Clemson Graduate School Catalog, 1966-1967

Clemson University

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<th>January</th>
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ANNOUNCEMENTS OF
THE GRADUATE SCHOOL
FOR
1966 - 1967
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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 pages 36, 38)
2. Submit Plan for Graduate Study (G. S. Form 2 or G. S. Form 2d) (See page 31.)

3. If necessary, submit request for changes in Plan for Graduate Study. (See page 31.)

4. Satisfy any prescribed foreign language examination and other qualifying examinations prerequisite to admission to candidacy. (See pages 35, 39.)

5. Apply for admission to candidacy for a degree (G. S. Form 4) after completing at least half the prescribed residence and course work and after passing any prescribed qualifying examinations. (See pages 31, 40.)

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 35.)

7. Submit completed thesis or dissertation to advisory committee chairman and arrange for final examination by the advisory committee. (See pages 33, 36, 40.)

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, Tillman Hall.
UNIVERSITY CALENDAR

SESSION 1966-1967

Graduate School foreign language examination       August  6
Matriculation, new students                             August 19
Matriculation, current students                        August 20
Registration, new students                             August 22
Registration, Current students                        August 22, 23
Late registration fee                                   August 24
Classes begin, abbreviated schedule                    August 24
Last day for matriculation                             August 30
Last day to add a subject                             September  6
Last day to drop a subject without
record of drop                                           September 20
Last day to order diploma for mid-year graduation     September 20
Preliminary reports due                               October 10
Last day to drop a subject                             November 11
Last day to withdraw from college without
having grades recorded                                  November 11
Graduate School foreign language examination          November 12
Thanksgiving Holidays                                 November 24-26
Last day for thesis and oral examination               December  3
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<th>Event</th>
<th>Date</th>
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<tr>
<td>Examinations begin</td>
<td>December 8</td>
</tr>
<tr>
<td>Mid-year graduation</td>
<td>December 17</td>
</tr>
<tr>
<td>Matriculation, new students</td>
<td>January 3</td>
</tr>
<tr>
<td>Registration, all students</td>
<td>January 5, 6</td>
</tr>
<tr>
<td>Late registration fee applies</td>
<td>January 7</td>
</tr>
<tr>
<td>Classes begin, abbreviated schedule</td>
<td>January 7</td>
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<tr>
<td>Last day for matriculation</td>
<td>January 13</td>
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<tr>
<td>Last day to add a subject</td>
<td>January 20</td>
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<tr>
<td>Last day to order diploma for June graduation</td>
<td>February 3</td>
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<tr>
<td>Graduate School foreign language examination</td>
<td>February 4</td>
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<tr>
<td>Preliminary reports due</td>
<td>February 20</td>
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<td>Easter Holidays begin at 1 p.m.</td>
<td>March 23</td>
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<td>Classes resume</td>
<td>March 28</td>
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<td>Last day to drop a subject</td>
<td>April 3</td>
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<td>Last day to withdraw from college without having grades recorded</td>
<td>April 3</td>
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<td>Honors and Awards Day—classes suspended at 12 noon</td>
<td>April 5</td>
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<tr>
<td>Examinations begin</td>
<td>April 26</td>
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<td>Commencement</td>
<td>May 6</td>
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CLEMSON UNIVERSITY BOARD OF TRUSTEES

Life Members

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

Term Expires 1968

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

Term Expires 1970

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

A. W. Rigsby, Secretary  Clemson

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PERSONNEL

OFFICERS OF ADMINISTRATION

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

Jack Kenny Williams, Ph.D. ________ Vice-President for Academic Affairs and Dean of the University

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

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

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
THE GRADUATE COUNCIL

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 and Environmental 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.

Sang Oh Park, Ph.D., Assistant Professor of Industrial Management.

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

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, and is fully accredited by the Southern Association of Colleges and Schools. The fifty-four graduate curriculums under the Colleges of Agriculture and Biological Sciences, Arts and Sciences, and Engineering, and the Schools of Architecture, Education, and Industrial Management and Textile Science form a background of training for the hundreds of occupations which Clemson graduates enter.

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

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

THE GRADUATE SCHOOL

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

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

**Full-Time Students.** The 1966-1967 charges for regular full-time graduate students are shown below:

### First Semester

<table>
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<tr>
<th>Charge</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Tuition</td>
<td>$75</td>
</tr>
<tr>
<td>Matriculation Fee (Non-Refundable)</td>
<td>5</td>
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<tr>
<td>Maintenance and Activities Fee</td>
<td>136</td>
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<td>Library Fee</td>
<td>12</td>
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<td>Medical Fee</td>
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<td>Room Fee</td>
<td>120-150</td>
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<td>Board</td>
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</table>

**Total First Semester**  $573-603

Tuition and fees for the full semester are payable in advance at the beginning of each semester. In addition, one-half of the semester's board and $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>Service</th>
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<tbody>
<tr>
<td>Tuition (per semester hour)</td>
<td>$6.00</td>
</tr>
<tr>
<td>Matriculation Fee (non-refundable)</td>
<td>5.00</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>
<tr>
<td>Medical Fee (optional)</td>
<td>15.00</td>
</tr>
</tbody>
</table>

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

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

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

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

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

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

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

**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.

**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.

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

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

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

**Monsanto Fellowship.** A $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.

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

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

Textile Research Institute Research Fellowship. An award of up to $3,000 plus tuition and fees to a student in the sciences or engineering. The recipient's dissertation research will be conducted on a textile-oriented problem.
Warwick Chemical Foundation Fellowships. Income from a fund, donated in memory of Manfred Caranci, available annually for awards to students in Chemistry.

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

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

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

On July 1, 1966 the Computer Center will install an IBM/360, Model 40, with 65,000 bytes of core storage. The system will include a card reader/punch, a keyboard printer, a line printer, and two disk storage units. The center also operates an RPC-4000 computing system with paper tape input/output. A non-credit seminar on computer programming is offered each semester, and the Center’s library of standard programs and procedures is available for graduate research.

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-two newspapers and 4053 serial titles—periodicals, reports, bulletins and the like—are received regularly. Six hundred and thirty-two of these are foreign publications and 1750 are abstracted in chemical abstracts. Microfilm and microcard readers are provided for consulting material that is in microtext.

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

- Monday through Friday: 7:45 a.m. to 11:00 p.m.
- Saturday: 7:45 a.m. to 6:00 p.m.
- Sunday: 2:00 p.m. to 11:00 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 3,776, two students being assigned to a room. The University also has 340 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 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>
</thead>
<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 of another week</td>
<td>$5.50 for full week plus $1.00 per night for part of week</td>
<td>$6.00 for full week plus $1.00 per night for part 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 nine dormitories available for housing 3,632 male students. The room rent varies from $120 to $150 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.

Two dormitories for women have been completed. Each building is designed with 72 rooms accommodating 144 women. The room rent varies from $138 to $150 per semester, depending upon the dormitory facilities.

Dining Hall. Cost per semester $210. 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 190 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 May 10 for first semester housing; before November 10 for second semester housing; or before March 10 for summer housing.

Booklets describing these facilities are available and will be furnished upon request to the Housing Office of the University. Monthly rental fees are: Prefabs, $30.00; Littlejohns, $36.00 for interior and $39.00 for end units; East Campus, $48.00.

MEDICAL EXAMINATIONS
Completion of a medical history and physical examination record is required of all new students entering Clemson University
for the first time and all former students not in attendance for a period of 3 years or more. This examination must be completed by the student and the student's own physician or the Health Service of the school from which he graduates or transfers. This examination will be reported on a special form provided for this purpose by the Director of Admissions and Registration. The new four page form revised August 1965 should be used. No other form is acceptable. This form will be sent after provisional acceptance is granted. No new student will receive final acceptance until this certificate is completed and has been received by the Director of the Student Health Service.

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

**STUDENT HEALTH SERVICE**

The Student Health Service maintains a complete outpatient department and a 40-bed infirmary. The staff consists of 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 regulations of the Graduate School and the requirements for degrees. Failure to follow the regulations and requirements almost inevitably results in complications for which the Graduate School cannot assume responsibility.

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

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

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

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

GRADUATE DEGREES AND CURRICULUMS

Courses and Degrees. Courses are offered leading to the degree of Master of Science in the following fields: Agricultural Economics,

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 rela-
tion 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. Neither a transcript exceeding minimum requirements nor satisfactory scores on the Graduate Record Aptitude Test alone will assure a student's admission. Rather his total record must indicate the 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.
With the permission of his major adviser and department head, a provisionally admitted student may apply at any time to the Dean of the Graduate School for reclassification to full standing.

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

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

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

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

**Academic Standards.** Graduate students are graded on the same A-B-C-D-F scale as undergraduates. Provisionally admitted students must maintain a B average during their first academic semester in order to remain in the Graduate School. 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. 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.

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

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

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

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

**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.

**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. Additionally, a graduate student may not establish credit through examination in any course for which he was previously registered as an auditor.

**Acceptance of Transfer Credit.** The credit requirements for advanced degrees must be satisfied through registrations at Clemson University, except that on the recommendation of the student's
major adviser and the approval of the Dean of the Graduate School, a student may earn in some accredited institution other than Clemson 6 credits in campus courses toward one of the Master's degrees and as many as 48 credits toward a Doctor's degree.

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

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

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

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

**Admission to Candidacy for a Degree.** Admission to the Graduate School does not qualify a student as a candidate for an advanced degree. Such candidacy depends upon the acceptance by the Dean of the Graduate School of a written request for admission to candidacy. This request (Graduate School Form #4) may be filed by the student as follows: for the Master's degree, after he has completed fifteen hours of course work; for the Doctoral degree, after he has completed a major share of his course work and has successfully completed his preliminary examinations. Listed below are deadline dates for the following: filing for admission to candidacy for a

*An academic semester is defined as a minimum of nine credit hours of course work taken during a given semester. An academic year is defined as the total of two academic semesters.
degree; ordering a diploma; taking final oral and/or written examinations; and submitting theses or dissertations.

For those taking the Master's degree on Aug. 13, 1966

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>June 4, 1966</td>
<td>Last day for filing GS4, “Admission to Candidacy for a Degree”</td>
</tr>
<tr>
<td>June 15</td>
<td>Last day to order a diploma</td>
</tr>
<tr>
<td>July 30</td>
<td>Final day for oral and/or written examinations</td>
</tr>
<tr>
<td>Aug. 6</td>
<td>Final date for submitting thesis to the Graduate Office</td>
</tr>
</tbody>
</table>

For those taking the Master's degree on Dec. 17, 1966

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug. 30, 1966</td>
<td>Last day for filing GS4, “Admission to Candidacy for a Degree”</td>
</tr>
<tr>
<td>Sept. 20</td>
<td>Last day to order a diploma</td>
</tr>
<tr>
<td>Dec. 3</td>
<td>Last day for oral and/or written examinations.</td>
</tr>
<tr>
<td>Dec. 10</td>
<td>Final date for submitting thesis to the Graduate Office</td>
</tr>
</tbody>
</table>

For those taking the Master's degree on May 6, 1967

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 13, 1967</td>
<td>Last day for filing GS4, “Admission to Candidacy for a Degree”</td>
</tr>
<tr>
<td>Feb. 3</td>
<td>Last day to order a diploma</td>
</tr>
<tr>
<td>Apr. 22</td>
<td>Last day for oral and/or written examinations</td>
</tr>
<tr>
<td>Apr. 29</td>
<td>Final date for submitting thesis to the Graduate Office</td>
</tr>
</tbody>
</table>

For those taking the Master's degree on Aug. 5, 1967

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 19, 1967</td>
<td>Last day for filing GS4, “Admission to Candidacy for a Degree”</td>
</tr>
<tr>
<td>June 15</td>
<td>Last day to order a diploma</td>
</tr>
<tr>
<td>July 22</td>
<td>Last day for oral and/or written examinations</td>
</tr>
<tr>
<td>July 29</td>
<td>Final date for submitting thesis to the Graduate School.</td>
</tr>
</tbody>
</table>
For those taking the Doctor of Philosophy degree on Aug 13, 1966

June 15, 1966  Last day to order a diploma
July 16        Last day to present completed dissertation to student's advisory committee
July 30        Last day for final oral examination
Aug. 6         Final day for submitting dissertation to the Graduate Office

For those taking the Doctor of Philosophy degree on Dec. 17, 1966

April. 17, 1966 Last day for filing GS4, “Admission to Candidacy for a Degree”
Sept. 20       Last day to order a diploma
Nov. 19        Last day to present completed dissertation to student's advisory committee
Dec. 3         Last day for final oral examination
Dec 10         Final date for submitting dissertation to the Graduate Office

For those taking the Doctor of Philosophy degree on May 6, 1967

Sept. 6, 1966  Last day for filing GS4, “Admission to Candidacy for a Degree”
Feb. 3, 1967   Last day to order a diploma
April 8        Last day to present completed dissertation to student's advisory committee
Apr. 22        Last day for final oral examination
Apr. 29        Final date for submitting dissertation to the Graduate Office

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

Theses and Dissertations. Each candidate for an advanced degree in each curriculum requiring a thesis must prepare this thesis under the direction of a major adviser. Six hours of credit are required for the research leading to the required Master of Science
or Master of Arts thesis. Nine hours of credit are required for the Master of Architecture thesis. Eighteen hours of research credit are required for the Doctor of Philosophy degree.

Three 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 $3.75 per copy must be paid to the Bursar and the Bursar's receipt submitted to the Graduate School Office at the time the thesis or dissertation is submitted. If the student desires, he may have additional copies bound for himself at a cost of $3.75 a copy. The responsibility for placing the thesis in proper final form rests with the student and the chairman of his advisory committee. A statement of special procedures for writing a thesis or dissertation at Clemson University may be obtained from the Graduate School Office.

The student will prepare one additional copy of the abstract and title sheet 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.

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 sum-

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*Multilith copies are acceptable. Xerox copies will be accepted under certain conditions.
maries 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 Aug. 6, and Nov. 12, 1966, and for Feb. 4 and Apr. 15, 1967. The language examinations are taken from sources supplied by the student's major department to the Language Department.

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

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

**Application for a Diploma.** A formal application for a diploma must be placed by the student with the Director of Admissions and Registration within 4 weeks following the opening of the final semester of enrollment or by 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 semester in graduate residence at the University. No graduate credit will be allowed for any course completed in less than five weeks. All course work which is to be credited toward a Master of Science or Master of Arts degree must have been completed not more than six calendar years prior to the date on which the degree is to be awarded; except that when approved by the student's department head and the Dean of
the Graduate School, as many as six semester hours of course work completed outside the six-year limit of time may be validated by written re-examination. Such examination will be under the direction of the department regularly offering the course or courses for which the student seeks validation. Course work completed outside the six-year limit of time at an institution other than Clemson University may not be transferred to Clemson for graduate credit.

The Student's Advisory Committee. As soon as the student arrives on the campus to begin his graduate studies 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 approve the student's preliminary study plans, 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.

Final Examination. Each candidate for a Master's degree, after the completion of the thesis, if required, and at least two weeks before the degree is to be awarded, must pass such examination as may be required by the student's advisory committee. The examination, which may be oral and/or written, will ascertain the general knowledge of the candidate with particular reference to the major and minor subjects and the thesis or research report. Included with those members of the faculty and staff invited to attend the examination will be the members of the Graduate Council and the Dean of the Graduate School. Immediately after the
examination the examining committee will notify the Dean of the Graduate School of the findings. This notification will be made on Graduate School Form 7.

**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 Mas-
ter 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 registration 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 departments in consultation with the student will recommend to the
Graduate Dean for approval and formal appointment an advisory committee composed of at least four professors. One member of the committee will be designated as chairman and normally he will direct the student's dissertation. The advisory committee will aid the student in planning his course work to achieve the required competence. This planning will include the selection of specific courses, 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 committee will also arrange for the student's preliminary and final comprehensive examinations and initiate the recommendations for the awarding of his degree.

Residence Requirements. 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 concern cannot be achieved where a student holds, throughout the period of his study, a full-time job not concerned with research in his field.

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

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; 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 stu-
dent'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 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 600 series or enrollment for graduate credit in 300 or 400 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.

*Ag Ec 352—PUBLIC FINANCE—3 cr. (3 and 0) FS
*Ag Ec 357—CONSERVATION OF NATURAL RESOURCES—3 cr. (3 and 0) FS
Ag Ec 402—ECONOMICS OF AGRICULTURAL PRODUCTION—3 cr. (3 and 0) F
Ag Ec 451—AGRICULTURAL COOPERATION—2 cr. (2 and 0) F
Ag Ec 452—AGRICULTURAL POLICY—3 cr. (3 and 0) FS
Ag Ec 456—PRICES—3 cr. (3 and 0) FS
Ag Ec 460—AGRICULTURAL FINANCE—2 cr. (2 and 0) FS
Ag Ec 502—ECONOMICS OF AGRICULTURAL PRODUCTION—3 cr. (3 and 0)

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

*May be used for graduate credit under special conditions only.
Ag Ec 503—LAND ECONOMICS—3 cr. (3 and 0)
A study of the characteristics of land and of the physical, legal, social and economic principles and problems relating to the control and use of land resources.

Ag Ec 504—WATER RESOURCE POLICIES—3 cr. (3 and 0)
A study of the economic, social and legal aspects of the control, use, development and management of water resources, with special emphasis upon public policies relating thereto.

Ag Ec 506—ECONOMIC DEVELOPMENT IN AGRICULTURAL AREAS—3 cr. (3 and 0)
A critical examination of the theories of economic growth and development and their application to areas or regions. Also, a survey of methods of regional economic analysis with emphasis on both the macro- and micro-economic aspects.

Ag Ec 507—AGRICULTURAL MARKETING PROBLEMS—3 cr. (3 and 0)
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: Permission of instructor.

Ag Ec 508—APPLIED QUANTIFICATIONS IN AGRICULTURAL ECONOMICS—3 cr. (3 and 0)
A survey of the mathematical tools requisite for a concise description of the principles in the economics of agriculture. Models are formulated as media for empirical research. Microeconomic theory under the assumptions of perfect competition is emphasized. The relations among demand, supply, cost, revenue, and productivity are examined in a framework for agriculture. Attention is given to selected statistical applications in agricultural economics. Prerequisite: Permission of instructor.

Ag Ec 514—CONTEMPORARY ECONOMIC PROBLEMS—3 cr. (3 and 0)
A critical review of the nature of contemporary economic problems, the background out of which they developed, the remedies which have been applied, and possible alternatives. (Special emphasis will be given to problems relating to agriculture and rural life.)

Ag Ec 551—SEMINAR IN RESEARCH METHODOLOGY—1 cr. (1 and 0)
A survey of logic and the scientific method; the formulation, initiation and carrying out of research problems in economics and business; methods and problems of obtaining and analyzing economic data; the role of electronic computers and data processing systems, and group discussions of the proposed thesis problems of individual students. (Required of all graduate students who have not already had a comparable course.)
Ag Ec 591—SEMINAR RESEARCH—Credits to be arranged.

Ag Ec 604—SEMINAR IN RESOURCE ECONOMICS—3 cr. (3 and 0)
  Study of special problems and recent periodical literature relating to the 
  control, management, development and use of land and water resources in 
  the United States and in other parts of the world. **Prerequisite:** Agricultural 
  Economics 503 or 504.

Ag Ec 606—SEMINAR IN AREA ECONOMIC DEVELOPMENT—3 cr. 
  (3 and 0)
  A study of recent research developments in the field of economic de- 
  velopment, including a review of research publications, journal articles, 
  and other literature, with special emphasis given to a critical examination 
  of objectives, analytical techniques and procedures used in area or regional 
  development efforts. **Prerequisite:** Agricultural Economics 506.

Ag Ec 607—ECONOMICS OF CONSUMPTION, DEMAND, AND MARKET 
  STRUCTURE—3 cr. (3 and 0)
  An advanced study in the theory of, and the research related to consumer 
  behavior; economic consequences of individuals' and firms' decisions upon 
  supply and demand; general interdependency among economic variables. 
  **Prerequisite:** Agricultural Economics 507.

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 educa-
  tional 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) supervising 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.

**AGRICULTURAL ENGINEERING**

A. W. Snell, Department Head

Courses are offered leading to the Master of Science degree.

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

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

*AgE 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) S

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 simplification, dehydrating and drying, refrigeration, storage, and related subjects.

AgE 506—INSTRUMENTATION IN AGRICULTURAL AND BIOLOGICAL RESEARCH—3 cr. (2 and 3)

A course designed to acquaint the graduate student in agriculture and the biological sciences with fundamental mathematical and physical principles involved in measuring and recording physical phenomena studied in agricultural research. Methods and instruments used in measuring temperature, humidity, fluid pressure and flow, force, velocity, acceleration, mechanical strain and displacement, color and chemical composition are studied. Transducers and sensing elements, amplifiers, and recording instruments are related to each other through the appropriate electrical circuitry. Not open to engineering students. Prerequisite: general physics.

*May be used for graduate credit under special conditions only.
AgE 511—TILLAGE AND SOIL DYNAMICS—3 cr. (3 and 0)
Soil physical and dynamic properties are related to the actions of tillage tools, tractive vehicles and plant growth and development. Some major topics dealt with are soil strength parameters, seedling environment and emergence mechanics of tillage implements, soil compaction causes and effects, tractive efforts of wheel and track-type vehicles and off-the-road locomotion. **Prerequisite:** AgE 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 573—RADIOLOGICAL HEALTH—3 cr. (2 and 3)
Sources of ionizing radiation and radioisotopes in man's environment will be illustrated, and methods of protection from these sources will be discussed. The engineering aspects of detection, shielding, and disposal of radioactive materials will be studied. **Prerequisite:** Ch 491 or the equivalent.

AgE 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.

AgE 674—RADIOLOGICAL HEALTH ENGINEERING—3 cr. (2 and 3)
This is a continuation of Radiological Health with a more detailed study of radiation protection from air, water, food, and solids through engineering procedures. This course is offered primarily for engineering students. **Prerequisite:** AgE 573 or the equivalent.

Environmental Health

EnH 571—ENVIRONMENTAL HEALTH—3 cr. (3 and 0)
The interactions of man with his environment will be surveyed. Detrimental health factors such as pathogens, insect pests, ionizing radiation, and toxic chemical residues acting through air, water, food, and solids will be emphasized. Methods of detection and control of these health hazards will be included. **Prerequisite:** Graduate standing.
EnH 593—ENVIRONMENTAL HEALTH SEMINAR I—1 cr. (1 and 0)
A discussion of current advances and research developments in the area of environmental health. Both the students and the staff will participate. **Prerequisite:** Graduate standing.

EnH 594—ENVIRONMENTAL HEALTH SEMINAR II—1 cr. (1 and 0)
A continuation of EnH 593. **Prerequisite:** Graduate standing.

**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 X-ray diffraction, differential thermal analysis equipment, a cytogenetics laboratory, controlled environmental chambers, and graduate student laboratories in an air-conditioned building.

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

*Gen 302—GENETICS—3 (2 and 3) FS
Gen 451—GENETICS—3 cr. (3 and 0) F
Gen 453—GENETICS LABORATORY—I cr. (0 and 3) F
Gen 501—CYTOGENETICS—3 cr. (2 and 3) S, odd numbered years.

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

*Agron 308—SOIL AND PLANT ANALYSIS—3 cr. (3 and 6) S
*Agron 310—FORAGE AND PASTURE CROPS—3 cr. (3 and 0) S
*Agron 312—FORAGE CROPS LABORATORY—1 cr. (0 and 3) S
Agron 403—SOIL CLASSIFICATION—2 cr. (1 and 3) F

*Courses which may be used by students majoring in other fields.
Agron 405—PLANT BREEDING—3 cr. (2 and 3) S
Agron 407—PRINCIPLES OF WEED CONTROL—3 cr. (2 and 3) F
Agron 410—COTTON AND OTHER FIBER CROPS—2 cr. (2 and 0) S, even numbered years.
Agron 411—GRAIN CROPS—2 cr. (2 and 0) F, even numbered years.
Agron 412—TOBACCO AND SPECIAL USE CROPS—2 cr. (2 and 0) F, odd numbered years.
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) F, odd numbered years.
The application of basic concepts and physiologic aspects of growth and culture to crop management practices.
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 504—THEORY AND METHODS OF PLANT BREEDING—3 cr. (3 and 0) F, even numbered years.
Concepts and principles of plant breeding and genetics as applied to the development and maintenance of improved crop varieties. Theoretical considerations of the various breeding methods are emphasized.
Agron 505—SOIL FERTILITY—3 cr. (3 and 0) S, even numbered years.
A study of the essential nutrients in the soil-plant system with emphasis on mechanisms of retention and transport; supplies and availability; reactions and interactions; deficiency diagnosis and remedies. Concepts and techniques for evaluating soil fertility problems will be studied.
Agron 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, even numbered years.
A study of fundamental principles of soil physics, methods of physical analysis of soils, and applications of soil physics in Agriculture.
Agron 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 512—CROP ECOLOGY AND LAND USE—3 cr. (3 and 0) F, even numbered years.

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

Agron 520—PESTICIDE RESIDUES IN SOILS AND WATER—3 cr. (3 and 0) S, odd numbered years.

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

Agron 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

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

Courses are offered leading to the Doctor of Philosophy degree.

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. Endocrinology and reproduction will be reviewed briefly.

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 physiology. 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.

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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 301—GENERAL BACTERIOLOGY—4 cr. (3 and 3) FS SS**

*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.

*May be used for graduate credit under special conditions only.

**May be used for graduate credit only by students with majors in fields other than the biological sciences.

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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, aero-biosis, anaerobiosis, nutrition of bacteria and degradation of proteins, carbohydrates, and fats. **Prerequisites:** Bact 301, 401.

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.

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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 metabolic pathways in living organisms. The electron transport system, the metabolic pathways of carbohydrates, and lipids, 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. A discussion of the metabolic pathways followed by proteins, amino acids, 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)
A discussion of the biochemical processes affecting nutrients during digestion and utilization. Factors and conditions influencing such processes and their relationship to an organism's total environment 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. **Prerequisites:** 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 Master of Science and Doctor of Philosophy degrees.

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

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

The second program in bio-engineering applies the methodology and technology of engineering systems design to problems ranging from the collection of physiological processes. Topics covered include analog and digital simulation or cardiovascular and respiratory systems, methods and procedures involved in the collection and processing of physiological data, and the mathematical modeling of biological components such as muscle tissue and bone.

Normally students enrolling in the second program have a strong academic background in mathematics, computer application and instrumentation. Course work in physiology and physical chemistry would also be included.
In general the bio-engineering program is open to students possessing degrees in engineering and to those with degrees in science who have credits for certain prescribed engineering courses.

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

- **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)**
- **ME 404—PHYSICAL SYSTEMS ANALYSIS—3 cr. (3 and 0)**
- **ME 560—ADV. PHYSICAL SYSTEMS ANALYSIS—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 OF VASCULAR PLANTS—3 cr. (1 and 6) FS**
- **Bot 401—PLANT PATHOLOGY—3 cr. (2 and 3) FS**

*May be used for graduate credit under special conditions only.
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 457—PHYCOLOGY—3 cr. (2 and 3) S, odd numbered years

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

Bot 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

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

**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 507—SEMINAR—1 cr. (1 and 0) F and 1**

A review of areas of the botanical sciences not covered by formal courses, with special emphasis on the review of literature, and organization and presentation of material by students. (May be taken for credit only twice.)

**Bot 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 507—SPECIALIZED CERAMICS—3 cr. (3 and 0)
An advanced study of one of the divisions of ceramics. The student may select either structural products, refractories, whitewares, abrasives, enamels, glass, elements, or raw materials processing.
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.

CrE 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 momentum transport, energy transport, mass transport, differential contact operations 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—Credit to be arranged.

Graduate level laboratory experiments in kinetics, unit operations and thermodynamics. Emphasis will be placed on independent work. The student will be required to plan the experiments to achieve a given objective, perform the experimental work and prepare a technical report on the work.

ChE 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. Prerequisite: ChE 503.
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. **Prerequisite:** ChE 504.

ChE 605—CHEMICAL ENGINEERING KINETICS—3 cr. (3 and 0)  
A continuation of ChE 505. **Prerequisite:** 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—ELEMENTARY 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 431—ATOMIC AND MOLECULAR STRUCTURE—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.

*Courses which may be used by students majoring in other fields.
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 co-  
ordination compounds formed by these elements. Modern molecular struc-  
ture techniques and theories will be used to study these compounds. Pre-  
requisites 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 meth-  
ods. 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.

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 aro-  
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—Mathematical ASPECTS OF CHEMICAL SPECTROSCOPY 3 cr. (3 and 0)
A presentation of the elements of matrix algebra and group theory, and their application to the problems of molecular structure. Emphasis will be placed on the relation of the symmetry properties of molecules to selection
rules and factoring of secular equations encountered in electronic, vibra-
tional and NMR spectroscopy. **Prerequisite:** Ch 431.

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 natur-
ally 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 sur-
  face 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 re-
  cent 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 com-
  pounds 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, sanitation, 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—INTRODUCTORY 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)
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. **Prerequisites:** A knowledge of Fourier series, and partial differential equations.

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:** A knowledge of Fourier series, and partial differential equations.

*Approved for non-Civil Engineering majors only.
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) F
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 Ratio 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) S
Properties of concrete materials; mix design methods; properties of plastic and hardened concrete. **Prerequisite:** CE 320.
CE 531—FOUNDATION ENGINEERING—3 cr. (2 and 3) F

Requirements for satisfactory foundations, theory and design of shallow foundations, pressure distribution beneath rigid and flexible shallow foundations, bearing capacity and settlement of deep foundations, foundation failures. **Prerequisite:** CE 331.

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. **Prerequisite:** CE 331.

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, properties of compacted soils. **Prerequisite:** CE 331.

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 photographs, and site characteristics related to soil profile. Laboratory work includes soil mapping, economic selection of transportation routes and building sites, and location of soil deposits for engineering purposes.

CE 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 548—ENVIRONMENTAL ENGINEERING CHEM. II—2 cr. (2 and 0) S

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) S

Theoretical principles developed in CE 548 are applied to laboratory measurement and control of environmental engineering systems. Instru-
mental analysis and advanced analytical techniques are stressed. **Pre-requisite:** 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. **Pre-requisite:** Bact 301.

**CE 551—UNIT OPERATIONS & PROCESSES LABORATORY—2 cr S (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, transportation, or environmental 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.**

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**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) S

*Dy Sc 307—MARKET MILK—3 cr. (2 and 3) F, 1966 and alternate years.

Dy Sc 402—DAIRY MANUFACTURES—4 cr. (3 and 3) S, 1966 and alternate years.

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

Dy Sc 404—DAIRY PLANT MANAGEMENT—3 cr. (2 and 3) S, 1967 and alternate years.

Dy Sc 407—CHEESE AND BUTTER MANUFACTURE—3 cr. (2 and 3) F, 1967 and alternate years.

Dy Sc 452—DAIRY CATTLE FEEDING AND MANAGEMENT—3 cr. (2 and 3) S, 1967 and alternate years.

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

Dy Sc 455—ANIMAL REPRODUCTION LABORATORY—1 cr. (0 and 3) F, 1967 and alternate years.

Dy Sc 501—TOPICAL PROBLEMS—1 and 3 cr. F, S, SS.

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

Dy Sc 502—GENETICS OF DAIRY CATTLE IMPROVEMENT—3 cr. (3 and 0) S, 1966 and alternate years.

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

Dy Sc 503—PHYSIOLOGY OF REPRODUCTION AND MILK SECRETION—3 cr. (3 and 0) S, 1966 and alternate years.

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

Dy Sc 504—ENDOCRINOLOGY—3 cr. (3 and 0) S, 1967 and alternate years.

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

*Courses which may be used by students majoring in other fields.
Dy Sc 505—NEWER KNOWLEDGE OF DAIRY NUTRITION—3 cr.  
F, 1967 and alternate years.  
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) S, 1967 and  
alternate years.  
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, 1966 and  
alternate years.  
Provides advanced technological training in dairy plant processing,  
manufacturing, and management.

Dy Sc 509—RUMEN METABOLISM—3 cr. (2 and 3) F, 1966 and alternate  
years.  
Biochemical physiological and microbiological functions in the rumen.  
Consideration is given to ontogeny and structural anatomy. The laboratory  
emphasizes in vitro methodology used in studying the microbial metabolism  
of dietary constituents.

Dy Sc 591—RESEARCH—Credit to be arranged. F, S, SS

ECONOMICS

R. S. Lambert, Chairman

Courses are offered leading to the Master of Arts degree.

Students desiring to enroll in this curriculum will need at least twelve  
hours of undergraduate economics including a course in intermediate price  
theory, a reading knowledge of a modern foreign language, and a compre-  
hension of statistics. The statistics requirement may be met by satisfac-  
tory grades in undergraduate courses in statistics, by a special examina-  
tion, 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 DEVELOP-  
MENT—3 cr. (3 and 0) F

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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 405—PRINCIPLES OF GUIDANCE—3 cr. (3 and 0)
Principles, procedures, and policies of the guidance services. For all personnel workers.

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 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 405, 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 405, 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 405, 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 analysis of data; techniques of writing research reports; evaluation of source materials.

The following courses are applicable only to the Master of Education degree in Science Teaching.

Biol 450—BIOLOGY FOR HIGH SCHOOL TEACHERS—3 cr. (3 and 0)
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)

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 lab-
oratory 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 descriptive astronomy and the phenomena associated with the seasons, time systems, and current interests. Fundamental physical principles necessary to proper explanations will be introduced. The new Spitz planetarium at the University and night observations of the heavens will be used to supplement the lectures.

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 and Doctor of Philosophy degrees.

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 405—SPECIAL PROBLEMS—1 cr. (0 and 3)
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 425—INTRODUCTION TO THEORY AND DESIGN OF DIGITAL SYSTEMS—3 cr. (3 and 0)
EE 428—COMMUNICATIONS—3 cr. (3 and 0)
EE 430—MODELS OF TRANSISTORS AND DIODES—2 cr. (2 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—THEORY OF COMMUNICATION—3 cr. (3 and 0)
An integrated study of information theory, system analysis with random excitations and system synthesis. 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 508—COMMUNICATION SYSTEMS—3 cr. (3 and 0)
A continuation of EE 507, with emphasis on the overall systems aspects of various communications and modulation arrangements.
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 514—NONLINEAR AUTOMATIC CONTROLS—3 cr. (3 and 0)
A study of control systems in which nonlinear elements occur. In some cases these are used deliberately to achieve results not obtainable by other methods. Both graphical and analytical procedures are used.

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.

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.
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 three general areas of concentration are mechanics of solids, dynamics and fluid mechanics. Some limitations are imposed on the selection of courses to reflect the particular concentration. The normal minor area of study is mathematics. However, suitable complementary minor programs may also be arranged in physics, materials engineering, civil engineering, and mechanical engineering.

EM 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, brittle lacquer, and birefringent coatings. Also required is the conduct of an individual investigation and the preparation of a report of findings. Prerequisite: EM 304 and permission of instructor.

EM 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 following areas: mechanics of materials, fluid mechanics, heat transfer and electromagnetic theory. Special attention is given the method of deriving model laws from the differential equations governing a particular phenomena. Prerequisites: consent of instructor.
EM 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. **Prerequisite:** EM 531 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)
Continuation of Theory of Elasticity I. Complex variable methods of solutions. Three-dimensional problems including torsion, bending stress concentration, thermal stress, stress wave propagation. Approximate solutions of elasticity problems. **Prerequisite:** EM 531.

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. **Prerequisite:** EM 531, or consent of instructor.

EM 545—INTERMEDIATE DYNAMICS—3 cr. (3 and 0)
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. **Prerequisite:** EM 320, 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 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 505—SEMINAR IN ENGLISH LITERATURE I—3 cr. (3 and 0)

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's 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 461—SIMINAR—1 cr. (1 and 0)

Ent 462—SIMINAR—1 cr. (1 and 0)

Ent 463—INTRODUCTION TO RESEARCH—2 cr. (1 and 3)

Ent 508—TAXONY OF IMMATURE INSECTS—3 cr. (1 and 6)
Identification of immature insects with particular emphasis on the Holometabola. Each student will make and submit an identified collection of immature insects.

Ent 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.

*May be used for graduate credit under special conditions only—offered in alternate years.

**Ent 408 is taught in alternate years.
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 quantitatively describe environmental systems. Certain biological competencies are also required in order to properly apply engineering to environments of living systems. Enrollment is open to students having degrees in engineering or science. With the approval of his adviser, a Master's candidate in certain specialized areas may select a non-thesis option.

The M.S. and Ph.D. programs of study will be planned to augment the student's previous engineering or science background. The M.S. student may select a minor in the basic sciences or in another field of engineering. The Ph.D. student will select at least one minor from the fields of mathematics, chemistry, physics, or biology. Generally, a student with a science background will take a number of engineering courses, and a student with an engineering background will take several science courses. The major field of study will be interdisciplinary in nature, consisting of existing courses in engineering and the basic sciences. Core courses in air, water, and plant and animal environments are also available.
CE 443—ENVIRONMENTAL ENGR. CHEM. I—2 cr. (2 and 0)
Theory and control of the chemical processes employed in treatment of waste water. The principles of analytical and physical chemistry are applied to problems in environmental engineering.

CE 444—ENVIRONMENTAL ENGR. CHEM. LAB. I—2 cr. (0 and 6)
Theoretical relationships considered in CE 443 are applied to actual problems in analysis and control of water and waste treatment processes. **Prerequisite or concurrent:** CE 443.

ESE 542—SANITARY ENGINEERING PROCESSES—2 cr. (3 and 0) S
Theory and design of chemical and biological processes employed in sanitary engineering. (CE 542)

ESE 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 543)

ESE 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 543)

ESE 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 548)

ESE 549—ENVIRONMENTAL ENGR. CHEM. LAB. II—2 cr. (1 and 3)
Theoretical principles developed in ESE 548 are applied to laboratory measurement and control of environmental engineering systems. Instrumental analysis and advanced analytical techniques are stressed. **Prerequisite:** ESE 548 or permission of the instructor. (CE 549)

ESE 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 550)

ESE 551—UNIT OPERATIONS & PROCESSES LABORATORY—2 cr. (1 and 3)
Laboratory exercises in solids-liquids separations, ion-exchange, electrodialysis, and biological processes. Stress will be placed on the relation between theory and experimental results. (CE 551)
ESE 581—SPECIAL PROBLEMS—1-4 cr. FS
Problems are selected in the field of Environmental Systems Engineering to meet the interests and experience of student and instructor. (CE 589)

ESE 591—RESEARCH—1-6 cr.
May be taken more than one semester. (CE 591)

ESE 691—DOCTORAL RESEARCH—1-18 cr.
May be taken more than one semester. (CE 691)

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—4 cr. (3 and 3) FS
Role of statistics in research. Statistical inference, concepts, estimation, test of significance, principles of scientific investigation, analysis of variance including multiple comparison techniques, basic designs, simple and multiple linear regression and correlation mean square expectations, and variance components analysis. Prerequisite: Permission of instructor.

Ex St 503—REGRESSION AND LEAST SQUARES ANALYSIS—3 cr.
(3 and 0) F
Regression analysis; simple and multiple linear, curvilinear and multiple curvilinear; curve fitting; least squares and computer techniques for fitting of constants and analysis of planned experiments. Prerequisite: Ex St 501.

Ex St 504—SAMPLING—3 cr. (3 and 0) S
The principles of scientific sampling; finite population sampling; simple random, stratified, multistage, and systematic sampling; optimum allocation; methods of obtaining and reporting survey information. Sampling as related to environment and resources as well as economic and social problems will be considered. Prerequisite: Ex St 501.
Ex St 505—DESIGN AND ANALYSIS OF EXPERIMENTS—3 cr.
(3 and 0) S

Principles of design and analysis of experiments; review of basic designs; individual degrees of freedom, orthogonality and responses in the analysis of variance; covariance analysis; factorials, split-plot arrangements, confounding, incomplete block designs; transformations; non-parametric procedures; introduction to least squares methods for analysis of experiments, and response surface methodology. **Prerequisite:** Ex St 501.

**GEOLOGY**

**P. K. Birkhead, Chairman**

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

Geol 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—3 cr. (3 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.

Hist 402—MEDIEVAL HISTORY—3 cr. (3 and 0) F
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 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 the Department of Food Science and Biochemistry at 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 science, nutrition, and biochemistry. 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) S
*Hort 310—FLORICULTURE—3 cr. (2 and 3) S
*Hort 352—COMMERCIAL POMOLOGY—3 cr. (2 and 3) F
Hort 405—NUT TREE CULTURE—2 cr. (2 and 0) F, even numbered years.
Hort 406—NURSERY TECHNOLOGY—3 cr. (2 and 3) S
Hort 407—LANDSCAPE DESIGN—3 cr. (2 and 3) F
Hort 412—TURF MANAGEMENT—3 cr. (2 and 3) F
Hort 451—SMALL FRUIT CULTURE—3 cr. (2 and 3) S
Hort 456—TRUCK CROPS—3 cr. (3 and 0) S, even numbered years
Hort 460—LANDSCAPE DESIGN—5 cr. (3 and 6) F
Hort 464—FOOD PRESERVATION—3 cr. (2 and 3) F
Hort 468—INTRODUCTION TO RESEARCH—2 cr. (1 and 3) S
Hort 501—PROBLEMS IN SMALL FRUIT PRODUCTION—3 cr. (3 and 0) F, odd numbered years

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

*May be used for graduate credit under special conditions only.
Technical advances in horticulture. Consideration will also be given to experimental techniques including uses of specialized equipment in horticultural research.

A systematic study of sources of information on mineral nutrition and water relations of vegetable crops.

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

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.

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.

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

Special research problems in horticulture not related to a thesis, but designed to provide opportunities for research experience and training.

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

A continuation of Hort 509.

Credit to be arranged. F, S, SS.
INDUSTRIAL EDUCATION
A. F. Newton, Department Head

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—Credit to be arranged

In Ed 595—SPECIAL PROBLEMS I—3 cr. (3 and 0)

Directed study of special problems in the field of Industrial Education. Subject matter will vary with interests, experiences, and needs of the student.

In Ed 596—SPECIAL PROBLEM II—3 cr. (3 and 0)

Continuation of In Ed 595.

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—INDUSTRIAL APPLICATIONS OF STATICS—3 cr. (3 and 0) S

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

IE 417—SYSTEMS SIMULATION—3 cr. (3 and 0)

IE 511—OPERATIONS RESEARCH IN PRODUCTION CONTROL—3 cr. (3 and 0) S

Production planning and control problems are analyzed using the quantitative techniques of Operations Research. Linear and nonlinear programming, queuing theory, simulation, and statistics are used to solve real problems in forecasting, inventory control, and scheduling. Prerequisites: IE 411 and IE 414 or equivalents.
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 and 3) 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 613—SYSTEMS—ANALYSIS—3 cr. (3 and 0)**

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

**IM 691—THESIS RESEARCH—Credit to be arranged.**

**MATERIALS ENGINEERING**

**G. C. Robinson, Chairman**

Courses are offered leading to the Doctor of Philosophy degree.

The program in Materials Engineering is an interdisciplinary program which permits students to concentrate in courses directed towards the analysis and synthesis of material components of engineering systems. The student is expected to achieve a balance in course work between three major classifications of courses. The first classification is concerned with the atomic, molecular and microstructures of materials. The second group of courses consists of studies of the relationship between the structure and composition of materials to the mechanical thermal, electrical, optical and chemical properties of materials. The third classification is concerned with the selection, application, design and development of material components to solve specific engineering problems.

The courses included in the curriculum are drawn primarily from four disciplines; chemistry, physics, ceramic engineering and metallurgical engineering. Additional supporting courses are available from programs in electrical engineering, engineering mechanics and mathematics. Over sixty-five courses are available to the materials engineering programs from these disciplines.

Students are accepted in the materials engineering program possessing degrees in engineering, chemistry or physics. An individual program is designed for each student by his advisory committee to coordinate with
his previous education and to suit the particular educational goals of the student.

MatE 691—DOCTORAL RESEARCH—Credit to be arranged.

MATHEMATICS
C. V. Aucoin, Department Head

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

Students seeking the master's degree may choose a thesis or a non-thesis option. Work for this degree will consist of a minimum of thirty-one semester hours.

*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)
*Comp Sci 310—PROGRAMMING THE DIGITAL COMPUTER
*Math 313—STATISTICAL THEORY AND METHODS I—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 405—STATISTICAL THEORY AND METHODS II—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 I—3 cr. (3 and 0)
Math 413—INTRODUCTION TO MODERN ALGEBRA II—3 cr. (3 and 0)
Math 415—INTRODUCTION TO TOPOLOGY—3 cr. (3 and 0)
Math 417—MATHEMATICS PROGRAMS—3 cr. (3 and 0)

*May be used for graduate credit under special conditions only.
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)
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. Conformal mapping 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; Schreier, 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; incolusion 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, uni-
formly most powerful tests, methods of deriving tests. \textbf{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. \textbf{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. \textbf{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. \textbf{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. \textbf{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 631—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
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<tr>
<td>ME 404</td>
<td>PHYSICAL SYSTEMS ANALYSIS</td>
<td>3 cr.</td>
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<td>ME 407</td>
<td>HEAT TRANSFER II</td>
<td>3 cr.</td>
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<td>ME 411</td>
<td>GAS POWER</td>
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<tr>
<td>ME 412</td>
<td>STEAM POWER</td>
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<td>ME 421</td>
<td>PROPULSION SYSTEMS I</td>
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<td>ME 422</td>
<td>PRINCIPLES OF TURBOMACHINERY</td>
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<tr>
<td>ME 423</td>
<td>PROPULSION SYSTEM ANALYSIS</td>
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<td>ME 429</td>
<td>AIR CONDITIONING</td>
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<tr>
<td>ME 430</td>
<td>AIR CONDITIONING DESIGN</td>
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<td>ME 433</td>
<td>ELEMENTARY AERODYNAMICS</td>
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<td>ME 434</td>
<td>REFRIGERATION</td>
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<td>ME 464</td>
<td>LUBRICATION</td>
<td>2 cr.</td>
<td>(2 and 0) S</td>
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<tr>
<td>ME 501</td>
<td>THERMAL ENVIRONMENTAL ENGINEERING</td>
<td>3 cr.</td>
<td>(3 and 0)</td>
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<tr>
<td>ME 510</td>
<td>ADVANCED THERMODYNAMICS</td>
<td>3 cr.</td>
<td>(3 and 0) F</td>
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<tr>
<td>ME 511</td>
<td>GAS DYNAMICS II</td>
<td>3 cr.</td>
<td>(3 and 0) S</td>
</tr>
<tr>
<td>ME 512</td>
<td>BOUNDARY LAYER THEORY I</td>
<td>3 cr.</td>
<td>(3 and 0) F</td>
</tr>
</tbody>
</table>

A study of the effects of the thermal environment upon people, processes, and materials including a detailed analysis of the fundamental theories of refrigeration, psychrometrics, heat and mass transfer processes with moist air, periodic heat transfer in buildings, solar radiation, and cryogenics.

ME 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. **Prerequisites:** 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

ME 515—KINETIC THEORY OF GASES—3 cr. (3 and 0)

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 550—ADV. MECH. ENGR. DESIGN—3 cr. (3 and 0)
Principles of mechanical sciences applied to the analysis of machines, devices and mechanical systems. Analysis of state of stress, state of strain, elasticity, plasticity, working stresses, stress concentration, fatigue, impact and shock, thermal stresses, libration and contact stress. Applications to the design of machine frames, shafts, bearings, springs, gears and other machine elements. Prerequisite: ME 401.

ME 551—ADV. MECH. ENGR. DESIGN—3 cr. (3 and 0)
Continuation of ME 550. Prerequisite: ME 550.

ME 560—ADVANCED SYSTEM ANALYSIS I—3 cr. (3 and 0)
Complex problem formulation using component terminal equations and linear graph theory. Instrumentation and measurement processes for multi-

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—3 cr. (2 and 3)
A study of advanced x-ray diffraction, field ion microscope, electron microscope, neutron diffraction, torsional pendulum, advanced optical
microscopic methods, radioactive tracer techniques, methods employed to study metal structure, and interpretation of experimental data in terms of metallic structures.

MetE 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 the Master of Science and 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) F
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 591—RESEARCH—Credit to be arranged. FS, SS

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

**PHYSICS**

L. D. Huff, Department Head

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

All entering graduate students will take a placement examination at the beginning of their semester of attendance. This examination is administered by the graduate adviser to assist him in the scheduling of their courses.

**For the Master of Science degree:**

1. A student must have a reading knowledge of one foreign language.

2. A student is admitted to candidacy for the Master of Science degree upon the completion of a written qualifying examination covering major and minor fields. This examination must be completed one semester before the date on which the degree is expected.

3. A final oral examination on the subject matter of the major and minor fields and on the thesis. This examination will be given at least two weeks before the date on which the degree is to be granted.

**For the Doctor of Philosophy degree:**

1. A student who entered with a Bachelor's degree will take the qualifying examination for the Master of Science degree. If he performs to the satisfaction of the faculty, he may by-pass the Master's degree if he chooses. Otherwise he must obtain the Master of Science degree before he can be considered for continuance in the doctoral program.
2. Students are admitted to candidacy for the Doctor of Philosophy degree upon the successful completion of a written qualifying examination on the subject matter of the major and minor fields. This examination must be completed at least one academic year prior to the date on which the degree is expected.

3. The student must take a final oral examination on the dissertation only. This examination must be taken at least two weeks prior to the convocation on which the degree is expected.

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


*Courses which may be used by students majoring in other fields.
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 formulations 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 application 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 introduction 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 transistors, theories of magnetism and magnetic resonance phenomena.

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 nuclear particles.

Phys 554—NUCLEAR PHYSICS II— 3 cr. (3 and 0)
High energy radiation processes, nuclear reactions including nuclear fission; 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 ef-
   fects 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 representa-
   tion; 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; intro-
   duction 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, radio-
   activity 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 Phi-
losophy 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 Doctor of Philosophy degree is offered in Animal Physiology and Nutrition on an inter-departmental basis.

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 other appropriate species. Chemical and biological assays of nutrients will be performed using acceptable methods and species.

*Courses may be used by students majoring in other fields.
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 agents.

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 359—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 411—HISTORY OF SOCIAL THOUGHT—3 cr. (3 and 0)

Soc 421—SOCIOLOGICAL THEORY—3 cr. (3 and 0)

Soc 431—COMPLEX ORGANIZATIONS—3 cr. (3 and 0)

Soc 441—SOCIAL STRATIFICATION—3 cr. (3 and 0)

Soc 451—SOCIOLOGY OF MEDICINE—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.

Graduate students will be accepted with backgrounds in other areas of study provided that they have taken sufficient course work in mathematics, chemistry and physics. Appropriate undergraduate courses will be re-
quired in the Department of Textiles in special cases. Minors normally will be taken in chemistry, physics or mathematics.

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 511—CLIMATOLOGY—3 cr. (3 and 0)
Study of the physical factors that affect climate and the development of the general circulation patterns of the world. The climates of the world are discussed and related to the activities of man. **Prerequisite:** Consent of instructor.

WRE 512—METEOROLOGY—3 cr. (3 and 0)
A course designed to provide the student with a physical description of the atmosphere and its interactions with the earth. Topics include condensation and precipitation processes, energy exchange, wind systems and weather development.

WRE 522—WATER MOVEMENT IN SOILS—3 cr. (3 and 0)
A study of theory and principles of water movement in soils. Principal topics include theory and application of flow of water through soil in unsaturated states, flow nets and seepage forces, and the fundamentals of engineering design with respect to ground water problems and soil moisture relationships. **Prerequisite:** Permission of instructor.

WRE 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.

WRE 562—ADVANCED HYDROLOGY—3 cr. (3 and 0)
Special work to strengthen the student's background in modern methods. Emphasis is laid on evaporation, infiltration and the synthetic hydrograph. **Prerequisite:** WRE 561.

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.

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—PROTOZOOLOGY—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.

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 507—USE OF RADIOISOTOPES IN BIOLOGICAL RESEARCH—3 cr. (2 and 3)

The types of radioisotopes useful in biological research will be studied, including methods of detection and measurement in biological systems. **Prerequisites:** Graduate standing and permission of instructor.

*May be used for graduate credit under special conditions only.

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Zool 508—RADIOBIOLOGY—3 cr. (2 and 3)
A study of the effects of various types of radiation upon cells, tissues, and organs of animals. Various methods of evaluation and quantitation of effects will be employed in the laboratory. **Prerequisites:** Graduate standing and permission of the instructor.

Zool 509—TOXICOLOGY—3 cr. (2 and 3)
Toxicologic methods, modes of action, signs and symptoms of poison, and antidotes will be studied. Special emphasis will be given deleterious effects from commonly used chemicals. Quantitative aspects of toxicology will be demonstrated in the laboratory. **Prerequisites:** An Ph 505 and permission of instructor.

Zool 510—MAMMALOGY—3 cr. (2 and 3)
A study of the taxonomy, distribution, ecology and economic importance of mammals with emphasis on South Carolina and North American forms. **Prerequisites:** Zool 101, 103, and 301 or permission of instructor.

Zool 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 phylla (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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