FS
*Bot 356—TAXONOMY—3 cr. (1 and 6) FS

*May be used for graduate credit under special conditions only.
Bot 401—PLANT PATHOLOGY—3 cr. (2 and 3) FS
Bot 404—CYTOLOGY—4 cr. (3 and 3) F, odd numbered years
Bot 405—FOREST PATHOLOGY—3 cr. (2 and 3) F
Bot 406—PLANT ANATOMY—3 cr. (2 and 3) F, even numbered years.
Bot 451—MORPHOLOGY OF THE FUNGI—3 cr. (2 and 3) F, even numbered years
Bot 452—PLANT ECOLOGY—3 cr. (3 and 0) S, even numbered years
Bot 455—PLANT MORPHOLOGY—4 cr. (2 and 6) S, odd numbered years
Bot 456—PLANT VIROLOGY—3 cr. (3 and 0) S, even numbered years
Bot 502—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 of this region. Emphasis is placed on field collection, identification, morphology, and cytology through lectures, student reports, and laboratory work. Prerequisite: Bot 451.

Bot 503—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 401 or 405.

Bot 504—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 352, 401 or 405; organic chemistry.

Bot 505—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 505 for special problems performed in connection with other graduate courses.
Bot 506—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 352, 401 or 405, Organic Chemistry.

Bot 511—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 352, organic chemistry, or permission of instructor.

Bot 512—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 352, organic chemistry, or permission of instructor.

Bot 513—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 352, organic chemistry, or permission of instructor.

Bot 514—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 591—RESEARCH—Credit to be arranged.

Bot 691—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 402—SOLID STATE CERAMICS—3 cr. (3 and 0)

CrE 403—GLASSES—3 cr. (3 and 0)
CrE 404—ENAMELS—3 cr. (3 and 0)
CrE 410—ANALYTICAL PROCESSES—3 cr. (3 and 0)
CrE 412—RAW MATERIAL PREPARATION—3 cr. (3 and 0)
CrE 416—ELECTRONIC CERAMICS—3 cr. (3 and 0)
CrE 418—PROCESS CONTROL—3 cr. (3 and 0)
CrE 419—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)
CrE 420—SCIENCE OF ENGINEERING MATERIALS—3 cr. (3 and 0)
CrE 509—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 510—CERAMIC ENGINEERING THERMODYNAMICS—3 cr. (3 and 0)
The application of thermodynamics with special reference to physical and chemical changes in ceramic systems.
CrE 511—CERAMIC ENGINEERING KINETICS—3 cr. (3 and 0)
Theory and measurement of the rates and mechanisms of reactions in ceramic processes.
CrE 512—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 513—NUCLEAR CERAMICS—3 cr. (3 and 0)
A study of the properties, selection, and uses of ceramic materials in nuclear reactors
CrE 514—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 515—COLLOIDAL AND SURFACE SCIENCE—3 cr. (3 and 0)
The theory and application of colloidal and surface chemistry to ceramic materials and processes.
ChE 516—CONSTITUTION AND STRUCTURE OF GLASSES—3 cr. (3 and 0)
A study of modern concepts of glass structure and properties.
CrE 521—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 522—ANALYTICAL PROCEDURES AND EQUIPMENT II—3 cr.
   (2 and 3)
   A continuation of CrE 521.

CrE 523—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 524—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 525—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 526—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 528—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 591—RESEARCH—Credit to be arranged.

CHEMICAL ENGINEERING

C. E. Littlejohn, Department Head

Courses are offered leading to the Master of Science and 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. A thesis is required for all graduate degrees in chemical engineering.

ChE 401—TRANSPORT PHENOMENA—3 cr. (3 and 0)
ChE 407—UNIT OPERATIONS LABORATORY II—2 cr. (0 and 6)
ChE 409—CHEMICAL ENGINEERING DESIGN II—2 cr. (0 and 6)
ChE 415—INTRODUCTION TO NUCLEAR ENGINEERING I—3 cr. (3 and 0)
ChE 416—INTRODUCTION TO NUCLEAR ENGINEERING II—3 cr. (3 and 0)
ChE 423—THEORY OF BIO-OXIDATION PROCESSES—2 cr. (2 and 0)
ChE 430—CHEMICAL ENGINEERING THERMODYNAMICS II—3 cr. (3 and 0)
ChE 450—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)
ChE 452—MOLECULAR AND TURBULENT TRANSPORT—3 cr. (3 and 0)
ChE 502—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 503—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 504—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 505—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 506—CHEMICAL ENGINEERING CALCULATIONS I—3 cr. (3 and 0)

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

ChE 507—CHEMICAL ENGINEERING CALCULATIONS II—3 cr. (3 and 0)

A continuation of ChE 506. Emphasis is given to the formulation and solution of more complex problems in the area of steady and unsteady transport.
ChE 508—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 509—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 510—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 520, 521, 522, 523—UNIT OPERATIONS—3 cr. (3 and 0)
Selected advanced topics in the four areas of transport, energy transport, mass transport and differential contact operation, and stage-wise contact operations. Special emphasis is placed on the application of theory and the results of recent research through the solution of comprehensive problems. Required of all chemical engineering students seeking the M.S. degree.

ChE 530—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 540—GRADUATE LABORATORY—3 cr. (0 and 9)
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 545, 546, 547—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 552—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 553—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 554—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 591—RESEARCH—Credit to be arranged.

ChE 602—PROCESS DYNAMICS AND CONTROL—3 cr. (3 and 0)
An extension of ChE 502; 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 502.

ChE 603—TRANSPORT PHENOMENA—3 cr. (3 and 0)
A consideration of problems in transport phenomena from the current literature.

ChE 604—CHEMICAL ENGINEERING THERMODYNAMICS—3 cr. (3 and 0)
A continuation of ChE 504. Includes non-ideal behavior of mixtures, statistical thermodynamics and irreversible processes.

ChE 605—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)
A continuation of ChE 505.

ChE 645, 646, 647—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 545-546.

ChE 654—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 554.

ChE 691—DOCTORAL RESEARCH—Credit to be arranged.
CHEMICAL PHYSICS

F. I. Brownley, Jr., Chairman (Chemistry)

L. D. Huff, Chairman (Physics)

Courses are offered leading to the Doctor of Philosophy 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.

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

CHEMISTRY

F. I. Brownley, Jr., 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. This examination will consist of a written examination, followed by an oral examination, both examinations to be held within a period of two weeks.

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 310—AGRICULTURAL BIOCHEMISTRY—4 cr. (3 and 3)
*Ch 323—ORGANIC CHEMISTRY—3 cr. (3 and 0)
*Ch 324—ORGANIC CHEMISTRY—3 cr. (3 and 0)
*Ch 330—INTRODUCTION TO PHYSICAL CHEMISTRY—4 cr. (4 and 0)
*Ch 331—PHYSICAL CHEMISTRY—3 cr. (3 and 0)
*Ch 332—PHYSICAL CHEMISTRY—3 cr. (3 and 0)
*Ch 333—PHYSICAL CHEMISTRY LABORATORY—2 cr. (0 and 6)
*Ch 334—PHYSICAL CHEMISTRY LABORATORY—2 cr. (0 and 6)
*Ch 339—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)
*Ch 340—PHYSICAL CHEMISTRY LABORATORY—1 cr. (0 and 3)
*Ch 402—INORGANIC CHEMISTRY—3 cr. (3 and 0)
Ch 411—INSTRUMENTAL ANALYSIS—4 cr. (2 and 6)
Ch 421—QUALITATIVE ORGANIC ANALYSIS—4 cr. (2 and 6)
Ch 423—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 424—GENERAL BIOCHEMISTRY—3 cr. (3 and 0)
Ch 454—INORGANIC SYNTHESIS—2 cr. (0 and 6)
Ch 472—ORGANIC SYNTHESIS—4 cr. (2 and 6)
Ch 491—INTRODUCTION TO RADIOCHEMISTRY—3 cr. (2 and 3)
Ch 505—INORGANIC CHEMISTRY—3 cr. (3 and 0)
A study of atomic crystal and molecular structure and its relationship to inorganic chemistry.
Ch 506—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 507—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 structure techniques and theories will be used to study these compounds. Prerequisites: Ch 331, 332, 402 or their equivalent.

Ch 508—CHEMISTRY OF THE NON-METALLIC ELEMENTS—3 cr.
(3 and 0)
The inorganic chemistry of the non-metallic elements, especially boron, silicon, phosphorous, and sulfur. Prerequisite: Ch 402.

Ch 511—ANALYTICAL CHEMISTRY—3 cr. (3 and 0)
Includes error analysis, the elementary statistical theory involved in procedures, and design of experiments and certain industrial control methods. Selected methods for the determination of a few elements not covered in the elementary courses are discussed as well as the less commonly used physio-chemical methods. Prerequisites: Ch 331, 332.

*Courses which may be used by students majoring in other fields.
Ch 512—CHEMICAL SPECTROSCOPIC METHODS—3 cr. (2 and 3)
   Designed to give the student an understanding of the principles of spec-
troscopic procedures. Both absorption and emission techniques will be
considered. Emphasis will be placed on ultraviolet and infrared as well as
visible spectra.

Ch 521—ORGANIC CHEMISTRY I—3 cr. (3 and 0)
   An intensive survey of modern organic chemistry with the emphasis on
theoretical concepts and mechanisms.

Ch 522—ORGANIC CHEMISTRY II—3 cr. (3 and 0)
   A continuation of Ch 521. Prerequisite: Ch 521.

Ch 523—ORGANIC REACTION MECHANISMS—3 cr. (3 and 0)
   The mechanisms of organic chemical reactions, both aliphatic and arro-
matic.

Ch 524—FUNDAMENTAL PRINCIPLES OF POLYMER CHEMISTRY—
   3 cr. (3 and 0)
   The organic chemistry of natural and synthetic macromolecules.

Ch 525—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 526—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 423.

Ch 529—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. Prerequisites: Ch 244,
423.

Ch 531—CHEMICAL THERMODYNAMICS—3 cr. (3 and 0)
   Primarily a study of classical thermodynamics, with emphasis on theory
and significance of energetics, and on systems of variable composition.
Prerequisite: Ch 331 or its equivalent.

Ch 532—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 534—STATISTICAL THERMODYNAMICS—3 cr. (3 and 0)
   A treatment of statistical thermodynamics. Prerequisite: Ch 531.
Ch 535—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 536—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 537—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 541—ATOMIC AND MOLECULAR STRUCTURE—3 cr. (3 and 0)
The purpose of this course is to strengthen the student’s understanding of atomic structure and to extend his knowledge of the structure of molecules. Major emphasis will be given to studying the relationship of structure to physical and chemical properties with examples drawn from both the organic and inorganic fields.

Ch 551-552—SEMINAR—0, 1, or 2 cr. (May be taken more than one semester.)

Ch 591—RESEARCH—Credit to be arranged.

Ch 621—HETEROCYCLIC COMPOUNDS—3 cr. (3 and 0)
The organic chemistry of heterocyclic compounds.

Ch 622—STEREOCHEMISTRY—3 cr. (3 and 0)
A study of all phases of stereochemistry as applied to organic compounds.

Ch 623—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 622 or permission of the instructor.

Ch 624—CHEMISTRY OF NATURAL PRODUCTS—3 cr. (3 and 0)
A continuation of Ch 623.

Ch 625—CURRENT TRENDS IN ORGANIC CHEMISTRY I—1 cr. (1 and 0)
A study of current trends and developments in organic chemistry.
Ch 630—ADVANCED PHYSICAL CHEMISTRY I—3 cr. (3 and 0)
This course is primarily a study of chemical kinetics and will include: rates and mechanisms, homogeneous and heterogeneous catalysis, and surface phenomena. **Prerequisite:** 534.

Ch 631—ADVANCED PHYSICAL CHEMISTRY II—3 cr. (3 and 0)
An advanced study of selected topics. Topics which may be included: irreversible thermodynamics, theory of liquids, electro-chemistry, or recent advances in other topics. **Prerequisite:** Ch 533.

Ch 650—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 691—DOCTORAL RESEARCH—Credit to be arranged. (May be taken more than one semester.)

**CIVIL ENGINEERING**

**J. H. Moore, Department Head**

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

Programs of study may be followed which have majors in structures and engineering mechanics, or transportation 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 331—SOIL MECHANICS—3 cr. (2 and 3)*

CE 412—URBAN TRANSPORTATION PLANNING—3 cr. (3 and 0)

CE 419—GENERAL PHOTOGRAMMETRY—3 cr. (2 and 3)

CE 431—APPLIED SOIL MECHANICS—3 cr. (2 and 3)

CE 434—CONSTRUCTION COSTS AND ESTIMATES—3 cr. (2 and 3)

CE 435—ENGINEERING PROJECT ANALYSIS—3 cr. (2 and 3)

CE 443—ENVIRONMENTAL ENGINEERING CHEM. I—2 cr. (2 and 0)

CE 444—ENVIRONMENTAL ENGINEERING CHEM. LAB I—2 cr. (0 and 6)

*Approved for non-Civil Engineering majors only.*
CE 453—ADVANCED STRUCTURAL ANALYSIS—3 cr. (3 and 0)
CE 490—SPECIAL PROJECTS—1-3 cr. (1-3 and 0-0)
CE 501—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 502—STRUCTURAL ENGINEERING II—3 cr. (3 and 0) S
   Design of concrete structures by ultimate strength theory; design of pre-stressed concrete structural members. Composite design with concrete and metals. Prerequisite: CE 309, CE 404.

CE 503—MODEL ANALYSIS—3 cr. (2 and 3)
   Methods of determining moments and stresses from a study of models; principals of similitude; use of the Beggs deformator.

CE 504—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. Prerequisite: Math 306 and a knowledge of Fourier series.

CE 505—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: Math 306 and a knowledge of Fourier series.

CE 506—STRUCTURAL VIBRATION—3 cr. (3 and 0)
   Analysis and design of structures subjected to dynamic loading. Response will be investigated for both lumped and distributed parameter systems of one or many degrees of freedom. Approximate design methods, earthquake analysis and design, and blast-resistant design. Prerequisite: Permission of the instructor.

CE 507—NUMERICAL AND APPROXIMATE METHODS OF STRUCTURAL ANALYSIS—3 cr. (3 and 0)
   Application of finite difference equations, iterative procedures and relaxation methods to the solution of structural problems. Introduction to the matrix formulation of structural problems. Application of matrix methods to the vibration of structures, and analysis and stability of statically loaded beams, frames, space frames and stiffened shell structures.

CE 510—TRAFFIC ENGINEERING: OPERATIONS—3 cr. (3 and 0) F
   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 411.

**CE 511—TRAFFIC ENGINEERING: GEOMETRIC DESIGN—3 cr.**

(2 and 3) S

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 411.

**CE 512—BITUMINOUS PAVING MATERIALS—3 cr.** (2 and 3)

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

**CE 513—HIGHWAY AND AIRPORT PAVEMENT DESIGN—3 cr.**

(3 and 0) S

Structural design of rigid and flexible pavements; design of bases and subbases; theory of stresses and application of plate bearing, triaxial, and California Bearing Rates design methods to flexible pavements; Westergard analysis for rigid pavements; pavement evaluation methods. **Prerequisites:** CE 331, 411.

**CE 519—HIGHWAY RESEARCH—2 to 4 cr.**

Independent investigation of some problems in highway engineering.

**CE 520—CEMENT, AGGREGATES, AND CONCRETE—3 cr.** (2 and 3)

Properties of concrete materials; mix design methods; properties of plastic and hardened concrete. **Prerequisite:** CE 320.

**CE 531—SOIL 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. **Prerequisites:** CE 331, CE 431.

**CE 532—ADVANCED SOIL MECHANICS—4 cr.** (3 and 3) S

Stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, design of flexible retaining walls and bulkheads, solution of problems by elastic theory. **Prerequisites:** CE 331, CE 431.

**CE 533—PHYSICAL AND PHYSIO-CHEMICAL PROPERTIES OF SOILS—4 cr.** (3 and 3)

Formation of soils, soil minerals, soil structure, permeability, swelling pressures, pore pressure theory as related to shear strength and consolidation, critical analysis of consolidation and shear strength tests. **Prerequisites:** CE 331, CE 431.

**CE 534—AIR PHOTO INTERPRETATION OF SOILS—3 cr.** (2 and 3)

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

CE 542—SANITARY ENGINEERING PROCESSES—3 cr. (3 and 0) S

Theory and design of chemical and biological processes employed in sanitary engineering.

CE 543—UNIT OPERATIONS OF SANITARY ENGINEERING—3 cr.
(3 and 0) F

Theory and design of unit operations employed in sanitary engineering treatment processes.

CE 546—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 547—SELECTED TOPICS IN WATER RESOURCES ENGINEERING—3 cr. (3 and 0) FS

A comprehensive study of topics in the field of water resources engineering not covered in other courses. Special emphasis to be placed on studies of the current literature and the findings of current research. Topics covered will vary from year to year to keep pace with new developments and to fit best the needs of graduate classes.

CE 548—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 549—ENVIRONMENTAL ENGR. CHEM. LAB. II—2 cr. (1 and 3)

Theoretical principles developed in CE 548 are applied to laboratory measurement and control of environmental engineering systems. Instrumental analysis and advanced analytical techniques are stressed. Prerequisite: CE 548 or permission of the instructor.

CE 550—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 551—UNIT OPERATIONS & PROCESSES LABORATORY—2 cr.
(1 and 3)

Laboratory exercises in solids-liquid separations ion-exchange, electrodialysis, and biological processes. Stress will be placed on the relation between theory and experimental results.
CE 589 and 590—SPECIAL PROBLEMS I AND II—1-3 cr.

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

CE 591—RESEARCH—Credit to be arranged.

CE 691—DOCTORAL RESEARCH—Credit to be arranged.

DAIRY SCIENCE

W. A. King, Department Head

Courses are offered leading to 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. Several undergraduate courses in dairy sciences would be required of a student desiring to study for the M. S. degree 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.

*Dy Sc 306—CHEMICAL AND PHYSICAL NATURE OF MILK—3 cr.
(2 and 3)

*Dy Sc 307—MARKET MILK—3 cr. (2 and 3)

Dy Sc 402—DAIRY MANUFACTURES—4 cr. (3 and 3)

Dy Sc 403—ANIMAL NUTRITION—3 cr. (3 and 0)

Dy Sc 404—DAIRY PLANT MANAGEMENT—3 cr. (2 and 3)

Dy Sc 407—CHEESE AND BUTTER MANUFACTURE—3 cr. (2 and 3)

*Courses which may be used by students majoring in other fields.
Dy Sc 452—DAIRY CATTLE FEEDING AND MANAGEMENT—3 cr.  
(2 and 3)

Dy Sc 453—ANIMAL REPRODUCTION—3 cr. (3 and 0)

Dy Sc 455—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3)

Dy Sc 501—TOPICAL PROBLEMS—1 to 3 cr. FS  
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.

Dy Sc 502—GENETICS OF DAIRY CATTLE IMPROVEMENT—3 cr.  
(3 and 0)

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

Dy Sc 503—PHYSIOLOGY OF REPROCUTION AND MILK SECRETION—3 cr. (3 and 0) S  
The influence of the endocrine glands on reproduction and on milk  
secretion.

Dy Sc 504—ENDOCRINOLOGY—3 cr. (3 and 0) S  
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.

Dy Sc 505—NEWER KNOWLEDGE OF DAIRY NUTRITION—3 cr.  
(3 and 0) F  
The application of the latest information on digestion, metabolism, and  
the nutritional requirements of dairy cattle.

Dy Sc 507—FERMENTED DAIRY PRODUCTS—3 cr. (2 and 3) F  
The biological and chemical changes involved in the processing and aging  
of cheese and fermented dairy products.

Dy Sc 508—INDUSTRIAL DAIRY SCIENCE—3 cr. (3 and 0) S  
Provides advanced technological training in dairy plant processing, manu-  
facturing, and management.

Dy Sc 509—RUMEN METABOLISM—3 cr. (2 and 3) F  
Biochemical, physiological and microbiological functions in the rumen.  
Consideration will be given to ontogeny and structural anatomy. The lab-  
oratory will emphasize in vitro methodology used in studying the microbial  
metabolism of dietary constituents.

Dy Sc 591—RESEARCH—Credit to be arranged. FS

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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 403—DEVELOPMENT OF ECONOMIC THOUGHT—3 cr. (3 and 0) F
Econ 404—COMPARATIVE ECONOMIC SYSTEMS—3 cr. (3 and 0) F
Econ 407—NATIONAL INCOME AND EMPLOYMENT ANALYSIS—3 cr. (3 and 0) S
Econ 410—ECONOMIC DEVELOPMENT—3 cr. (3 and 0) S
Econ 412—INTERNATIONAL TRADE AND ECONOMIC DEVELOPMENT—3 cr. (3 and 0) F
Econ 416—DEVELOPMENT OF THE MODERN ECONOMY—3 cr. (3 and 0) S
Econ 420—ECONOMICS OF TAXATION—3 cr. (3 and 0) S
Econ 500—ADVANCED ECONOMIC ANALYSIS—3 cr. (3 and 0)
   An extensive and critical examination of demand and supply, and marginal analysis. Some consideration is given to linear programming as an analytical tool in solving economic problems.
Econ 510—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 511—SEMINAR IN LABOR ECONOMICS—3 cr. (3 and 0)
Econ 512—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 521—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.

Econ 522—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. Also, a survey of welfare economics.

Econ 591—RESEARCH—Credit to be arranged.

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

Courses are offered leading to the Master of Education degree with subject specialties in English, history and government, mathematics, or science teaching.

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.

Students who enroll in the programs specializing in the teaching of English or history and government must demonstrate competence in the following four areas:
  a. History and philosophy of education.
  b. Educational tests and measurements; analysis of the individual.
  c. Curriculum development; specialized or advanced methodology.
  d. Introduction to research in education; educational source materials.

Courses previously taken at the undergraduate level or courses that are taken to meet the M. Ed. requirements will be accepted in satisfying this requirement.

Ed 406—HISTORY AND PHILOSOPHY OF EDUCATION—3 cr. (3 and 0)
Ed 494—SCHOOL AND COMMUNITY RELATIONSHIPS—3 cr. (3 and 0)
Ed 497—AUDIO VISUAL AIDS IN EDUCATION—3 cr. (3 and 0)
Ed 503—ADVANCED METHODS IN TEACHING—3 cr. (3 and 0) F
The principles and practices involved in promoting effective learning.
Ed 505—PRINCIPLES OF GUIDANCE—3 cr. (3 and 0)
Principles, procedures, and policies of the guidance services. For all personnel workers.
Ed 508—EDUCATIONAL TESTS AND MEASUREMENTS—3 cr.
(3 and 0) S
Construction, use, and interpretation of tests, subjective and standardized. Familiarizing with measurement applications.
Ed 509—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. Prerequisites: Ed 505, 508.
Ed 510—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 505, 508, 509.
Ed 511—PUBLIC SCHOOL ADMINISTRATION (FINANCE)—3 cr.
(3 and 0)
A study of sound principles and suitable procedures relating to school administration and finance.
Ed 513—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. Prerequisites: Ed 505, 508.
Ed 530—TECHNIQUES OF SUPERVISION—THE PUBLIC SCHOOLS—3 cr. (3 and 0) SS
Designed for teachers, supervisors, and administrators who are interested in improving, coordinating and evaluation instruction. Modern trends of supervisory practices are emphasized.
Ed 531—EVALUATION OF SECONDARY SCHOOL INSTRUCTION—3 cr.
(3 and 0) SS
A study of the techniques of determining the effectiveness of classroom instruction, with emphasis on curriculum.
Ed 590—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 analy-
sis 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 450—BIOLOGY FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)

Biol 500—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 450—REVIEW OF GENERAL CHEMISTRY I—3 cr. (3 and 0)

Ch 550—REVIEW OF GENERAL CHEMISTRY II—3 cr. (2 and 3)

Geol 500—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 550—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 remonstrated through numerous field excursions.

Phys 460—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr.
   (3 and 0)

Phys 501—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 502—PHYSICS FOR HIGH SCHOOL TEACHERS II—3 cr. (3 and 0)
   A continuation of Physics 501 covering electricity and magnetism, optics, and an introduction to atomic and nuclear physics.
Phys 504—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 de-
scriptive 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 sup-
plement the lectures.

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

The following course is offered during the Summer Sessions as a service
to elementary school teachers. It is not applicable to a graduate degree at
Clemson.

Ed 460—CURRICULUM DEVELOPMENT IN THE ELEMENTARY
SCHOOL—3 cr. (3 and 0)

ELECTRICAL ENGINEERING

J. N. Thurston, Department Head

Courses are offered leading to the Master of Science degree.

Graduate students in electrical engineering normally complete a minor
in mathematics or physics, although consideration will be given to minors
in other fields. Since a thesis is required, each student is urged to consult
with his adviser early in the program in order to facilitate the search for a
suitable topic.

EE 402—ENGINEERING ANALYSIS—1 cr. (1 and 0)
EE 403—ENERGY CONVERSION—3 cr. (3 and 0)
EE 409—ELECTRICAL ENGINEERING LABORATORY V—1 cr. (0 and 3)
EE 410—FEEDBACK CONTROL SYSTEMS—3 cr. (3 and 0)
EE 419—ELECTRICAL MACHINERY LABORATORY—1 cr. (0 and 3)
EE 420—POWER SYSTEM ANALYSIS—3 cr. (3 and 0)
EE 421—ELECTRICAL MACHINERY—3 cr. (3 and 0)
EE 431—ELECTRONICS III—3 cr. (3 and 0)
EE 433—ELECTRONICS III LABORATORY—1 cr. (0 and 3)
EE 436—RADIATION AND WAVE PROPAGATION—3 cr. (3 and 0)
EE 501—TRANSIENTS IN LINEAR SYSTEMS—3 cr. (3 and 0)

A study of linear electrical and mechanical systems using the Laplace transformation to determine transient as well as steady-state response.

EE 503—SEMINAR—1 cr. (1 and 0)

The graduate student's understanding of the interrelationships of physics, mathematics and engineering is probed by means of oral and written questions, and by student presentation of topics related to research problems.

EE 507—STATISTICAL THEORY OF COMMUNICATION—3 cr. (3 and 0)

An integrated study of information theory, system analysis with random excitations and system synthesis from a statistical statement of the desired performance. Elementary idealized systems are discussed rather than more detailed practical ones, and an effort is made to give an account of the present state of the art. Throughout the course basic principles are emphasized.

EE 510—ANALYTICAL DESIGN OF LINEAR FEEDBACK CONTROLS I
—3 cr. (3 and 0)

A study of procedures for optimizing feedback control system design. Performance indices and allowable errors are used as design specifications, and trial-and-error methods are avoided. The analysis is based upon principles of probability and statistics, and requires a familiarity with conventional design techniques.

EE 511—ELECTRIC POWER STATIONS—3 cr. (3 and 0)

A study of station lay-out, generating equipment, exciters, transformers, meters, switching and protective devices. Economical arrangement and operation are emphasized.

EE 512—ANALYTICAL DESIGN OF LINEAR FEEDBACK CONTROLS II
—3 cr. (3 and 0)

This is the second semester sequence to EE 510. The analysis is extended to limitation of saturation tendencies and minimum bandwidth requirements. Application is made to a practical problem.

EE 513—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 515—NETWORK ANALYSIS AND SYNTHESIS I—3 cr. (3 and 0)

Advanced treatment of linear passive network theory. After review and broadening of undergraduate analysis, emphasis is upon synthesis. It includes the fundamental work of Foster and Cauer. Synthesis from the expression for driving-point impedance is covered. This is done for RC and RLC networks.
EE 516—NETWORK ANALYSIS AND SYNTHESIS II—3 cr. (3 and 0)
This course is a sequel to EE 515. It includes the fundamental works of Brune and Darlington. Synthesis is also extended to transfer impedance.

EE 518—ELECTRONIC CIRCUITS—3 cr. (3 and 0)
Applications of recently developed electronic elements in amplifiers, switching circuits and other modern devices.

EE 519—ELECTRONIC CIRCUITS LABORATORY—1 cr. (0 and 3)
A laboratory course designed to accompany EE 518.

EE 521—RADIATION AND WAVE PROPAGATION—3 cr. (3 and 0)
An advanced study of electric fields, vector analysis, Maxwell’s equations and their use in the study of wave guides, radiation and wave propagation.

EE 525—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 528—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.

EE 529—PULSE TECHNIQUES LABORATORY—1 cr. (0 and 3)
A laboratory course designed to accompany EE 528.

EE 536—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 545—SELECTED TOPICS IN ELECTRICAL ENGINEERING—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 591—RESEARCH—Credit to be arranged.

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ENGINEERING MANAGEMENT
C. H. Whitehurst, Jr., Chairman

Courses are offered leading to the Doctor of Philosophy degree.

This degree is offered 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.

Four basic academic areas constitute the “core” of the program: management, engineering, economics, and mathematics and statistics. The program normally requires at least sixty hours of graduate course work.

Courses will be selected from the four “core” areas.

ENGINEERING MECHANICS
R. W. Moorman, Department Head

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

Enrollment in these programs is open to students possessing baccalaureate or master's degrees in any branch of engineering and to those with degrees in physics or applied mathematics who have credit for certain prescribed courses in engineering.

The two general areas of concentration are mechanics of solids and fluid mechanics or applied hydraulics. 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 420—HYDRAULIC ENGINEERING—3 cr. (3 and 0)
EM 450—MECHANICAL VIBRATIONS—3 cr. (3 and 0)
EM 470—EXPERIMENTAL STRESS ANALYSIS—3 cr. (2 and 3)
EM 501—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, brit-
tle 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 521—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 523—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 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:** EM 521 and 527, or consent of instructor.

**EM 525—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 527—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 529—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 521 and 527, or consent of instructor.

**EM 531—THEORY OF ELASTICITY I—3 cr. (3 and 0)**

EM 532—THEORY OF ELASTICITY II—3 cr. (3 and 0)

EM 534—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. Prerequisites: EM 529, 531.

EM 545—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. Prerequisites: EM 202, 527, or consent of instructor.

EM 552—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. Prerequisites: EM 320, 521, 527, or consent of instructor.

EM 553—THEORY OF VISCOUS FLUID FLOW—3 cr. (3 and 0)
A continuation of EM 552. 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 552.

EM 556—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 561—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. Also required is the conduct of an individual investigation and the preparation of a report of findings. Prerequisite: Permission of instructor. A student may not receive credit for this course and EM 460.
EM 562—ADVANCED HYDROLOGY—2 cr. (2 and 0)
Special work to strengthen the student's background in modern methods. The technical literature is used extensively for the latest developments. Emphasis is laid on evaporation, infiltration and the synthetic hydrograph. **Prerequisite:** EM 561.

EM 564—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. Topics include porous media, ground-water hydraulics, quality of ground-water, and relationship of surface-water and ground-water. The principles developed are applied to water supply, waste disposal, construction, and irrigation. **Prerequisite:** Approval of instructor.

EM 570—FLOOD CONTROL—3 cr. (3 and 0)
A study of the hydrology of floods and the engineering considerations relating to their control. Topics considered in the scope of control measures are economic justification, types of control structures, and survey of flood control measures on major streams in the U. S. **Prerequisite:** EM 460 or EM 561.

EM 572—HYDRAULIC PROJECTS—3 cr. (3 and 0)
Devoted to the detailed investigation of engineering problems in hydraulics and related fields. Application of theoretical principles developed in previous courses is emphasized. Subjects include: Spillway and stilling basins, reservoirs; inverted siphons. **Prerequisites:** EM 420 or 561, 556.

EM 589, 590—SEMINAR—0 or 1 cr. (1 and 0) (May be taken more than one semester.)

EM 591—Credit to be arranged.

EM 632—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. **Prerequisites:** EM 521, 531.

EM 680, 681, 682—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 691—DOCTORAL RESEARCH. Credit to be arranged. (May be taken more than one semester.)
ENGLISH

H. M. Cox, Department Head

Courses are offered leading to 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.

Engl 405—SHAKESPEARE—3 cr. (3 and 0) F
Engl 406—SHAKESPEARE—3 cr. (3 and 0) S
Engl 409—CHAUCER—3 cr. (3 and 0) F
Engl 415—INTRODUCTION TO DRAMA—3 cr. (3 and 0) F
Engl 416—INTRODUCTION TO DRAMA—3 cr. (3 and 0) S
Engl 423—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0) F
Engl 424—A SURVEY OF AMERICAN LITERATURE—3 cr. (3 and 0) S
Engl 425—THE ROMANTIC REVIVAL—3 cr. (3 and 0) F
Engl 427—VICTORIAN POETRY AND PROSE—3 cr. (3 and 0) S
Engl 431—THE RESTORATION AND EIGHTEENTH CENTURY—3 cr. (3 and 0) S
Engl 435—SOUTHERN LITERATURE—3 cr. (3 and 0) F
Engl 436—MILTON AND HIS AGE—3 cr. (3 and 0) S
Engl 437—THE ENGLISH NOVEL—3 cr. (3 and 0) F
Engl 438—CONTEMPORARY POETRY—3 cr. (3 and 0) F
Engl 439—CONTEMPORARY FICTION—3 cr. (3 and 0) S
Engl 440—LITERARY CRITICISM—3 cr. (3 and 0) S
Engl 441—WORLD LITERATURE—3 cr. (3 and 0) F
Engl 442—WORLD LITERATURE—3 cr. (3 and 0) S
Engl 443—17th CENTURY POETRY AND PROSE—3 cr. (3 and 0)
Engl 503—SEMINAR IN AMERICAN LITERATURE I—3 cr. (3 and 0)
Engl 504—SEMINAR IN AMERICAN LITERATURE II—3 cr. (3 and 0)
Engl 505—SEMINAR IN ENGLISH LITERATURE I—3 cr. (3 and 0)
    An intensive study of a selected group of major British writers.
Engl 506—SEMINAR IN ENGLISH LITERATURE II—3 cr. (3 and 0)
    Conducted on the same plan as Engl 505 with a different group of writers.
Engl 590—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 of Arts degree.
Engl 591—RESEARCH—Credit to be arranged.

ENTOMOLOGY

J. H. Cochran, Department Head

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

*Ent 305—ECONOMIC ENTOMOLOGY—3 cr. (2 and 3)
*Ent 306—ECONOMIC ENTOMOLOGY—3 cr. (2 and 3)
**Ent 405—INSECT MORPHOLOGY—4 cr. (3 and 3)
**Ent 408—GENERAL AND TAXONOMIC ENTOMOLOGY—5 cr. (3 and 6)
Ent 468—INTRODUCTION TO RESEARCH—2 cr. (1 and 3)
Ent 508—TAXONOMY OF IMMATURE INSECTS—3 cr. (1 and 6)
    Identification of immature insects with particular emphasis on the Holometabola. Each student will make and submit an identified collection of immature insects.

*May be used for graduate credit under special conditions only.
**Ent 405 and 408 are taught in alternate years.

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Ent 556—MEDICAL ENTOMOLOGY—3 cr. (2 and 3)
Disease vectors of animals with emphasis on insects and related Arthropod disease carriers. **Prerequisite:** Ent 301.

Ent 560—PRINCIPLES OF INSECT CONTROL—3 cr. (3 and 0)
The mechanical, physical, cultural, biological, chemical and legal aspects of insect control.

Ent 561—INSECT TOXICOLOGY—3 cr. (2 and 3)
History, development, application, chemical nature and mode of action of insecticides. **Prerequisites:** Chem 220 and Ent 405.

Ent 562—INSECT PHYSIOLOGY—3 cr. (2 and 3)
The physiology of nutrition, digestion, respiration, excretion, nervous and hormonal systems. **Prerequisites:** Chem 220 and Ent 405.

Ent 563—SPECIAL PROBLEMS IN ENTOMOLOGY—3-6 cr.
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 590—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 591—RESEARCH—Credit to be arranged.

Ent 691—DOCTORAL RESEARCH—Credit to be arranged.

**ENVIRONMENTAL SYSTEMS ENGINEERING**

**L. G. Rich, Program Director**

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

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.

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.

Ex St 401—INTRODUCTORY STATISTICS—3 cr. (2 and 3) FS
Ex St 462—STATISTICS APPLIED TO ECONOMICS—3 cr. (3 and 0) S
Ex St 501—STATISTICAL METHODS I—4 cr. (3 and 3) F

Role of statistics in research. Statistical inference, concepts, estimation, test of significance, principles of scientific investigations, analysis of variance including multiple comparison techniques, basic designs, linear regression and correlation, covariance analysis, mean square expectations, and variance component analysis. Prerequisite: Permission of instructor.

Ex St 502—STATISTICAL METHODS II—3 cr. (3 and 0) S

Individual degrees of freedom, orthogonality, and responses in the analysis of variance; factorials, split-plot arrangements, confounding, incomplete block designs, multiple regression, curvilinear regression, curve fitting, transformations, and non-parametric procedures. Prerequisite: Ex St 501.

Ex St 512—DESIGN AND ANALYSIS OF EXPERIMENTS—3 cr. (3 and 0) F

A course for graduate students in the experimental sciences in which detailed examination will be made of the basis of the techniques and scope of validity in the application of statics to the design, analysis and interpretation of experiments. Prerequisite: Ex St 502.
GEOLOGY

C. Q. Brown, Chairman

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

Geol 306—MINERALOGY—3 cr. (2 and 3)
Geol 307—OPTICAL MINERALOGY—3 cr. (2 and 3)
Geol 309—PETROLOGY—3 cr. (2 and 3)
Geol 311—STRATIGRAPHY AND SEDIMENTATION—3 cr. (3 and 0)
Geol 402—STRUCTURAL GEOLOGY—3 cr. (3 and 0)
Geol 403—INVERTEBRATE PALEONTOLOGY—3 cr. (2 and 3)
Geol 404—ECONOMIC GEOLOGY—2 cr. (2 and 0)
Geol 411—RESEARCH PROBLEMS—3 cr. (0 and 9)
Geol 412—RESEARCH PROBLEMS—3 cr. (0 and 9)

HISTORY AND GOVERNMENT

R. S. Lambert, Department Head

Courses are offered leading to the Master of Arts degree.

A student who wishes to pursue graduate study toward a Master of Arts degree in history must 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.

Gov 401—COMPARATIVE GOVERNMENT—3 cr. (3 and 0)
Hist 402—MEDIEVAL HISTORY—3 cr. (3 and 0)
Hist 403—HISTORY OF THE SOUTH—3 cr. (3 and 0) S
Hist 408—INTERNATIONAL RELATIONS SINCE 1914—3 cr. (3 and 0) S
Hist 410—HISTORY OF COLONIAL AMERICA—3 cr. (3 and 0) F
Hist 411—UNITED STATES, 1783-1850—3 cr. (3 and 0) S
Hist 412—UNITED STATES, 1850-1900—3 cr. (3 and 0) F
Hist 413—UNITED STATES SINCE 1900—3 cr. (3 and 0) S
Hist 507—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 508—INTERNATIONAL RELATIONS SINCE 1914—3 cr. (3 and 0)
Not open to students who took History 408.

Hist 511—HISTORIOGRAPHY AND SEMINAR IN U. S. HISTORY TO 1850—3 cr. (3 and 0) F
Hist 512—HISTORIOGRAPHY AND SEMINAR IN U. S. HISTORY SINCE 1850—3 cr. (3 and 0) S

Hist 520—COLONIAL AMERICAN CIVILIZATION—3 cr. (3 and 0)
Not open to students who took Hist 410.

Hist 522—U. S. 1850-1900—3 cr. (3 and 0)
Not open to students who took Hist 412.

Hist 591—RESEARCH—Credit to be arranged.

HOME ECONOMICS

The Master of Science degree in Home Economics with emphasis on nutrition is offered by the Department of Home Economics at Winthrop College in cooperation with Clemson University. The degree requires the completion of 15 semester hours in home economics, a thesis for which six semester hours of credit is given, and courses at Clemson in food technology, nutrition, and related areas. Twelve semester hours of work must be completed in courses for graduate students only.

Students interested in this program should write for further details to the Chairman of the Department of Home Economics, Winthrop College, Rock Hill, South Carolina.
HORTICULTURE
T. L. Senn, Department Head

Courses are offered leading to 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.

*Hort 308—LANDSCAPE DESIGN—3 cr. (2 and 3)
*Hort 310—FLORICULTURE—3 cr. (2 and 3)
*Hort 352—COMMERCIAL POMOLOGY—3 cr. (2 and 3)
Hort 405—NUT TREE CULTURE—2 cr. (2 and 0)
Hort 406—NURSERY TECHNOLOGY—3 cr. (2 and 3)
Hort 407—LANDSCAPE DESIGN—3 cr. (2 and 3)
Hort 412—TURF MANAGEMENT—3 cr. (2 and 3)
Hort 451—SMALL FRUIT CULTURE—3 cr. (2 and 3)
Hort 456—TRUCK CROPS—3 cr. (3 and 0)
Hort 460—LANDSCAPE DESIGN—5 cr. (3 and 6)
Hort 464—FOOD PRESERVATION—3 cr. (2 and 3)
Hort 468—INTRODUCTION TO RESEARCH—2 cr. (1 and 3)
Hort 501—PROBLEMS IN SMALL FRUIT PRODUCTION—3 cr. (3 and 0) F

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

*May be used for graduate credit under special conditions only.
Hort 502—ADVANCES IN HORTICULTURE—3 cr. (2 and 3) F
Technical advances in horticulture. Consideration will also be given to experimental techniques including uses of specialized equipment in horticultural research.

Hort 503—EXPERIMENTAL OLERICULTURE I—3 cr. (3 and 0) F, odd numbered years
A systematic study of sources of information on mineral nutrition and water relations of vegetable crops.

Hort 504—SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICULTURE—3 cr. (3 and 0) S, even numbered years
Discussions on topics from current scientific periodicals and on other research and developments in ornamental horticulture.

Hort 505—QUALITY CONTROL FOR HORTICULTURAL CROPS—3 cr. (2 and 3) F
Includes quality control methods and equipment such as special titrations, taste panels, refractometers, succulometers, tenderometers, and colorimeters; the role of sugars, salts, and acids and chemical preservatives in foods; quality grade standards, and special problems. Prerequisites: Bact 301, Hort 464.

Hort 506—POST-HARVEST HANDLING OF HORTICULTURAL CROPS—3 cr. (2 and 3) 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 507—POMOLOGY—3 cr. (3 and 0) S, even numbered years
A study of the growth and development of deciduous fruits with emphasis on the peach and apple. Prerequisite: Hort 352.

Hort 508—SPECIAL PROBLEMS IN HORTICULTURE—2 cr. (2 and 0) S
Special research problems in horticulture not related to a thesis, but designed to provide opportunities for research experience and training.

Hort 509—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 510—SEMINAR II—1 cr. (1 and 0) S
A continuation of Hort 509.

Hort 591—RESEARCH—Credit to be arranged.

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INDUSTRIAL EDUCATION

A. F. Newton, Chairman

Courses are offered leading to the Master of Industrial Education degree.

In Ed 401—INDUSTRIAL EDUCATION LABORATORY—3 cr. (1 and 6) F
In Ed 405—TESTS AND MEASUREMENTS IN INDUSTRIAL EDUCATION—3 cr. (3 and 0) F

In Ed 416—DESIGN AND OPERATION OF INDUSTRIAL EDUCATION LABORATORIES—3 cr. (2 and 3) FS

In Ed 422—VOCATIONAL EDUCATION PROGRAMS—3 cr. (3 and 0) S
In Ed 425—TEACHING INDUSTRIAL SUBJECTS—3 cr. (3 and 0) FS
In Ed 432—ADVANCED WOODWORKING—2 cr. (1 and 3) SS
In Ed 435—ADVANCED WELDING—2 cr. (1 and 3) SS
In Ed 436—ADVANCED MATERIAL FORMING—2 cr. (1 and 3) SS
In Ed 438—ADVANCED MACHINING—2 cr. (1 and 3) SS
In Ed 441—COMPREHENSIVE GENERAL SHOP PRACTICES—2 cr. (1 and 3) F, SS

In Ed 496—PUBLIC AND INDUSTRIAL RELATIONS FOR VOCATIONAL TEACHERS AND SUPERVISORS—3 cr. (3 and 0) SS

In Ed 515—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.

In Ed 520—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.

In Ed 540—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.

In Ed 545—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.
In Ed 561—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.

In Ed 591—RESEARCH IN INDUSTRIAL EDUCATION—3 cr.
In Ed 596—RESEARCH IN INDUSTRIAL EDUCATION—3 cr.

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 404—ENGINEERING ECONOMIC ANALYSIS—3 cr. (3 and 0) FS
IE 407—QUALITY CONTROL—3 cr. (3 and 0) F
IE 410—ENGINEERING AND ORGANIZATION—3 cr. (3 and 0) FS
IE 411—WORK FLOW SYSTEMS AND CONTROL—3 cr. (3 and 0) S
IE 414—METHODS OF OPERATIONS RESEARCH I—3 cr. (3 and 0) F
IE 415—METHODS OF OPERATIONS RESEARCH II—3 cr. (3 and 0) S
IE 416—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 501, 502, 503, 504, and 505.

A thesis or non-thesis option is allowed. Students selecting the non-thesis option will be required to earn six credits in courses at the 500 level.
to replace thesis credits. These courses must be approved by the student’s major adviser.

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 accepted as 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.

**IM 401—MARKETING ANALYSIS—3 cr. (3 and 0) FS**

**IM 402—PRODUCTION PLANNING AND CONTROL—3 cr. (3 and 0) FS**

**IM 404—MANAGERIAL ECONOMICS—3 cr. (3 and 0) FS**

**IM 405—ECONOMICS OF TRANSPORTATION—3 cr. (3 and 0) F**

**IM 406—THEORY OF INDUSTRIAL LOCATION—3 cr. (3 and 0) S**

**IM 408—WORK SIMPLIFICATION AND STANDARDIZATION—3 cr.**

\( (2 \text{ and } 3) \text{ FS} \)

**IM 500—ADVANCED MANAGEMENT SIMULATION—1 cr. (0 and 3) FS**

A simulation of a competitive industry. Students are given the responsibility 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 background and experience. The purpose of this simulation is to provide guided experience in management decision making under conditions of uncertainty.

**IM 501—QUANTITATIVE ECONOMIC ANALYSIS—3 cr. (3 and 0) S**

An application of quantitative techniques including an introduction to econometric models as a potential method for solving many of the problems arising in a modern industrial enterprise. **Prerequisite:** IM 311 or permission of instructor.

**IM 502—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 503—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 504—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 505—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.

IM 506—LOCATION OF ECONOMIC ACTIVITY—3 cr. (3 and 0) F

A study of the general factors which determine an industry’s location in a particular region or regions of a market-system economy. Stressed will be the application of the analytical tools of regional science such as input-output analysis and regional econometric models.

IM 591—THESIS RESEARCH—Credit to be arranged.

IM 610—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.

IM 611—SEMINAR IN DECISION THEORY—2 cr. (2 and 0) F

Research seminar in quantitative analysis and in management decision-making. Selected treatment of linear and non-linear programming, markov processes, Lagrange multipliers, game theory, difference and differential equations, transform methods, and modern decision theories. Review of technical literature general discussion of the structure of decision process; dynamic modeling and simulation are included. Prerequisite: Permission of instructor.

IM 612—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 conference table. Prerequisite: IM 502 and permission of instructor.

IM 691—THESIS RESEARCH—Credit to be arranged.

MATERIALS ENGINEERING

G. C. Robinson, Chairman

Courses are offered leading to the Doctor of Philosophy degree.
Attention in the materials engineering curriculum is focused upon materials utilized in electronic products, parts for spacecraft, and components of nuclear reactors. Courses provide an understanding of the behavior, analyses, and application of ceramics, metals, and plastics. Major emphasis is placed on the atomic, molecular, and crystalline structure of the materials for the explanation of their behavior.

Courses included in the curriculum are drawn from departments in four disciplines: chemistry, physics, ceramics, and metallurgy, and are grouped under five general headings:

1. The nucleus
2. Development of material properties from the nucleus
3. Laboratory techniques
4. Application and design
5. Auxiliary courses on production

Over sixty-five courses are offered under these headings.

**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 this degree will consist of a minimum of thirty-one semester hours in one of the four following specified programs.

**ANALYSIS**—Required Courses: 502, 503, 504, 508, 510, 511, 521, 590; plus 6-9 hours in approved minor.

**APPLIED MATHEMATICS**—Required Courses: 407, 503, 504, 508, 509, or 516, 510, 511, 590; plus 6-9 hours in approved minor.

**NUMERICAL ANALYSIS**—Required Courses: 429, 503, 505, 506, 508 or 509, 510, 511, 590; plus 6-9 hours in approved minor.

**PROBABILITY AND STATISTICS**—Required Courses: 402, 403, 404, 503, 510, 511, 513, 514, 590; plus two courses elected from: 429, 452, 502, 505, 508, 521.

Students choosing the non-thesis option are required to prepare a term paper in connection with the 590 course.
Students choosing the thesis option must take 590 and 591 and will prepare their theses in connection with these two courses. Also, the number of required hours in the minor field may be decreased by three.

A reading knowledge of French, German, or Russian is required for the master’s degree in Mathematics. This requirement should be met as early in the student’s program as is possible.

*Math 305—FOUNDATIONS OF ANALYSIS—3 cr. (3 and 0)
*Math 306—ORDINARY DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)
*Math 308—COLLEGE GEOMETRY—3 cr. (3 and 0)
*Math 313—STATISTICAL METHODS—3 cr. (3 and 0)
Math 402—THEORY OF PROBABILITY—3 cr. (3 and 0)
Math 403—STATISTICAL INFERENCE—3 cr. (3 and 0)
Math 404—INTRODUCTION TO STOCHASTIC PROCESSES—3 cr. (3 and 0)
Math 407—PARTIAL DIFFERENTIAL EQUATIONS—3 cr. (3 and 0)
Math 408—TOPICS IN GEOMETRY—3 cr. (3 and 0)
Math 409—NUMERICAL METHODS FOR COMPUTERS—3 cr. (3 and 0)
Math 411—LINEAR ALGEBRA—3 cr. (3 and 0)
Math 412—INTRODUCTION TO MODERN ALGEBRA—3 cr. (3 and 0)
Math 413—INTRODUCTION TO TOPOLOGY—3 cr. (3 and 0)
Math 417—MATHEMATICS PROGRAMS—3 cr. (3 and 0)
Math 429—INTRODUCTION TO NUMERICAL ANALYSIS—3 cr. (3 and 0)
Math 451—VECTOR ANALYSIS—3 cr. (3 and 0)
Math 452—LINEAR PROGRAMMING—3 cr. (3 and 0)
Math 453—ADVANCED CALCULUS I—3 cr. (3 and 0)
Math 454—ADVANCED CALCULUS II—3 cr. (3 and 0)
Math 455—LAPLACE TRANSFORMS—3 cr. (3 and 0)
Math 457—APPLIED MATHEMATICS I—3 cr. (3 and 0)

*May be used for graduate credit under special conditions only.
Math 458—APPLIED MATHEMATICS II—3 cr. (3 and 0)
Math 463—MATHEMATICAL ANALYSIS I—3 cr. (3 and 0)
Math 464—MATHEMATICAL ANALYSIS II—3 cr. (3 and 0)
Math 501—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. Prerequisite: Math 403 and 411.
Math 502—GENERAL LINEAR HYPOTHESIS II—3 cr. (3 and 0)
   A continuation of Math 501.
Math 503—STOCHASTIC PROCESSES I—3 cr. (3 and 0)
   Principal topics include: theory and analysis of time series, recurrent events, markov chains, random walks, renewal theory, application to communication theory, and operation research. Prerequisite: Math 404. Replaces Math 513.
Math 504—STOCHASTIC PROCESSES II—3 cr. (3 and 0)
   A continuation of Math 503.
Math 505—ADVANCED METHODS IN PROBABILITY AND DESCRIPTIVE TITLE 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 405 and 411.
Math 521—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 464. This course replaces Math 510.
Math 522—REAL ANALYSIS II—3 cr. (3 and 0)
   A continuation of Math 521. This course replaces Math 511.
Math 523—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 464.
Math 524—COMPLEX ANALYSIS II—3 cr. (3 and 0)
   A continuation of Complex Analysis I with an introduction to topological analysis.
Math 525—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 454 and 411 or 464.

Math 526—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 525.

Math 531—FOURIER SERIES—3 cr. (3 and 0)

Fourier series with applications to the solution of boundary value problems in the partial differential equations of physics and engineering; and introduction to Bessel functions and Legendre polynomials, with applications. **Prerequisite:** Math 545 or 464. This course replaces Math 508.

Math 533—OPERATIONAL MATHEMATICS—3 cr. (3 and 0)

A study of the operational properties of the Laplace and other integral transforms. The applications are chiefly to problems in engineering and physics that involve differential equations, with emphasis on boundary value problems in partial differential equations. **Prerequisite:** Math 454. This course replaces Math 509.

Math 535—COMPLEX VARIABLES—3 cr. (3 and 0)

Elementary functions. Differentiation and integration of analytic functions. Taylor and Laurent series. Contour integration and residue theory. Schwartz-Christoffel transformation. **Prerequisite:** Math 453. This course replaces Math 503.

Math 537—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. Fundamentals sufficiency theorems. **Prerequisite:** Math 464 or 454.

Math 539—INTEGRAL EQUATIONS—3 cr. (3 and 0)


Math 551—ABSTRACT ALGEBRA I—3 cr. (3 and 0)

A review of fundamental theory of Math 412-413 plus a development of many algebraic systems through the unified approach of a group with operators; chain conditions; Fitting's Lemma; Shcreier, Krull-Schmidt, and Jordan-Holder theorems in a general setting; elements of Noetherian rings; introduction to Galois Theory.
Math 552—ABSTRACT ALGEBRA II—3 cr. (3 and 0)
Continuation of 551.

Math 553—ADVANCED LINEAR ALGEBRA—3 cr. (3 and 0)
Properties of finite dimensional vector spaces: bases, dimension, transformations, projections and orthogonality. **Prerequisites:** Math 411 and Math 412. This course replaces Math 502.

Math 555—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 rencontres" and the "probleme des menages." **Prerequisite:** Math 411.

Math 557—GROUP THEORY—3 cr. (3 and 0)
Elements of group theory, symmetry groups, group representations, irreducible representation, physical applications, symmetric group, continuous group. This course replaces Math 501.

Math 561—NUMERICAL ANALYSIS—3 cr. (3 and 0)
A continuation of Math 429. A study of least squares, Chebyshev polynomials, rational functions, Fourier approximation, nonperiodic functions, linear filters, smoothing and differentiating, exponential approximation, inversion of matrices, eigenvalues. This course replaces Math 505.

Math 563—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 polynomials. **Prerequisite:** Math 454. This course replaces Math 506.

Math 571—GENERAL TOPOLOGY I—3 cr. (3 and 0)
R. L. Moore's Axioms for point set topology; consequences of these axioms. **Prerequisite:** Math 464.

Math 572—GENERAL TOPOLOGY II—3 cr. (3 and 0)
Continuation of Math 571 with an introduction to algebraic topology.

Math 581—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. This course replaces Math 556.

Math 583—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. This course replaces Math 557.
Math 585—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; incollection and metric considerations; complex elements; planar collineations. **Prerequisite:** Math 408 or consent of the instructor. This course replaces Math 515.

Math 591—RESEARCH—Credit to be arranged.

Math 601—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 402 and 522.

Math 602—PROBABILITY THEORY II—3 cr. (3 and 0)


Math 603—ADVANCED STOCHASTIC PROCESSES—3 cr. ((3 and 0)

Markov Process, martingales, stationary processes, Linear least squares prediction-stationary (wide sense) processes. **Prerequisites:** Math 404 and 601.

Math 605—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 403 and 522.

Math 606—DECISION THEORY II—3 cr. (3 and 0)

A continuation of Math 605.

Math 607—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 502.
Math 625—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 526.

Math 627—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 522.

Math 628—FUNCTIONAL ANALYSIS II—3 cr. (3 and 0)

A continuation of Math 627.

Math 629—FUNCTIONAL ANALYSIS III—3 cr. (3 and 0)

A continuation of Math 627-28; special topics, including survey of current literature and open questions in the field.

Math 630—FUNCTIONAL ANALYSIS IV—3 cr. (3 and 0)

A continuation of Math 629.

Math 641—APPLIED MATHEMATICS I—3 cr. (3 and 0)


Math 642—APPLIED MATHEMATICS II—3 cr. (3 and 0)

A continuation of 641.

Math 675—CONVEXITY I—3 cr. (3 and 0)

Hyperplanes and separation theorems, characterizations of convex sets, local convexity, Helly-type theorems, convex functions. **Prerequisite:** Math 628.

Math 676—CONVEXITY II—3 cr. (3 and 0)

Continuation of Math 675—Survey of current literature and discussion of open questions.

Math 680—SPECIAL TOPICS IN PROBABILITY—3 cr. (3 and 0)

Math 681—SPECIAL TOPICS IN MATHEMATICAL STATISTICS—3 cr. (3 and 0)

Math 682—SPECIAL TOPICS IN ANALYSIS—3 cr. (3 and 0)
Math 683—SPECIAL TOPICS IN FUNCTIONAL ANALYSIS—3 cr. (3 and 0)
Math 684—SPECIAL TOPICS IN APPLIED MATHEMATICS—3 cr. (3 and 0)
Math 685—SPECIAL TOPICS IN ALGEBRA—3 cr. (3 and 0)
Math 686—SPECIAL TOPICS IN CONVEXITY—3 cr. (3 and 0)
Math 691—DOCTORAL RESEARCH—Credit to be arranged.

MECHANICAL ENGINEERING
T. C. Hardin, Department Head

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

To be accepted to do graduate work in mechanical engineering at Clemson, a student should have a minimum grade-point ratio of 2.5 (Clemson equivalent) for his undergraduate work. In the evaluation of an applicant's record, more emphasis is placed on the last two years of undergraduate work than on the earlier work. Those applicants qualifying for admission but having an overall four-year average lower than a B will be admitted provisionally until they demonstrate the capability of performing satisfactorily at the graduate level.

In addition to satisfying the Graduate School requirements for residence and languages, doctoral students will take, in addition to their major, either twelve hours each in two minor fields or eighteen hours in one minor field. In either case, a minimum of sixty hours course work beyond the bachelor's level will normally be required.

ME 401—PRINCIPLES OF MECHANICAL ENGINEERING DESIGN—3 cr. (3 and 0) FS
ME 402—MECHANICAL ENGINEERING ANALYSIS AND DESIGN—5 cr. (3 and 6)
ME 403—GAS DYNAMICS—3 cr. (3 and 0) S
ME 404—ATOMATIC CONTROL ENGINEERING—4 cr. (3 and 3) F
ME 407—HEAT TRANSFER II—3 cr. (3 and 0) F
ME 411—GAS POWER—4 cr. (3 and 3) F
ME 412—STEAM POWER—3 cr. (2 and 3) S
ME 421—PROPULSION SYSTEMS I—3 cr. (3 and 0) S
ME 422—PRINCIPLES OF TURBOMACHINERY—3 cr. (2 and 3) S
ME 423—PROPULSION SYSTEM ANALYSIS—1 cr. (0 and 3)
ME 429—AIR CONDITIONING—3 cr. (3 and 0) S
ME 430—AIR CONDITIONING DESIGN—1 cr. (0 and 3)
ME 433—ELEMENTARY AERODYNAMICS—3 cr. (3 and 0) F
ME 434—REFRIGERATION—2 cr. (2 and 0)
ME 464—LUBRICATION—2 cr. (2 and 0) S
ME 501—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, psychrometries, heat and mass transfer processes with moist air, periodic heat transfer in buildings, solar radiation, and cryogenics.

ME 510—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. Pre-requisites: One year of thermodynamics and registration in Math 306.

ME 511—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. Prerequisite: ME 403, ME 433.

ME 512—BOUNDARY LAYER THEORY I—3 cr. (3 and 0) F

ME 513—ADVANCED GAS DYNAMICS III—3 cr. (3 and 0) F

ME 514—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 511, Math 454.

ME 515—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 statistics. **Prerequisite:** ME 510.

ME 524—PROPULSION SYSTEMS—3 cr. (3 and 0) S
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 534—ADVANCED HEAT TRANSFER—3 cr. (3 and 0) S
Physical properties; conduction, in simple bodies; convection with and without phase changes; radiation in simple systems; luminous and non-luminous gaseous radiation; applications. **Prerequisites:** ME 407 or 6 credits in heat transfer; Math 306 or equivalent.

ME 540—KINEMATICS II—3 cr. (3 and 0)

ME 591—RESEARCH—Credit to be arranged.

ME 612—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 512.

ME 614—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 615—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 630—CONDUCTION HEAT TRANSFER—3 cr. (3 and 0) S
Physical properties; steady conduction in one and two-dimensional systems; periodic and transient systems; heat conduction with change in phase; moving heat sources. **Prerequisite:** ME 407.
ME 631—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 632—RADIATION HEAT TRANSFER—3 cr. (3 and 0) S
Radiation properties; analysis of radiation heat transfer; applications. **Prerequisite:** ME 407.

**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 502—RESEARCH TECHNIQUES IN PHYSICAL METALLURGY—2 cr. (1 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 505—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 506—PHYSICAL METALLURGY II—3 cr. (3 and 0)
A continuation of MetE 505.

**MICROBIOLOGY**

W. M. Epps, Department Head

Courses are offered leading to the Master of Science degree. 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

Courses are offered leading to Doctor of Philosophy degree.

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 meat and dairy animals. Minors are available in animal physiology and biochemistry.

Candidates for a degree in Nutrition may choose courses in animal science, food science, dairy science, poultry science, biochemistry, chemistry, physiology, zoology, bacteriology, experimental statistics and other appropriate disciplines.

Nutr 551—NUTRITION SEMINAR I—1 cr. (1 and 0)
Major topics will be current research and development in nutrition. Both student research and the literature will be discussed. Prerequisite: One course in biochemistry and one in nutrition.

Nutr 552—NUTRITION SEMINAR II—1 cr. (1 and 0)
This course is a continuation of Nutrition Seminar I, and will include further discussion of current research and literature on topics to be selected by the instructor and students. Some discussion of the history and men of nutrition will also be included.

Nutr 691—DOCTORAL RESEARCH—Credit to be arranged. (May be taken more than one semester.)

PHYSICS

L. D. Huff, Department Head

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

Graduate students majoring in Physics are normally expected to take the following four courses as a part of their graduate program; Physics 521, 522, 541 and 542. Candidates for the Master of Science degree must have a
reading knowledge of one modern foreign language. It is suggested that students select a minor in mathematics, chemistry or one of the branches of engineering. Students may choose a thesis or a non-thesis program. A student choosing the non-thesis option will complete such special requirements as are assigned by department advisers.

*Phys 321—MECHANICS I—3 cr. (3 and 0)
*Phys 322—MECHANICS II—3 cr. (3 and 0)
*Phys 325—EXPERIMENTAL PHYSICS—4 cr. (2 and 6)
*Phys 326—EXPERIMENTAL PHYSICS—4 cr. (2 and 6)
*Phys 341—ELECTRICITY AND MAGNETISM—3 cr. (3 and 0)
*Phys 351—INTRODUCTION TO MODERN PHYSICS—3 cr. (3 and 0)
Phys 404—ASTRODYNAMICS—3 cr. (3 and 0)
Phys 432—PHYSICAL OPTICS AND INTRODUCTION TO SPECTROSCOPY—3 cr. (3 and 0)
Phys 441—ELECTRICITY AND MAGNETISM—3 cr. (3 and 0)
Phys 446—SOLID STATE PHYSICS—3 cr. (3 and 0)
Phys 452—INTRODUCTORY NUCLEAR PHYSICS—3 cr. (3 and 0)
Phys 455—MODERN PHYSICS II—3 cr. (3 and 0)
Phys 460—MODERN PHYSICS FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)
Phys 465—THERMODYNAMICS AND STATISTICAL MECHANICS—4 cr. (4 and 0)
Phys 471—ELECTRON MICROSCOPY—3 cr. (2 and 3)
Phys 473—X-RAY CRYSTALLOGRAPHY—3 cr. (2 and 3)
Phys 505—SPECIAL PROBLEMS—3 cr. (3 and 9)

A special course for physics graduate students who have chosen the non-thesis optional curriculum. Emphasis will be on methods in research. This course requires the completion of a problem which demonstrates a basic knowledge of the application of research techniques.

Phys 513—THERMODYNAMICS AND STATISTICAL MECHANICS—3 cr. (3 and 0)

Classical statistical mechanics and the derivation of the laws of thermo-

*Courses which may be used by students majoring in other fields.
dynamics. Statistical treatment of the thermodynamics of irreversible
processes.

Phys 521—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 formul-
ations freely used.

Phys 522—CLASSICAL MECHANICS II—3 cr. (3 and 0)
Special relativity in classical mechanics, Hamilton’s equations, canonical
transformations, Hamilton-Jacobi theory, small oscillations.

Phys 541—ELECTRODYNAMICS I—3 cr. (3 and 0)
The field theory of electromagnetism. Maxwell’s equations and their ap-
plication to the study of electromagnetic wave production and propagation,
wave optics and theories of interference and diffraction.

Phys 542—ELECTRODYNAMICS II—3 cr. (3 and 0)
The production and propagation of electromagnetic waves are studied using
Maxwell’s equations as a starting point. Discussions of wave guides,
diffraction phenomenon, and boundary effects are included. An introduc-
tion to the theory of electrons and microscopic phenomena is given.

Phys 545—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 546—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 transis-
tors, theories of magnetism and magnetic resonance phenomena.

Phys 551—INTRODUCTION TO QUANTUM MECHANICS—3 cr. (3 and 0)
The Schroedinger wave equation is used to solve some of the simpler
problems of atomic physics. Emphasis is on physical interpretation of the
results.

Phys 553—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 nu-
clear particles.

Phys 554—NUCLEAR PHYSICS II—3 cr. (3 and 0)
High energy radiation processes, nuclear reactions including nuclear fis-
sion; scattering, natural and induced nuclear disintegration.
Phys 556—CRYSTALLOGRAPHY—3 cr. (3 and 0)
A systematic study of the external and internal symmetry of crystals as revealed by their physical properties.

Phys 575—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 585—COLLOQUIUM—1 cr. (1 and 0)
Selected topics. Required of all Physics graduate students each semester in residence.

Phys 591—RESEARCH—Credit to be arranged.

Phys 622—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 651—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 652—QUANTUM MECHANICS II—3 cr. (3 and 0)
Continuation of Physics 651 including time dependent perturbations; radiation absorption and emission; relativistic quantum mechanics; introduction to quantum electrodynamics.

Phys 655—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 656—ADVANCED MODERN PHYSICS II—3 cr. (3 and 0)
A continuation of Physics 655. Topics of special interest to instructor and students will be considered.

Phys 666—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 691—DOCTORAL RESEARCH AND DISSERTATION—Credit to be arranged.
May be taken more than one semester.
PLANT PATHOLOGY
W. M. Epps, Chairman

Courses are offered leading to the Master of Science and Doctor of Philosophy degrees. See Botany for a listing of courses available.

PLANT PHYSIOLOGY
W. M. Epps, Chairman

Courses are offered leading to the Master of Science degree. See Botany for a listing of courses available.

POULTRY SCIENCE
B. D. Barnett, Department Head

Courses are offered leading to the Master of Science degree.

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

Enrollment is not limited to holders of degrees from the poultry curriculum or from agriculture. Chemistry, physics, economics and biology majors will find challenging course work and thesis problems utilizing their special knowledge.

A graduate student in poultry science will be delayed unless his previous training included chemistry and the biological sciences.

The department research program emphasizes pathology, physiology and nutrition. The student will select a minor in a related field.

*PS 354—POULTRY BREEDING—3 cr. (2 and 3)
*PS 355—POULTRY GRADING AND PROCESSING—3 cr. (2 and 3)
*PS 356—INCUBATION AND BROODING—3 cr. (2 and 3)
PS 401—POULTRY ENVIRONMENT TECHNOLOGY—3 cr. (2 and 3)
PS 451—POULTRY NUTRITION—3 cr. (2 and 3)
PS 458—POULTRY DISEASES AND PARASITES—4 cr. (3 and 3)
PS 460—SEMINAR—2 cr. (2 and 0)
PS 501—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

*Courses may be used by students majoring in other fields.
other appropriate species. Chemical and biological assays of nutrients will be performed using acceptable methods and species.

PS 504—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 agent.

PS 505—SEMINAR—1 cr. (1 and 0) F
Report on special topics or original research by students, staff and visiting speakers.

PS 591—RESEARCH—Credit to be arranged.

**SOCIOMETRY**

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 459—THE COMMUNITY—3 cr. (3 and 0)
RS 461—RURAL LEADERSHIP—3 cr. (3 and 0)
RS 501—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 404—SOCIAL ANTHROPOLOGY—3 cr. (3 and 0)
Soc 405—INDUSTRIAL SOCIOLOGY—3 cr. (3 and 0)
Soc 407—SOCIOLOGICAL THEORY—3 cr. (3 and 0)
Soc 408—SOCIAL STRUCTURE—3 cr. (3 and 0)
Soc 409—SELECTED TOPICS IN SOCIOLOGY—3 cr. (3 and 0)

**TEXTILE CHEMISTRY**

T. A. Campbell, Jr., Chairman

Courses are offered leading to the Master of Science degree. For Ph.D. requirements see Ph.D. in Chemistry with major in Textile Chemistry.

The School of Industrial Management and Textile Science has excellent equipment for teaching and research. The laboratories have the best facilities available for chemical and physical testing, and the many wet-processing units are designed to permit experimental work with a wide range of textile processes.
Graduate work in textile chemistry is open to students who have sufficient background in chemistry. Those without textile degrees must take selected undergraduate courses in this field to give them necessary background.

TC 315—CHEMISTRY OF FIBERS—3 cr. (3 and 0)

TC 475—CELLULOSE CHEMISTRY—2 cr. (2 and 0)

TC 511—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 512—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 511.

TC 521—ADVANCED CELLULOSE CHEMISTRY—3 cr. (3 and 0)

The chemistry of cellulose and closely related polysaccharides, through a systematic study of the extensive volume of research which has been completed on these substances.

TC 531—THE PHYSICAL CHEMISTRY OF DYEING—3 cr. (3 and 0)


TC 591—RESEARCH—Credit to be arranged.

WATER RESOURCES ENGINEERING

L. G. Rich, Chairman

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

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, Civil Engineering, Chemical Engineering, Engineering Mechanics, and Geology. The major and minor work can be made up of courses from the above departments as well as supporting departments such as Agricultural Economics, Agronomy, Mathematics, Physics, Chemistry, Experimental Statistics, Biology, Economics, and Forestry.

WRE 561—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. This changes the course designation from EM 561.

WRE 562—ADVANCED HYDROLOGY—2 cr. (2 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 561. This changes the course designation from EM 562.

WRE 564—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. This changes the course designation from EM 564.

WRE 591—RESEARCH—Credit to be arranged.
WRE 691—DOCTORAL RESEARCH—Credit to be arranged.

ZOOLOGY
J. H. Cochran, Department Head

Courses are offered leading to the Master of Science degree.

*Zool 302—VERTEBRATE EMBRYOLOGY—3 cr. (2 and 3)
Zool 403—PROTOZOOGY—3 cr. (2 and 3)
Zool 456—PARASITOLOGY—3 cr. (2 and 3)
Zool 458—CELL PHYSIOLOGY—3 cr. (2 and 3)
Zool 501—ANIMAL HISTOLOGY—3 cr. (2 and 3)

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. Prerequisites: Zool 307.

Zool 502—HISTOLOGICAL TECHNIQUES—3 cr. (1 and 6)
The fixing, staining, sectioning, and identification of all tissues, glands and organs of animals. Prerequisites: Zool 101, 103.

*May be used for graduate credit under special conditions only.
Zool 503—ANIMAL ECOLOGY—4 cr. (2 and 6)
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 504—ORNITHOLOGY—3 cr. (2 and 3)
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 505—ANIMAL PATHOLOGY—3 cr. (3 and 0)
Designed to acquaint the student with the cause, prevention, and treatment of pathogenic diseases.

Zool 506—COMPARATIVE ANIMAL PHYSIOLOGY—3 cr. (3 and 0)
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 458 or permission of the instructor.

Zool 511—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 512—RECENT ADVANCES IN ZOOLOGY AND ENTOMOLOGY II—1 cr. (1 and 0)
A continuation of Zool 511.

Zool 513—EVOLUTION—3 cr. (3 and 0)
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 552—PRINCIPLES AND METHODS OF SYSTEMATIC ZOOLOGY—2 cr. (2 and 0)
Presents the problems which confront the taxonomist in the zoological sciences and the conventional practices which have been developed to handle them.

Zool 556—ECONOMIC ZOOLOGY—3 cr. (2 and 3)
A study of all phyla (exclusive of class insecta) to include those animals either beneficial or destructive to man. Prerequisites: Zool 101, 103.

Zool 563—SPECIAL PROBLEMS—(1-4 cr.)
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 591—RESEARCH—Credit to be arranged.
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