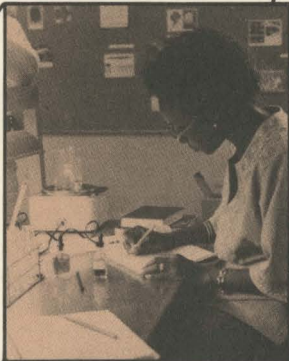
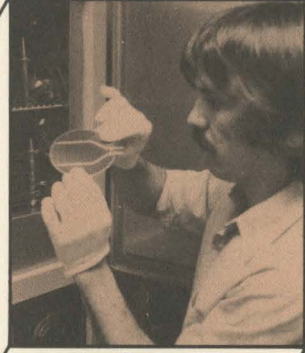
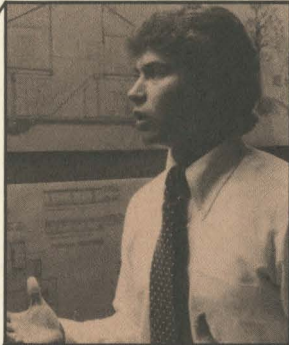


# The Graduate School



## PURPOSE OF CATALOG

The purpose of this catalog is to provide prospective students with a general description of Clemson University and give detailed information regarding the various colleges and departments within the University and curricula offered by the University. Inasmuch as the educational process necessitates change, the information and educational requirements in this catalog represent a flexible program which may be altered where such alterations are thought to be in the mutual interest of the University and its students.

The provisions of this catalog do not constitute any offer for a contract which may be accepted by students through registration and enrollment in the University. The University reserves the right to change without notice any fee, provision, offering, or requirement in this catalog and to determine whether a student has satisfactorily met its requirements for admission or graduation. The University further reserves the right to require a student to withdraw from the University for cause at any time.

Each curriculum (Form GS-2) shall be governed by the requirements in effect on the date of enrollment. If a student withdraws from the University and subsequently returns or does not remain continuously enrolled (summers excluded), the requirements in effect at the time of return will govern.

## STUDENT RESPONSIBILITY

All colleges and departments establish certain academic requirements which must be met before a degree is granted. Advisors, department heads, and deans are available to help the student understand and arrange to meet these requirements, but the student is responsible for fulfilling them. If, at the end of a student's course of study the requirements for graduation have not been satisfied, the degree will not be granted. For this reason, it is important for each student to acquaint himself or herself with all academic requirements throughout his or her college career and to be responsible for completing all such requirements within prescribed deadlines and time limits.

Except as they apply to undergraduate students only, graduate students are subject to the usual procedures and regulations of the University as listed in the general catalog, *Clemson University Announcements*, and in particular to those dealing with academic dishonesty.

## EQUAL OPPORTUNITY IN PROGRAMS AND ACTIVITIES

Federal laws prohibit discrimination under programs and activities receiving Federal financial assistance. The statutes listed below are applicable to Clemson University and provide in part:

### **Title VI of the Civil Rights Act of 1964**

"No person in the United States shall, on the ground of race, color, or national origin, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

### **Title IX of the Education Amendments of 1972**

"No person in the United States shall, on the basis of sex, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any education program or activity receiving Federal financial assistance."

### **Section 504 of the Rehabilitation Act of 1973**

"No otherwise qualified handicapped individual in the United States shall, solely by reason of his handicap, be excluded from the participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance."

Clemson University conducts its programs and activities involving admission and treatment of students, employment, teaching, research, and public service in a nondiscriminatory manner as prescribed by Federal law and regulation.

Inquiries concerning the above may be addressed to:

President	Director
Clemson University	or Office for Civil Rights
Clemson, South Carolina 29631	Department of Health, Education, and Welfare
	Washington, D. C. 20201



## DEADLINE DATES

For those who expect to receive a graduate degree on:

**August 8, 1981**

### **Last day for:**

\*Filing Form GS2, Graduate Degree Curriculum June 5, 1981

†Filing Form GS4, Admission to Candidacy and Diploma Order June 5, 1981

Oral and/or written examination July 17, 1981

### **(Optional)**

Preliminary review of completed (signed) theses and dissertations, prior to printing, by the Graduate School Office July 24, 1981

Final submission of theses and dissertations to the Graduate School Office July 31, 1981

## CHECK LIST ON GRADUATE SCHOOL PROCEDURES

The graduate student should carefully note this check list as well as the above deadline dates.

1. Select (in consultation with the appropriate department head) a major advisor and advisory committee. (See page 31.)
2. Submit Graduate Degree Curriculum (GS Form 2). (See page 32.)
3. Satisfy any prescribed language requirement and comprehensive examination prerequisite to admission to candidacy. (See pages 38, 42 and 43.)
4. Apply for admission to candidacy for a degree and order diploma (GS Form 4) after completing at least half the prescribed course work. (See pages 32 and 33.)
5. Submit completed thesis (if required) or dissertation to advisory committee chairman and arrange for final examination by the advisory committee. (See pages 36, 39 and 44.)
6. Pay binding fee to the bursar and submit approved copies of thesis or dissertation to the Graduate School. Doctoral candidates pay for abstract publication in Dissertation Abstracts. (See page 37.)

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

\*Although Form GS2 will be accepted up through the deadline dates listed, students are encouraged to submit this form within the time frame suggested under "Filing of a Graduate Degree Curriculum" on page 32. The filing dates are deadlines for signed forms to be in the Graduate School Office and include any revisions (content and/or committee members) to an earlier approved Form GS2.

†These deadline dates refer to filing, with the Graduate School, of forms carrying all required signatures.

<b>December 17, 1981</b>	<b>May 7, 1982</b>	<b>August 7, 1982</b>
September 10, 1981	January 27, 1982	June 4, 1982
September 10, 1981	January 27, 1982	June 4, 1982
November 25, 1981	April 16, 1982	July 16, 1982
December 3, 1981	April 23, 1982	July 23, 1982
December 10, 1981	April 30, 1982	July 30, 1982

## EXPLANATION OF COURSE LISTINGS

Courses are listed alphabetically within the college that offers them. In certain departments offering more than one course sequence, the secondary courses (not leading to a major or a minor) are listed immediately after those normally associated with the degree program or departmental name. The list of courses offered under each program includes for each course the catalog number, title of course, credit in semester hours, class/laboratory hours per week, and, for courses numbered 700 or above, the description of the course. Where courses are offered on a schedule, there is a designation F, S, or SS following the class/laboratory hours, indicating whether the course is customarily offered in the fall, spring, or summer school.

Graduate credit can be earned only for courses numbered 600 or above. Courses listed in this catalog in the 600-699 series are taught concurrently in the same classroom setting as the corresponding 300/400 series undergraduate courses. These are described in the general catalog, *Announcements 1980-81*, which may be obtained from the director of undergraduate admissions.

Courses numbered in the 300 and 400 sequence are primarily for advanced undergraduates but are also offered for graduate credit when they carry the corresponding 600-level number. Students who receive graduate credit in such courses must be required to do extra work of an appropriate nature as determined by the department and be graded according to graduate standards.

Some course listings under certain programs may contain 700-, 800-, and 900-level courses with a number, title, credits and hours, but no description. These courses are administered by a department other than the one under which they are listed. A note above the listing of the courses will explain where the descriptions are located.

The 700-level courses are designed primarily for the degrees which emphasize professional practice rather than research.

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## GRADUATE PROGRAMS AND COURSE OFFERINGS

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Agricultural Economics	M.Ag., M.S. 46
Community and Rural Development (no major or minor)	49
Agricultural Mechanization	M.Ag. 50
Agronomy	M.Ag., M.S., Ph.D. 51
Animal and Food Industries	M.S. 53
Animal Physiology	Ph.D. 53
Animal Science	M.Ag. 57
Applied Economics	Ph.D. 58
Dairy Science	M.Ag. 58
Entomology	M.Ag., M.S., Ph.D. 59
Environmental Science	Minor 61
Experimental Statistics	Minor 62
Food Science	Minor 62
Genetics	Minor 64
Horticulture	M.Ag., M.S. 65
Nutrition	M.N.S., M.S., Ph.D. 68
Plant Pathology	M.Ag., M.S., Ph.D. 71
Plant Physiology	Ph.D. 73
Poultry Science	M.Ag. 74
Wildlife Biology	M.S. 75
College of Architecture	79
Architecture	M.Arch. 81
Building Science (no major or minor)	83
City and Regional Planning	M.C.R.P. 84
Visual Studies	M.F.A. 88
Art and Architectural History (no major or minor)	90
College of Education	93
Administration and Supervision	M.Ed., Ed.S. 97
Agricultural Education	M.Ag.Ed. 94
Elementary Education	M.Ed. 96
Industrial Education	M.In.Ed. 108
Personnel Services	M.Ed. 97
Reading	M.Ed. 97
Secondary Education	M.Ed. 96
Vocational/Technical Education	Ed.D. 111
College of Engineering	113
Agricultural Engineering	M.Engr., M.S., Ph.D. 114
Bioengineering	M.S., Ph.D. 116
Ceramic Engineering	M.Engr., M.S. 120

Chemical Engineering	M.Engr., M.S., Ph.D.	122
Civil Engineering	M.Engr., M.S., Ph.D.	124
Computer Engineering	M.S.	131
Electrical Engineering	M.Engr., M.S., Ph.D.	134
Engineering Mechanics	M.S., Ph.D.	140
Environmental Systems Engineering	M.Engr., M.S., Ph.D.	142
Materials Engineering	M.S.	146
Mechanical Engineering	M.Engr., M.S., Ph.D.	149
Systems Engineering	M.S., Ph.D.	153
College of Forest and Recreation Resources		157
Forestry	M.For., M.S.	158
Recreation and Park Administration	M.R.P.A.	161
College of Industrial Management and Textile Science		165
Accounting (no major or minor)		166
Finance (no major or minor)		167
Business Administration	M.B.A.*	171
Economics	M.A.	167
Engineering Management	Ph.D.	170
Management	M.S.	171
Hospital Administration (no major or minor)		173
Industrial Management (no major or minor)		173
Management Science	Ph.D.	174
Textile and Polymer Science	Ph.D.	176
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Textile Science	M.S.	178
College of Liberal Arts		181
English	M.A.	182
History	M.A.	185
Political Science (no major or minor)		188
Psychology (no major or minor)		189
Sociology	Minor	189
Rural Sociology (no major or minor)		183

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



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Family Health Nursing	M.S. 192

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Botany	M.S. 201
Chemistry	M.S., Ph.D. 204
Computer Science	M.S. 209
Geology	Minor 211
Mathematical Sciences	M.S., Ph.D. 212
Microbiology	M.S., Ph.D. 223
Physics	M.S., Ph.D. 226
Astronomy (no major or minor)	231
Zoology	M.S., Ph.D. 232

FALL SEMESTER 1981

Monday-Tuesday — Orientation, new students	August 17-18
Wednesday — Registration, all students	August 19
Thursday — Late registration	August 20
Friday — Late registration fee applies	August 21
Friday — Classes begin regular schedule	August 21
Thursday — Last day for registration	August 27
Thursday — Last day to add a subject	August 27
Thursday — Last day to order diploma for	September 10
Thursday — Last day to drop a subject	September 17
Monday — Preliminary reports due	October 12
Wednesday — Last day to drop a subject or	October 28
withdraw from the University without	
receiving final grades based on full	
semester requirements	
Monday-Friday — Preregistration	November 9-13
Wednesday — Thanksgiving holidays begin	November 25
after last class	
Monday — Classes resume	November 30
Monday — Examinations begin	December 7
Thursday — Midyear graduation	December 17

SPRING SEMESTER 1982

Monday — Orientation, new students	January 4
Tuesday — Registration, all students	January 5

## CLEMSON UNIVERSITY CALENDAR SUMMER 1981 — SUMMER 1982

### SUMMER SESSIONS 1981

(Classes meet Monday-Friday except as indicated.)

#### First Session

May 18	Monday — Registration
May 19	Tuesday — Classes begin
June 24-25	Wednesday-Thursday — Examinations

#### Second Session

June 29	Monday — Orientation, new students
June 30	Tuesday — Registration
July 1	Wednesday — Classes begin
July 25	Saturday — Classes meet
August 5-6	Wednesday-Thursday — Examinations
August 8	Saturday — Graduation

### FALL SEMESTER 1981

August 17-18	Monday-Tuesday — Orientation, new students
August 19	Wednesday — Registration, all students
August 20	Thursday — Late registration
August 21	Friday — Late registration fee applies
August 21	Friday — Classes begin regular schedule
August 27	Thursday — Last day for registration
August 27	Thursday — Last day to add a subject
September 10	Thursday — Last day to order diploma for midyear graduation
September 17	Thursday — Last day to drop a subject without record
October 12	Monday — Preliminary reports due
October 28	Wednesday — Last day to drop a subject or withdraw from the University without receiving final grades based on full semester requirements
November 9-13	Monday-Friday — Preregistration
November 25	Wednesday — Thanksgiving holidays begin after last class
November 30	Monday — Classes resume
December 7	Monday — Examinations begin
December 17	Thursday — Midyear graduation

### SPRING SEMESTER 1982

January 4	Monday — Orientation, new students
January 5	Tuesday — Registration, all students

January 6	Wednesday — Late registration
January 7	Thursday — Late registration fee applies
January 7	Thursday — Classes begin regular schedule
January 13	Wednesday — Last day for registration
January 13	Wednesday — Last day to add a subject
January 27	Wednesday — Last day to order diploma for May graduation
February 3	Wednesday — Last day to drop a subject without record
March 1	Monday — Preliminary reports due
March 12	Friday — Last day to drop a subject or withdraw from the University without receiving final grades based on full semester requirements
March 12	Friday — Spring holidays begin after last class
March 22	Monday — Classes resume
April 7	Wednesday — Honors and Awards Day; classes suspended at 12 noon
April 12-16	Monday-Friday — Preregistration
April 26	Monday — Examinations begin
May 7	Friday — Commencement

### SUMMER SESSIONS 1982

(Classes meet Monday-Friday except as indicated.)

#### First Session

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

#### Second Session

June 28	Monday — Orientation, new students
June 29	Tuesday — Registration
June 30	Wednesday — Classes begin
July 2	Friday — Classes suspended
July 10	Saturday — Classes meet
July 24	Saturday — Classes meet
August 4-5	Wednesday-Thursday — Examinations
August 7	Saturday — Graduation

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## THE UNIVERSITY

### **INTRODUCTION**

Clemson University is a coeducational land-grant university offering 78 fields of undergraduate study and 58 areas of graduate study in nine colleges. The academic units are the Colleges of Agricultural Sciences, Engineering, Architecture, Education, Forest and Recreation Resources, Industrial Management and Textile Science, Liberal Arts, Nursing, and Sciences. Fully accredited by the Southern Association of Colleges and Schools, the graduate curricula form a background of education for the hundreds of occupations which Clemson graduates enter.

Present on-campus enrollment totals about 10,900 students, which includes about 1,500 graduate students. The 600-acre main campus is located on the shores of Lake Hartwell in the northwestern part of South Carolina, approximately two and one-half hours' driving time from both Atlanta, Georgia, and Charlotte, North Carolina.

### **UNIVERSITY GOVERNMENT AND ADMINISTRATION**

The University is governed by a board of thirteen members, including six elected by the state legislature and seven self-perpetuating life members, in accord with the will of Thomas G. Clemson. The Board of Trustees is primarily responsible for setting policy and approving budgets and expenditures. The University's day-to-day operations are administered by its president; vice-presidents for academic affairs, business and finance, and student affairs; and the president's executive staff. The president of the University is the chief executive and administrative officer.

Academic deans are responsible for programs and personnel in their individual colleges and report directly to the provost. At the direction of the provost, the academic deans coordinate graduate programs and research with the dean of the Graduate School.

The dean of the Graduate School and vice provost coordinates all graduate programs and advises the provost on policies and regulations pertaining to graduate study and research. Matters concerning graduate admissions policies, graduate student programs, and the granting of graduate degrees are coordinated through this office. The dean chairs the Graduate Curriculum Committee and the Commission on Graduate Studies and Research.

**Board of Trustees**

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- Paul W. McAlister, Chairman of the Board ..... Laurens, S. C.
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**Executive Officers and Deans**

- Bill Lee Atchley, Ph.D. ....President
- W. David Maxwell, Ph.D. ....Provost and Vice President  
for Academic Affairs
- Walter T. Cox, B.S. .... Vice President for Student Affairs
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- Arnold E. Schwartz, Ph.D. .... Dean of the Graduate School  
and Vice Provost
- Jerome V. Reel, Ph.D. .... Vice Provost
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- J. Charles Jennett, Ph.D. .... Dean, College of Engineering
- Benton H. Box, D.For. .... Dean, College of Forest  
and Recreation Resources
- Ryan C. Amacher, Ph.D. .... Dean, College of Industrial  
Management and Textile Science

Robert A. Waller, Ph.D. . . . . Dean, College of Liberal Arts  
 Mary Lohr, Ed.D. . . . . Dean, College of Nursing  
 Henry E. Vogel, Ph.D. . . . . Dean, College of Sciences

**COMMISSION ON GRADUATE STUDIES AND RESEARCH**

The Commission on Graduate Studies and Research exists to study, formulate, and recommend to the President's Council general policies and procedures pertaining to graduate studies, graduate student academic affairs, research, and resources and services that affect graduate studies and research. Areas of specific concern include:

- Admission standards and procedures; student research; financial assistance and awards through scholarships, fellowships, and assistantships; library resources; housing; and other matters relating to the academic environment of graduate students.
- University faculty research and the immediate and long-range goals of the University in research and graduate studies.
- Continuing education, extension and other public educational programs related to graduate credit.

The commission is composed of 10 members: the dean of the Graduate School (chairperson), one administrative representative from each of two colleges appointed by the president of the University upon the recommendation of the provost, one faculty representative from each college elected by the college faculty, the chairperson of the Faculty Senate Research Committee, a representative from the library as selected by the provost, a faculty senator elected by the Senate, the director of the Office of University Research, and three graduate student representatives elected by the Graduate Student Association.

**GRADUATE SCHOOL**

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

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

**Graduate Curriculum Committee**

The Graduate Curriculum Committee shall be advisory to the provost and shall be comprised of a vice provost or other member of the provost's staff designated by him or her as (non-voting) chairperson, plus the respective chairpersons of the graduate curriculum committees of the academic colleges.

This committee shall process all requests for graduate curricular changes emanating from the colleges after favorable action by the faculties thereof and make recommendations concerning them to the provost. In doing so, the committee will be guided by all applicable University rules and regulations and by the policies established by the President's Council upon the recommendation of the appropriate commission(s) thereof.

The provost and vice president for academic affairs will take the recommendations of the Graduate Curriculum Committee to the Council of Academic Deans for its scrutiny and advice. The provost and vice president for academic affairs will then transmit his or her recommendations to the president for final approval and will inform the President's Council, in summary form, of those curricular changes the president has approved.

Appeals regarding admissions, degree requirements or other policy decisions affecting the welfare of graduate students are referred to the Graduate Curriculum Committee or, if appropriate, to the Commission on Graduate Studies and Research. The appeal must be presented in writing to the dean of the Graduate School or to members of the commission.

Graduate students and faculty who are not members of the Curriculum Committee are free to attend its meetings.

### **Graduate Student Association**

The Graduate Student Association (GSA) provides a voice for all graduate students by investigating problems or issues that concern graduate students and making recommendations to the proper authorities.

The GSA elects representatives to various University councils which may elicit graduate student opinions. It also seeks to support and promote an academic and cultural atmosphere in the University community and establish better interdepartmental communications among graduate students.

The GSA is composed of a Steering Committee with elected officers including at least one graduate student from each department on campus.

### **ROBERT MULDROW COOPER LIBRARY**

Current resources and facilities of Clemson's library make it one of the most important research institutions in the Southeast. Today, the library has a collection of more than 13,000 subscriptions and 900,000 volumes. Outstanding collections of journals, books, and primary research materials have been developed in many areas, especially agriculture, natural and physical sciences, economics, and technology. In the social sciences, particularly strong manuscript collections have been developed around the papers of Vice President John C. Calhoun, South Carolina Governor James F. Byrnes, and Senator Edgar A. Brown. These and other resources are drawn on by scholars from all over the United States, Japan, and Europe.

Extensive use of the collection is made by borrowers from many parts

of the Southeast through modern, efficient techniques. The Cooper Library is linked by computer terminals to more than 1,500 other libraries through OCLC Inc. for cataloging and interlibrary loan services. Online bibliographic retrieval is available through the powerful data-base searching capabilities of Lockheed and SDC search services.

The library is primarily used by students, staff, and faculty of Clemson University who are engaged in the instructional, research, and service efforts of the institution. The resources are available to, and frequently used by, other citizens of the state under liberal use policies. Other individuals have access to the library under special arrangements through library public service staff.

The main library consists of six approximately equal floors which occupy a total of 145,000 useable square feet of floor space. Almost 70,000 linear feet of shelving provide space for 1.25 to 1.5 million volumes. Seating space accommodates 1,365 readers.

In addition to the main library, a major branch is operated at the College of Architecture in Lee Hall. This branch has more than 2,000 square feet of space, 25,097 volumes, 260 serials subscriptions, and seating for 60 users. There are also organized college and departmental libraries in the College of Industrial Management and Textile Science (Sirriner Hall), and the departments of Chemistry and Geology (Brackett Hall), Physics (Kinard Laboratory), Horticulture (P&AS), and Chemical Engineering (Earle Hall).

Except for adjustments in scheduling during holiday periods, the main library is open Monday-Thursday, 7:45 a.m.-1 a.m.; Friday, 7:45 a.m.-11 p.m.; Saturday, 8 a.m.-6 p.m.; Sunday, 1 p.m.-1 a.m.

Library policy governing undergraduate students also applies to graduate students. All students must present validated I.D. cards to check out library materials. However, a graduate student may be granted the privilege of extended loan for one semester subject to recall. The following regulations apply to extended loans:

1. The privilege is not given automatically but must be requested for each book. Otherwise a two-week due date will be stamped in the book. The privilege applies only to those books in which the borrower's major research is concentrated and should be used with discretion.

2. Graduate students must have a graduate validation sticker attached to their I.D. cards if they wish to have the privilege of extended loans and other graduate privileges.

3. The date stamped in the book indicates the date the book is due. After that date overdue fines apply. Since overdue notices are sent as a favor to the borrower, failure to receive such a notice does not excuse the borrower from payment of fines. Circumstances may prevent the library from sending overdue notices.

4. If a book is recalled, regulations apply the same as for undergraduate students. The due date is changed and higher fines are assessed when the books are not returned by that date.



5. Information guides may be obtained at the public service desks of the libraries. There are two useful publications. *Library Guide* provides general information and floor plans of the library. It also includes schedules of fines for materials returned when past due, and for payment for lost or damaged books. *Regulations Governing Fines, Notices and Delinquent Borrowers* provides details on these library policies. Failure to pay library accounts prohibits the student from registering for the next semester or receiving a diploma if graduating.

### **COMPUTER CENTER**

The Clemson University Computer Center operates an IBM System 370/3033 with 12 megabytes of main storage, which is available to graduate students for course work and research. The center supports FORTRAN, COBOL, PL/1, ALGOL, PASCAL, ASSEMBLER, and a number of simulation and special-purpose languages. A large library of statistical and mathematical routines is available to users.

Every effort is made to provide rapid turnaround to users. Processing of students' short jobs is accomplished within minutes; turnaround for all but the very longest jobs is completed within a few hours. Programming assistance is available when needed.

In addition to batch facilities, the University has over 150 time sharing terminals on campus. Interactive computational facilities are available for faculty and student use on both a private line and dial up basis.

The main Computer Center in the basement of the R. F. Poole Agricultural Center is open from 7:45 a.m.-11:30 p.m., Monday-Friday; 8:00 a.m.-6:00 p.m., Saturday; and 2:00-11:30 p.m., Sunday. Remote centers are located in Brackett, Lee, Martin, Riggs, and Sirrine Halls. The Brackett Center and the Lee Hall Graphics Center are open Monday-Friday, 8:00 a.m.-5:00 p.m. The Martin, Riggs and Sirrine Centers are open Monday-Friday, 8:00 a.m.-11:30 p.m.; Saturday, 8:00 a.m.-6:00 p.m.; Sunday, 2:00-11:30 p.m.

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## **STUDENT SERVICES**

### **HOUSING**

#### **Single Students**

Residence halls and apartments are located on the main campus and provide excellent accommodations at economical rates for graduate and undergraduate students. All residence hall rooms are air conditioned and equipped with clothes lockers, study desks, chairs, and single or convertible bunk beds with inner spring mattresses. Two students are assigned to a room. Apartments have two bedrooms, living room and kitchen. Four students are assigned to each unit.

Graduate students interested in single student accommodations should write directly to the Housing Office, Mell Hall, Clemson University, Clemson, South Carolina 29631, to obtain information regarding assignments. This should be accomplished promptly for there is a critical shortage of on-campus housing. To request a space, applicants should contact the Housing Office at least three to six months prior to the date scheduled for enrollment. A \$75 advance payment is required to reserve a room in University residence halls. This payment is made to the Housing Office in accordance with room reservation instructions provided by that office.

Prospective students should understand that during periods between semesters all residence halls are closed.

Semester fees are as follows:

#### Residence Halls

Johnstone Hall: Sections A, B, C, D, E, F . . . . . \$350.00

Annexes A, F . . . . . 360.00

Donaldson, Bowen, Wannamaker,

Bradley and Norris . . . . . 360.00

Benet, Young, Cope, Geer and Sanders . . . . . 360.00

Mauldin, Barnett, Smith, Manning,

Lever and Byrnes . . . . . 385.00

Clemson House (two occupants) . . . . . 385.00

Clemson House . . . . . 415.00

(with kitchenettes, three or four occupants)

#### Apartments

Calhoun Courts (4 occupants) . . . . . 500.00

East Campus (4 occupants) . . . . . 475.00

#### **Married Student Housing**

The University provides comfortable and economical housing for its married students with 150 apartments conveniently located near the campus. Applications and booklets describing these facilities are available upon request from the University's Housing Office. Monthly rental fees range from \$90 to \$200.

Students who have received graduate assistantships or fellowships are given priority in assignments to married student housing. To qualify for this priority, students must submit applications to the Housing Office before May 1 for first semester housing, before November 1 for second semester housing, and before March 1 for summer housing.

#### **Off-Campus Housing**

Commercial housing in the surrounding community accommodates the majority of graduate students, both married and single. A complimentary listing of realty companies and other contacts is available upon request from the Housing Office.

### **International Students**

The International Services Office assists international students in finding housing in the local community as well as on campus. Requests for on-campus housing should be made well in advance of arrival at Clemson since space is severely limited.

### **FOOD SERVICE**

The University offers two economical board plans and also provides meals on a cash basis in two student dining halls with unlimited seconds on all items with the exception of some entree selections.

The meal plans are as follows:

1. Five-Day Board Plan — 15 meals, Monday through Friday, excluding holidays, \$365 per semester.
2. Seven-Day Board Plan — 21 meals, Monday through Sunday, excluding holidays, \$425 per semester.

Summer school fees for either plan are on a prorated basis.

Both meal plans begin immediately after the student obtains a meal card at the beginning of a semester or session and end after the evening meal on the day of graduation. The dining halls remain open between the two regular summer sessions. The meal card is personal and may not be loaned, transferred, or sold to another person.

Graduate students have the option at the time of their enrollment of selecting one of the two board plans (five- or seven-day) on a semester or session basis or paying cash for individual meals at the prevailing prices.

Board plans for graduate students are selected on a semester or session basis and may not be discontinued as long as the student remains enrolled, except in the case of marriage or circumstances which are determined by the University to be beyond the student's control. Refunds, when authorized, will be made on a prorated basis. Students may change from the five- to the seven-day board plan at any time during the semester or session by paying the added cost.

### **HEALTH SERVICE**

All students living in University residence halls, all students enrolled in 12 or more semester hours even though they do not live in residence halls, and all international students are required to subscribe to the University health plan. The health plan provides a variety of services including infirmary care, outpatient treatment for illnesses and injury, mental health counseling, dermatology and gynecological care.

The \$55 per semester medical fee (summer session fees are on a prorated basis) covers the services of the University physicians and health service staff for most illnesses and injuries. It also includes complete X-ray services and all laboratory work done in the health service lab.

Items not covered by the fee include physical examinations for employment or transfer to another school, outside physicians called in for

consultation, medical or surgical services performed away from campus, ambulance service, and tests that must be sent to reference labs. Charges for these are at cost to the health service, resulting in substantial savings to the student. Dental care is not offered by the health service but can be obtained locally at the student's expense.

Student Government offers an inexpensive plan of accident and sickness insurance designed to cover major medical expenses not covered by the health plan. Each year prior to the beginning of fall semester, complete information on this insurance plan is sent to all full-time students.

The health service is housed in Redfern Health Center and is complete with an outpatient department and a 24-bed hospital. The outpatient clinic is open 8:30-11:30 a.m. and 2-4:30 p.m. weekdays. Saturday's office hours are 9-11 a.m. only. On Sunday, physicians' rounds are the only services provided other than emergency treatment. Intercom boxes are stationed at each entrance for emergency use after hours.

The student health service has the basic function of providing medical care for the ill and injured; however, it attempts to put strong emphasis on health rather than illness. This emphasis begins with the entrance medical questionnaire which is designed to obtain information regarding medical history so as to better equip the staff in protecting the student from illness and to serve as a guide for the care of pre-existing medical problems.

## **INTERNATIONAL STUDENTS AND EXCHANGE VISITORS**

The International Services Office assists foreign students in academic, social, financial, and personal matters. It serves as a liaison office between Clemson University and the U.S. Immigration Service. All foreign students should report immediately to this office upon arrival at Clemson.

International students coming from abroad or transferring from another school are required to meet *academic, language, and financial* qualifications as determined by Clemson University. The Graduate Record Examination, Test of English as a Foreign Language (TOEFL) and transcripts of previous academic studies are some of the determinants used for appraising academic and language ability. Advanced payment of tuition and fees for one academic year is one of the determinants of financial ability. Students receiving an assistantship must deposit \$1,000, and students without an assistantship must deposit \$3,000. These deposits must be made prior to the issuing of a certificate of eligibility for entering the United States. Should a student not enroll at Clemson, the deposit will be refunded.

All foreign students receiving funds through or from Clemson University and all exchange visitors are required to be on a J-Visa. A willingness to change to a J-Visa is a prerequisite for receiving such funds or to become an exchange visitor.

Failure to maintain legal status with the Immigration Service will result in international students forfeiting continued enrollment at Clemson University.

Health and accident insurance is required and may be obtained through the International Services Office.

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**GRADUATE EXPENSES**
**EXPENSES, 1981-1982****Tuition and Fees**

Semester charges for graduate students are determined by the credit load, with no distinction between graduate and undergraduate credits.

Graduate students enrolled in 12 or more semester hours during a semester will pay the following fees:

Tuition .....	\$ 75.00*
University Fee .....	470.00*
Matriculation Fee (non-refundable) .....	5.00
Medical Fee .....	<u>55.00*</u>
Semester Total (excluding room and board) .....	\$605.00*

Payment of the above fees entitles the student to use Fike Recreation Center, attend University concerts, and obtain tickets to athletic events with the same privileges and restrictions as apply to undergraduates.

Graduate students enrolled in less than 12 credit hours during a semester will pay the following fees:

Tuition (per semester hour) .....	\$ 6.00*
University Fee (per semester hour) .....	38.00*
Matriculation Fee (non-refundable) .....	5.00
Medical Fee (optional for non-dormitory domestic students) .....	55.00*
Fike Recreation Center Fee (optional) .....	15.00

These fees do not provide for admission to athletic events, concert series presentations, or other such activities. Students electing not to pay the medical fee are responsible for arranging their own medical care.

**Auditing**

Charges for auditing are made each semester according to the following schedule:

Tuition (per semester hour) .....	\$ 3.00*
University Fee (per semester hour) .....	19.00*

**Graduate Assistants, Permanent University Staff and Faculty**

Graduate assistants, permanent University staff members and faculty will pay the following fees:

Tuition (per semester hour) .....	\$ 3.00*
University Fee (per semester hour) .....	19.00*
Matriculation Fee (non-refundable) .....	5.00

Use of Fike Recreation Center facilities by graduate assistants during the fall and spring semesters is at no additional cost while the summer fee is \$7.50 per session for all students. Graduate assistants utilizing the

\*Subject to change.

student health service must pay the medical fee of \$55.00\* per semester. Season athletic tickets may be purchased at the faculty-employee rates.

A graduate assistant is defined as a student with at least a bachelor's degree who is enrolled in a degree program and devotes a minimum of 10 and a maximum of 30 hours of service per week to the University. In order to receive reduced fees, a graduate assistant appointment must be in effect on or before the last day of regular registration. The appointment remains in effect through the last day of the academic semester or session or through the time of completion of all degree requirements within that semester or session. Otherwise, the student is liable for full fees applicable to South Carolina residents.

A permanent employee (as defined by the Clemson University Office of Business and Finance) is a person employed full time (37½-40 hours per week; 9 or 12 months per year) in a regular position, subject to the full control and responsibility of the University and receiving full remuneration for his or her services in the regular University budget.

Faculty should be aware of the policy restricting pursuit of advanced degrees as found under "University Employees" on page 30.

### **Athletic Contests and University Concerts**

Departmental graduate assistants and graduate resident assistants (see pages 22 and 23) will be eligible to purchase two season tickets at the faculty-employee rates. Applications must be completed at the Jervey Athletic Center ticket office.

Graduate students enrolled in 12 or more semester hours are full-time students and are eligible for tickets with the same restrictions and privileges as apply to undergraduate students. (See Undergraduate Catalog.)

Graduate students enrolled in less than 12 semester hours are considered part-time students and are not eligible for reduced price tickets. They may purchase tickets at the regular full prices. Part-time graduate students may elect to pay a full fee schedule of \$605\* which would entitle them to the same restrictions and privileges of undergraduate students.

Graduate students enrolled for less than 12 hours may attend University concerts upon purchase of a season ticket.

### **Graduation Fees**

The following graduation fees are in addition to the above charges:

Diploma	\$ 1.65*
Diploma Case	3.35*
Apparel for Graduation (attendance optional)	
Master's or Education Specialist Degree	
Candidates	22.20*
Doctoral Degree Candidates	30.45*

\*Subject to change.

Binding Fees for Thesis or Dissertation  
(if applicable) 18.75\*

Publication of Dissertation Abstract  
(if applicable) 30.00\*

Costs for preparation and duplication of the thesis, dissertation or departmental project report as well as binding fees for personal copies are extra charges to be borne by the student.

### Settlement of University Fees

The entire amount of the expense for each semester or summer session is due and payable at the beginning of each semester or summer session, and no student is officially enrolled until all expenses are satisfied. In special cases the University will accept, at the beginning of a semester, a non-interest bearing promissory note for a portion of the semester residence hall fee and semester-plan board fee. In such cases, the note for the first semester charges will be due October 1, and the note for the second semester charges will be due March 1. International graduate students are not eligible for this promissory note.

Upon certification by the dean of the Graduate School and upon authorization by the student of a payroll deduction for payment, deferred payment of academic fees may be granted to a student employed as a graduate assistant. The total amount deferred shall not exceed 50 percent of the sum of the student's assistantship for the first five consecutive pay periods for the semester. Payment of the amount deferred is to be made in five equal installments through payroll deduction beginning with the first pay period of the semester. Should an assistantship be terminated, any unpaid balance of funds deferred is payable immediately as well as any additional fees due. No deferred payments are permitted for summer sessions for any graduate student.

All other transactions relating to payment should be conducted with the Financial Management Division. All checks and money orders should be made payable to Clemson University. A personal check given in payment of University expenses which is returned by the bank unpaid immediately creates an indebtedness to the University.

### Past Due Student Accounts

Any indebtedness to the University which becomes past due immediately jeopardizes the student's enrollment, and no such student will be permitted to graduate or register for a subsequent semester or summer school term. Further, any student who fails to pay all indebtedness to the University may not be issued an honorable discharge, transcript, or diploma.

### Establishment of University Fees

The annual State Appropriation Act imposes the general requirement that student fees be fixed by the University Board of Trustees. The Act

\*Subject to change.

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

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## STUDENT EMPLOYMENT AND FINANCIAL ASSISTANCE

### **GRADUATE APPOINTMENTS**

More than 600 graduate students hold Clemson University appointments. These are of two kinds: (1) graduate assistantships requiring, for the most part, half-time employment and (2) fellowships, scholarships, or traineeships which require no service to the University.

Clemson University, as a member of the Council of Graduate Schools in the United States, subscribes to the following policy inherent in the resolution adopted by the Council regarding graduate appointments. In every case in which an appointment for the next academic year is offered to an actual or prospective student, the student, if acceptance is indicated before April 15, will have complete freedom through April 15 to submit in writing a resignation of the appointment in order to accept one elsewhere. However, an acceptance given or left in force after April 15 commits the student not to accept another appointment (at Clemson or elsewhere) without first obtaining a formal release from the first party to whom a commitment has been made. Similarly, an offer made after April 15 is conditional on presentation by the student of the written release from any previously accepted offer.

To be eligible for any graduate appointment, a graduate student must satisfy the appropriate minimum enrollment requirement as described in each section below. The University reserves the right to withdraw the appointment at any time because of failure to meet this requirement.

### **Departmental Graduate Assistantships**

Assistantships are available in instruction, research or extension. Such appointments may be on an annual basis or a nine-month basis with work periods and duties assigned by the department. Application forms can be obtained from the Graduate School or from department heads and should be completed and filed early in the academic year before the student enrolls. Selection of assistantship recipients as well as notification of the appointment, its duration, and the stipend are the responsibilities of the academic departments. All graduate assistants are granted partial remission of tuition and fees and enjoy certain other benefits provided for University staff personnel.



1. *Eligibility.* In order to qualify for one of the various departmental graduate assistantship appointments, a student must be enrolled in a degree program and must devote at least 10 but no more than 30 hours of service per week to the University for the entire semester or session. The normal assistantship is on a half-time basis requiring an average of 20 hours of service per week although the appointment may be for any number of hours from 10 (quarter-time assistantship) through 30 (three-quarter-time assistantship). However, an appointment for more than 20 hours of service per week will require a written request approved in advance by the Graduate School. Multiple employment of graduate students by the University (graduate appointments and/or hourly employment) is permitted. It is the responsibility of the secondary employer to receive permission of the primary employer and the Graduate School prior to assignment of any additional work and to ensure that the maximum work load of 30 hours per week is not exceeded. Upper limits on academic loads as related to hours of service per week are found in the section entitled "Credit Loads" on page 35.

2. *Minimum Enrollment.* A minimum enrollment is required for appointment as a departmental graduate assistant. During the academic year, students in a master's program or predoctoral students must enroll for at least nine credit hours per semester. A predoctoral student is defined as one who is working directly toward a doctoral degree without possession of a master's degree in a related discipline (as determined by the department) and has completed less than 30 semester hours of graduate credit toward the doctoral degree. Doctoral students who hold a related master's degree or who have completed 30 credit hours of graduate credit in their doctoral program must enroll for at least six credit hours per semester. Minimum enrollment in the summer sessions is one semester hour regardless of the degree objective. Undergraduate credits may be included in the minimum provided they are relevant to the student's degree program and required by the advisory committee. Credits in GS 799 may not be included in the minimum except in the summer sessions.

Graduate students should understand that the assistantship may be withdrawn at any time for failure to maintain a satisfactory academic status as described under "Academic Standards" on page 33.

### **Graduate Resident Assistantships**

Part-time employment on the program staff of the residence halls is available to qualified graduate students. In general, 20 hours of service per week is required, and compensation for such employment amounts to a room or apartment, partial remission of tuition and fees, and approximately \$1,000 per semester. Graduate resident assistants are subject to the credit load limitation found on page 35, and the required minimum enrollment is coincident with that of departmental graduate assistants. Interested applicants should apply directly to the Housing Office. A personal interview is required prior to final selection.

### **Fellowships, Scholarships and Traineeships**

A modest number of outstanding graduate students hold fellowships, scholarships or traineeships at Clemson University. These awards are received from a wide variety of governmental, foundation, industrial, alumni, or individual sources. Most such awards are made on a competitive basis to eligible applicants with scholarly potential and excellence being the sole criteria for the awards. The grant supports a student in full-time study and research in a program leading to an advanced degree. Stipends usually are considered tax-free by IRS, and the awards normally provide for tuition and fees and often for research expenses, as well as dependency allowances. Unless stipulated otherwise by the granter and/or donor, the student is required to enroll in the same minimum credit load as is applicable to departmental graduate assistants.

Fellowships, scholarships and traineeships are usually offered in early March. Inquiries may be made to the department of the student's major interest or to the Graduate School relative to available funds.

### **HOURLY EMPLOYMENT**

Employment on an hourly basis for a portion of a semester or session is possible in some departments. The maximum credit load is the same as that for graduate assistants found under "Credit Loads" on page 35. Enrolled graduate students (exclusive of full-time University employees) may not be employed by the University for more than 30 hours per week (graduate appointments and hourly employment combined), and no portion of the hourly employment shall be utilized to qualify students for benefits afforded those on graduate assistantship appointments.

### **OTHER FUNDS**

The Office of Student Financial Aid coordinates and/or administers loan assistance available to graduate students. The National Direct Student Loan Program is available to eligible students who establish financial need via the submission of the Financial Aid Form to College Scholarship Service; the deadline to apply is April 1. Graduate students who are seeking loan assistance are encouraged to apply for assistance through the Guaranteed Student Loan Program from their state of legal residence. The deadline to apply varies with each state program, but we recommend applying by May 1, prior to the academic year for which aid is requested. The Guaranteed Loan Program is recommended over the National Direct Student Loan Program in that employment constraints are imposed on students borrowing through the National Direct Student Loan Program. Other miscellaneous loan programs are available to accommodate the particular needs of students. In addition to other forms of graduate student employment, graduate students who establish financial need are eligible to participate in the College Work-Study Program as salaried or hourly employees.

Information and the appropriate forms are available in the Office of Student Financial Aid located in G01 Sikes Hall.

### **COOPERATIVE EDUCATION PROGRAM**

The Cooperative Education Program is a planned program in which graduate students at the University combine periods of academic study and periods of related work with a participating business, industry, agency, or organization. A minimum of two work periods is required, and the work periods normally take place after the student's first semester on campus.

All graduate students desiring to enter the program are requested to schedule an interview with the Office of Cooperative Education, 806 University Union, where application forms and additional information are available.

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## **ADMISSION REQUIREMENTS AND PROCEDURES**

### **MEDICAL REQUIREMENT**

Submission of a medical history is required of all students who subscribe to the health service and in particular of all full-time graduate students entering Clemson University for the first time. Prior to or during the registration period, the student will receive a medical questionnaire which is to be completed and returned to the director of student health services.

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

The University further requires that all new students receive a current tetanus toxoid series or have had a toxoid series or booster within 10 years.

### **ACADEMIC REQUIREMENTS**

Applications for admission should be submitted at least four weeks prior to the first date for matriculation listed on pages 8 and 9. International students and other applicants to programs requiring standardized test scores should complete these examinations at least three months prior to matriculation.

Applicants who do not enroll in courses within one year after the date of their acceptance normally will be required to reapply for admission. Credentials submitted for admission become the property of the University and are not returned.

There is no fee for Graduate School applications.

### **New Applicants**

As a minimum and general requirement for admission to any of the

University's graduate programs, a prospective student must hold at least a four-year bachelor's degree from an institution whose scholastic rating is satisfactory to the University and must have the approval of the department head or program coordinator in which the major work is planned. Although the quality of an applicant's previous academic record always plays an integral role in any admission decision, a general division in requirements, based on the degree objective, exists as follows:

1. *Master of Arts, Master of Science or Doctor of Philosophy Degrees.* Admission criteria, recommended by Graduate Council, include satisfactory scores on the aptitude portion of the Graduate Record Examination (GRE).\*

2. *The Professional Degrees.* Admission criteria, recommended by the individual colleges awarding the degree, may include professional experience and/or credentials as well as GRE aptitude scores.\*

International students, in addition to meeting the minimum and general requirement stated above, must submit satisfactory scores on the aptitude portion of the Graduate Record Examination\* regardless of the degree objective. A satisfactory score on the Test of English as a Foreign Language\*\* (TOEFL) is also required of international students whose native tongue is not English, but this requirement *may* be waived if the applicant has completed a four-year bachelor's degree in the United States.

Admission in all programs is restricted to those students whose academic records clearly indicate that they are prepared to benefit from graduate study, and the Graduate School reserves the right to require additional quantitative and aptitude examinations as well as personal interviews and/or oral examinations prior to reaching an admission decision. Neither an academic record exceeding minimum requirements, satisfactory scores on standardized tests, nor professional expertise alone will assure a student's admission. Rather, the total record must indicate the likelihood of successful graduate study.

### Conditional Acceptance

Notice of conditional acceptance may be given to highly qualified applicants prior to receipt of the degree they are presently pursuing; however, all requirements for this degree must be completed prior to enrolling in the proposed graduate program at Clemson University. Likewise, conditional acceptance may be given prior to receipt of satisfactory GRE scores, if required, but such scores must be received prior to or during the first semester of enrollment.

Clemson University seniors lacking less than a full semester of work to complete the requirements for their bachelor's degree may apply to a graduate program and, if granted conditional acceptance, be allowed to enroll in courses for graduate credit. Refer to "Clemson University Seniors" on page 29.

\*GRE scores more than five years old relative to date of initial enrollment will not be accepted.

\*\*TOEFL scores more than two years old relative to date of initial enrollment will not be accepted.

### **Applicants Presently Enrolled in the Graduate School**

Students enrolled in a master's degree program at Clemson University who wish to continue their studies in another master's program, a specialist program, or in a doctoral program *after completing their initial degree objective* may apply by submitting the normal application. This application must be supported by the student's advisory committee for the master's degree or other faculty designated by the graduate dean who are associated with the applicant's present or proposed program.

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

### **Change of Degree Program**

Students who have enrolled in a given degree program within the past two calendar years may request a change in major and/or degree without submitting a new application. Instead, the student must submit to the Graduate School a written request endorsed by the department head(s) or program chairperson(s) of the affected degree program(s). All program and Graduate School requirements must be met before final approval will be granted.

### **Duplication 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 a master's degree in a given field, received at another institution, become a candidate for an additional master's degree in the same field at Clemson.

## **ADMISSION CLASSIFICATIONS**

### **Admission to a Degree Program**

This is the classification of qualified students who become candidates for an advanced degree from Clemson University. Conditional acceptance (page 26) does not constitute admission to a degree program because certain required materials are pending. Admission to a degree program is possible only after all required application materials are present and will be in one of the following categories:

1. *Full Status.* The applicant's credentials equal or exceed every minimum admission criterion prescribed for the particular degree.

2. *Provisional Status.* At least one admission criterion prescribed for the particular degree is marginal. Such applicants will be required to remove the provisional status with a satisfactory academic performance during their first semester.\* Doctoral degree applicants will not be admitted provisionally.

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

In addition to meeting the minimum requirements for degree programs listed under "Degree Requirements" (page 37), the student must be recommended for admission by the program chairperson or department head and must meet any special departmental requirements.

### **Admission as a Non-Degree Student**

Admission in this category is restricted primarily to those persons who may benefit professionally from additional study at the graduate level, for example, public school teachers who are required to complete graduate courses for re-certification. In general, the only supportive material required for such admission is a valid transcript showing an appropriate background and confirming the awarding of a bachelor's degree or higher.

Non-degree students are ineligible to become candidates for advanced degrees or to receive a graduate appointment for financial assistance. Should the student subsequently be admitted to a degree program, a maximum of 12 semester hours of graduate credit taken at any campus (non-degree and/or transfer) can be applied toward the degree. In all cases the non-degree student must receive permission from the head of the department before enrolling in graduate courses. This classification is not open to international students.

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### **Admission as a Post-Baccalaureate Student**

A student may be accepted by the Graduate School as a post-baccalaureate student if he or she applies to a specific graduate degree program but does not have the appropriate academic background. Such a student must be recommended by the appropriate department or program chairperson and must fully meet all other requirements for admission to the particular degree program with respect to grade-point ratio and standardized test scores. A student in this category who is denied admission because of failure to meet the minimum requirements has access to the same appeal procedures as does any other student applying to the Graduate School.

Applicants will be classified as post-baccalaureate students if they are not qualified to take at least one graduate course per semester which can be included in the minimum hours required for the graduate degree. Additionally, any student required to complete more than 18 semester hours of undergraduate credits will be classified as post-baccalaureate. Until such time that the required number of undergraduate credit hours is less than or equal to 18 and the student is qualified to take, each semester, a graduate course which can be included in the minimum hours required for the graduate degree, he or she will remain classified as post-baccalaureate. A department or a student may request post-baccalaureate status even though the above criteria are satisfied.

At the time a post-baccalaureate student becomes eligible for classification as a graduate student, the decision as to eventual admission status (full-

status or provisional) will be made according to criteria utilized by the department and the Graduate School for all other applicants to the particular degree program. The post-baccalaureate student is expected to maintain a B average and receive no grade lower than C in order to qualify for admission to a graduate program.

Post-baccalaureate students may enroll in the same number of credits per semester as any undergraduate student but shall not enroll in graduate courses (600-level or above) or receive a graduate assistantship. No degree or certificate shall be awarded to students in a post-baccalaureate status, and such students who subsequently desire to obtain an additional baccalaureate degree must apply through the Office of Admissions and Registration. The applicability of credits earned toward the undergraduate degree will be determined by the policy pertaining to transfer students. Tuition and fees for post-baccalaureate students shall be those applicable to undergraduates with the exception of the application fee and admissions deposit.

A student possessing an undergraduate degree or a graduate degree who wishes to enroll in specific undergraduate courses for reasons other than future admission to the Graduate School shall not be classified as post-baccalaureate and shall be governed by policies established by the Office of Admissions and Registration.

## **ENROLLMENT IN GRADUATE COURSES**

### **Clemson University Seniors**

Enrollment in any graduate course is subject to approval by the department offering the course and the graduate dean. This approval is required prior to registration and may be obtained by completing and returning the appropriate form (GS Form 6) available at the Graduate School. The total course work load for the semester must not exceed 18 hours, and the cumulative graduate credit earned by seniors may not exceed 12 semester hours.

Seniors with a cumulative grade-point ratio of 3.0 or higher may enroll in 700- and/or 800-level courses and may choose to use these courses to meet requirements for the bachelor's degree. However, courses used for this purpose may not be counted later 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.

A Clemson senior with a cumulative grade-point ratio less than 3.0 may apply to the Graduate School for conditional acceptance as described on page 26. If accepted, the student may enroll in graduate courses subject to approval of GS Form 6.

### **Transient Graduate Students**

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

### **University Employees**

With the approval of the appropriate 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.

Limitations on the number of hours taken per semester are explained under "Credit Loads" on page 35.

### **Teacher Certification or Re-Certification**

Initial certification (endorsement) at the graduate level is available only in educational administration, reading and personnel services (elementary and secondary counseling). Students seeking admission to these programs should hold an appropriate teacher's certificate.

Those who possess a bachelor's degree or higher and who desire initial certification in a teaching area must complete the undergraduate courses needed for certification in a post-graduate status administered by the Office of Admissions and Registration and may not enroll in graduate courses until their eligibility for certification has been established by their major department.

Prospective students should understand that the material in this catalog applies only to requirements for graduate degrees and has no direct relation to certification or re-certification for public school teachers. The Graduate School gives no assurance that a program for a graduate degree and a program for a certificate, or re-certification thereof, will coincide. Students interested in professional certificates should, prior to beginning any work, confer with the dean of the College of Education or the appropriate department head in that college.

### **Restrictions**

Enrollment in any graduate course is subject to approval by the department offering the course and requires permission of the instructor whether or not such is specifically stated in the course description. In order to enroll in, or receive credit for, any courses of the 600 series or above, the student (with the exception of certain Clemson University seniors) must have been



officially admitted by the Graduate School either to a degree program (page 27) or as a non-degree student (page 28), or must have been granted conditional acceptance as described on page 26.

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

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## GENERAL GRADUATE SCHOOL REGULATIONS

Except as they apply to undergraduate students only, graduate students are subject to the usual procedures and regulations of the University and in particular to those dealing with academic dishonesty.

Immediately upon enrollment, a student should become acquainted with the degree requirements and the regulations of the Graduate School published in this catalog, particularly the deadline dates on pages 2 and 3. Each advisor and student should by all means have a current copy of the graduate catalog.

### **PROCEDURES TO FOLLOW IN PURSUING A DEGREE**

This is not a step-by-step outline of all procedures to be followed while pursuing a graduate degree, but is an explanation of primary details that must be completed during the process.

#### **The Major Advisor**

Before registering, a student must, with the aid and approval of the department head, select a major advisor. In departments with large faculties, new graduate students may be assigned to one professor until each student decides upon a particular interest. This advisor recommends and approves courses to be taken during the student's first semester. The course work selected should be of a fundamental or "core" nature so the advisory committee will have maximum flexibility to formulate the remainder of the student's program of study.

#### **The Advisory Committee**

An advisory committee will approve the student's graduate degree curriculum, supervise the graduate program, administer the preliminary and/or final comprehensive examination, and initiate the recommendation for the awarding of the degree. One member of the committee will be designated as chairman or major advisor and normally will direct the student's dissertation or thesis, if required. This committee is selected by the student and approved by the department head. Concurrently with submission of the graduate degree curriculum, the department head will forward recommendations to the dean of the college, who will, if he or she approves, then transmit the recommendation to the graduate dean.

A minimum of three faculty members shall be selected for a student seeking a master's or specialist's degree, and a minimum of four faculty members shall be selected for a student seeking a doctoral degree. Only Clemson University faculty who hold full-time faculty positions which carry eligibility for tenure can serve as major advisors or comprise the minimum membership of the committee. Part-time, visiting, and adjunct faculty may serve as *additional* members of the committee and as research advisors. The student and committee members are notified of the appointments by the graduate dean.

### **Filing of a Graduate Degree Curriculum**

A graduate degree curriculum (GS Form 2) must be filed with the Graduate School by those students who are in degree programs. Since fixed curriculums normally do not exist for graduate degrees, this planned program represents the formulation of an individual student's curriculum as recommended by the advisory committee. It must adhere to departmental as well as Graduate School policies. Courses taken in excess of those required by the advisory committee for the degree should not be listed on the curriculum. Graduate credit is received only for courses numbered 600 or above, and no student shall receive both undergraduate and graduate credit for the same course. The Graduate School discourages inclusion of 600-level courses in the minimum hours required for graduate degrees if these courses are clearly equivalents of undergraduate courses required for an undergraduate degree in the same major at Clemson University. Transfer credit appearing in the curriculum must adhere to the stipulations described under "Acceptance of Transfer Credit" on page 36.

Candidates for master's or specialist's degrees should submit the curriculum by the middle of their second semester\* and doctoral candidates no later than the beginning of their second year\* of study. Before a curriculum is approved, it must be reviewed and signed by the advisory committee. It is then submitted to department head(s) and college dean(s) for approval and is forwarded to the graduate dean for approval and appropriate distribution of copies.

### **Admission to Candidacy for a Degree**

Admission to the Graduate School does not qualify a student as a candidate for an advanced degree. Such candidacy depends upon the acceptance by the graduate dean of a written request for admission to candidacy. This request (GS Form 4) may be filed by the student as follows: for the master's degree, after completion of 15 hours of course work; for the Ph.D. degree, after completion of a major share of course work and successful completion of preliminary or qualifying examinations.

All students desiring admission to candidacy must have received full status admission to the Graduate School, have a satisfactory academic standing, and have on file an approved graduate degree curriculum (GS Form 2).

\*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.

### Application for a Diploma

A formal application for a diploma is placed by the student simultaneously when he or she applies for admission to candidacy (GS Form 4). This order is submitted to the graduate dean and must be re-submitted should the student not graduate on the anticipated date.

## ACADEMIC REGULATIONS

### Academic Standards

Most graduate courses are graded on an A-B-C-F scale. Thesis and dissertation research and several other courses are graded on a "pass-fail" basis. These courses are not included in the academic average; however, the grade is placed on the student's permanent record. Only credit hours for which a grade of pass is achieved will apply toward the number of credit hours required for the degree. The accumulation of grades of pass in thesis or dissertation research does not imply completion of the research, but indicates satisfactory progress only.

A minimum grade of C must be made on all course work to obtain graduate credit. The graduate student must maintain a cumulative B average in all graduate level courses (600-level or above). In addition, the graduate student must maintain a *cumulative* B average in *all courses*, including undergraduate courses but excluding ROTC and courses taken to meet language requirements. Students who fail to meet these requirements become ineligible for graduation and are placed on academic probation. Those who remain on probation for two consecutive semesters will not be permitted to continue a graduate program without the written approval of the graduate dean.

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

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

### Incomplete Graduate Course Work

Except for courses graded on a pass/fail basis, the grade of "incomplete" (I) may be given for incomplete work for any graduate course in which work remains undone and the student is unable to fulfill all requirements because of circumstances beyond his or her control. This grade is *not* given in lieu of unsatisfactory or failing grades received for completed courses for the opportunity of improving the grade later.

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

The grade of I will be valid in normal lecture or laboratory courses for only

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

Students receiving a grade of I in courses such as special problems or other unstructured, independent study courses as designated by the Graduate School must, in general, complete all work and receive a final grade within one calendar year. The only exceptions apply to students receiving the grade of I prior to completing enrollment in all other courses (exclusive of thesis or dissertation research) listed on their approved graduate degree curriculum, if one is on file, and who maintain continuous enrollment, excluding summer sessions, in pursuit of these courses. In such cases, the one calendar year deadline begins at the end of the term of enrollment in the final course(s) listed on the curriculum, excluding thesis or dissertation research.

A graduate student will not be permitted to repeat any portion or re-register for any course (except GS 799) for which the grade of I has been given, or register in any other course for the purpose of removing the grade of I. Should any work remain incomplete at the expiration of the appropriate deadlines described in the previous paragraphs, a grade of F will be recorded on the student's permanent record. Although the Graduate School will attempt to bring the deadlines to the attention of the student and department head, it is the sole responsibility of the graduate student to comply with these regulations.

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

### **Withdrawal from Courses**

To withdraw officially from any course, the student must make written application to his or her faculty advisor for permission to withdraw. Application must be made via the Schedule Change Form available in 104 Sikes Hall. The date on which the approved application is filed with the registrar is considered to be the date of withdrawal.

Failure to attend classes or verbal notification to instructors *does not constitute withdrawal*. Students who drop out of a course without officially withdrawing as previously described will be credited with a failure. Students who officially withdraw within the first four weeks of classes will have no grades recorded while those who officially withdraw after the first four weeks and prior to the last five weeks will have a grade of "W" (withdrawal)

entered on the official records. Students may not withdraw within the last five weeks of classes.

### Continuous Enrollment

Although continuous enrollment is not a formal requirement for an advanced degree, graduate students are expected to pursue their degrees with a minimum of interruption. Students who do not remain continuously enrolled (summers excluded) are subject to the requirements in effect at the time of return.

Only students who are enrolled are eligible to utilize University facilities and human resources and/or receive any form of financial aid. Students who have completed all required work and who find it necessary to be enrolled during a given semester so as to utilize facilities or human resources may enroll in GS 799 for a minimum of one credit.

### Credit Loads

University upper limits on graduate student loads per semester refer to graduate and undergraduate credits combined and should be attempted only by the most qualified students.

#### Maximum Credit Hours For:

<u>Student Category</u>	<u>Semester</u>	<u>6 Weeks Session</u>	<u>3 Weeks Session*</u>
Full-Time Student	18	6	3
Graduate Assistants (¼ time)	15	5	3
Graduate Assistants (½ time)	12	4	2
Graduate Assistants (¾ time)	9	3	1
Persons Employed Full Time	6	3	1

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Quarter-time, half-time and three-quarter-time graduate assistants are defined as those who contribute an average of 10, 20 and 30 clock hours per week, respectively, of service to the University for the entire semester. A person employed full time is defined as anyone employed five full working days per week regardless of the employer(s). Graduate students paid solely on an hourly basis are not classified as graduate assistants but are subject to the same limitation in credit loads described above.

For students whose hours of service per week fall between those defining each student category, the maximum credit load during a regular semester is found by linear interpolation. Any exceptions to the maximum credit loads must be requested by the department and approved in advance by the Graduate School.

### Auditing by Graduate Students

Audited courses do not carry credit, and the fact that a course has been audited is not noted on the graduate student's official record. Graduate auditors are not required to stand tests or examinations. However, the instructor, at his or her own discretion, may demand or deny the auditor's participation in class to whatever extent deemed desirable.

\*Should the six weeks and three weeks sessions run concurrently, the total credits will not be permitted to exceed the upper limit for the six weeks session.

A graduate student may not satisfy by audit a stated prerequisite for a graduate course. Additionally, a graduate student may not establish credit through examination in any course for which he or she was previously registered as an auditor.

### **Acceptance of Transfer Credit**

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

In all cases, the use of transfer credits must be recommended by the student's advisory committee and approved by the department. Under no circumstances will transfer credit be awarded for research or for courses in which a grade lower than B, or its equivalent, has been received. Quality points for courses taken at institutions other than Clemson University will not be included in the student's academic average.

Credits may be transferred for work completed at off-campus centers of accredited institutions provided such courses are acceptable, without reservation, in degree programs at those institutions. No credit will be given for continuing education units, correspondence, extension, or in-service courses, or for concentrated courses and workshops which award credits at a rate exceeding one credit per week.

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

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

### **Theses and Dissertations**

A candidate for an advanced degree in each curriculum requiring a thesis or dissertation must prepare this document under the direction of a research advisor. Six hours of credit are required for research leading to the Master of Science or Master of Arts thesis. Fifteen hours of credit are required for theses in the Master of Architecture and Master of Fine Arts degrees while nine hours of credit are required for the Master of City and Regional Planning degree. Eighteen hours of doctoral research credit (991) are required for the Doctor of Philosophy and Doctor of Education degrees exclusive of any research credits earned at the master's level.

Three copies of the thesis must be presented to the chairman of the student's advisory committee in sufficient time for the chairman to arrange

\*Refers to accreditation by one of the six regional Association of Colleges and Schools.

for a final examination to be held at least three weeks prior to the date on which the degree is expected. A doctoral dissertation must be completed and delivered to the student's advisory committee at least two weeks prior to the final examination. Three copies of the master's thesis and four copies of the doctoral dissertation must be submitted to the Graduate School by the deadline for the date on which the degree is conferred (see pages 2 and 3). A binding fee of \$18.75 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, additional copies may be bound at a cost of \$6.25 per copy. The responsibility for placing the thesis or dissertation in proper final form rests with the student. A guide for the preparation of theses and dissertations at Clemson University may be obtained from the Graduate School.

Candidates for doctoral degrees will prepare an additional copy of the abstract and title sheet to be submitted to the Graduate School. Ordinarily this abstract should not exceed 2,450 typewritten characters. It should be written and edited in such a way that it will be suitable for publication.

Doctoral students are required to pay a fee of \$30.00 to the bursar for microfilming and publication of the abstract. An additional fee of \$15.00 is required if copyright is desired.

### **Restriction on Use of Theses and Dissertations**

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

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## **DEGREE REQUIREMENTS**

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

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

### **MASTER'S DEGREE**

#### **Residence Requirements**

To receive the Master of Science or Master of Arts degree, the student

must complete at least nine semester hours of graduate credit on the Clemson University campus during one academic semester or two consecutive summer sessions of the program. However, all full-time University employees admitted to an advanced degree program may satisfy residence requirements by completing 15 semester hours of graduate credit on the campus during a continuous 12-month period. There are no residence requirements for professional degrees.

### **Time Limit**

All course work which is to be credited toward any of the master's degrees must have been enrolled in and completed within six calendar years prior to the date on which the degree is to be awarded. When recommended by the student's advisory committee and approved by the graduate dean, as many as six semester hours of course work completed outside the six-year limit may be validated by written examination. Such examinations will be under the direction of the department regularly offering the course or courses for which the student seeks validation. Course work completed outside the six-year time limit at an institution other than Clemson University may not be transferred to Clemson or validated for graduate credit.

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### **Course Work Required**

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

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

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

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

### **Language Requirement**

A reading knowledge of one approved foreign language is a departmental requirement for certain Master of Arts and Master of Science degrees. The required reading knowledge is equivalent to that provided



by two years of study of the language at the college level. The procedures for satisfying this language requirement are identical to those for the Ph.D. degree as listed on page 42.

### **Study in Absentia**

Although thesis research is normally performed at Clemson University, it is recognized that Clemson University may not have on its campus certain specialized equipment or facilities which would be desirable for advanced training at the master's level. Thus, for those cases in which thesis or other advanced study is required and the facilities to pursue such study are not available on the Clemson campus, permission may be granted for study in absentia. The requirements to be satisfied in such cases are identical to those listed under "Doctor of Philosophy Degree — Off-Campus Research," with the exception that the off-campus research supervisor need not hold the Ph.D. degree provided he or she is qualified and certified for the supervisory position by the department and college involved and by the graduate dean.

### **Final Examination**

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

### **SPECIALIST IN EDUCATION**

The foregoing degree requirements pertaining to residency, time limits, and final examination for professional master's degrees also apply to the Specialist in Education degree. Course work required includes 30 semester hours beyond the master's degree to be selected from five areas prescribed by the Department of Elementary and Secondary Education.

### **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 or her field 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, competency to plan and conduct research, and ability to express himself or herself adequately and professionally in oral and written language.

The advisory committee will aid the student in developing a graduate degree curriculum which will include the selection of specific courses and their sequence. Although no minimum course work requirements exist for the doctoral degree, committees are encouraged to require courses other than those which directly support the dissertation research. Work in the minor field or fields, if required, normally should comprise from 12 to 24 hours in courses carrying graduate credit. A minimum of 18 hours of doctoral research is required. Should the direction of study or research interest change, the student may request the appointment of a new advisor.

### **Residency Requirements**

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

1. In direct personal association with members of the faculty of the University.
2. Under direct tutelage and advisement of a research advisor and advisory committee in the department or program of the major.
3. Participating in other normal activities pertinent to graduate education such as seminars and close association with other student researchers.

To receive the Doctor of Philosophy degree, the student must complete at least 12 semester hours of graduate credit in two consecutive academic semesters or one semester and two summer sessions, taken consecutively, on the Clemson University campus.

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

### **Off-Campus Research**

Under special circumstances, it may appear desirable that doctoral research be conducted away from the Clemson University campus. If such research is to be performed *under the immediate direction of a Clemson University faculty member acting as dissertation advisor and supervisor,*

then in order to accommodate the student as well as to exercise proper and necessary control over this most important phase of doctoral study, the following additional requirements will be made:

1. *Written Consent and Research Plan.* The student must have the written consent of his or her dissertation advisor, full advisory committee, department head, college dean, and the graduate dean. Prior to the departure from campus, the student must submit a written plan for his or her research effort to the advisory committee for their approval. Such plan should include a discussion of the problem and the intended scope of the investigation and should be structured in terms of a specific time frame.

2. *Statement from Organization Where Research Will Be Conducted.* The advisory committee may require a statement from an appropriate officer of the organization at which the student will be located agreeing to one or all of the following: the student's plan to complete dissertation research using the organization's equipment and facilities; the apportioning of at least 25 percent or other appropriate amount of the student's employment hours to dissertation research; and the organization's release of patent rights or copyrights arising from discoveries or concepts which evolve during the course of the student's doctoral research.

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

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

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

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

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

#### **Time Limit**

All requirements for a Doctor of Philosophy degree must be completed within eight years from the date of enrollment in the degree program. If a student possesses a master's degree in the same or in a closely allied area of study, all requirements for the Doctor of Philosophy degree must be completed within six years from the date of enrollment in the degree program. Special limitations, applying to the result of the comprehensive examination, are found in the section describing this examination (page 43).

#### **Language Requirement**

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

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

Basic reading knowledge of each language is determined by one of the following three options:

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

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

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

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

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

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

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

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

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

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

### **Comprehensive Examinations Before Admission to Candidacy**

Satisfactory completion of the comprehensive examination, *i.e.*, a written or a written and oral examination taken after completion of most required course work, must occur no less than six months and no more than five years prior to the date of graduation. The function of the examination is to obtain objective evidence of an adequate intellectual mastery of the areas of the major and minor specializations.

The chairperson of the advisory committee will inform the Graduate School of the result, via Form GS5, within three weeks following the examination. The student's performance on this examination will determine whether he or she will be recommended for admission to candidacy for the degree.

Should the student fail to pass the comprehensive examination, he or

she may be given a second opportunity if so recommended by the advisory committee. A second failure shall result in the student being declared ineligible to receive the Doctor of Philosophy degree at Clemson University.

Some doctoral programs require preliminary or qualifying examinations prior to the comprehensive examination. Information about these examinations may be obtained from the individual departments.

#### **Final Doctoral Oral Examination**

The candidate for the Doctor of Philosophy degree must pass a final oral examination at least three weeks prior to the time of the commencement at which he or she plans to obtain the degree. The examination will be conducted by the student's advisory committee, and all faculty members are invited to participate. The Graduate School will be notified of the time and place of the examination at least 10 days prior to the time scheduled.

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

#### **DOCTOR OF EDUCATION DEGREE**

Degree requirements pertaining to residency, time limit, comprehensive and final examinations are the same as those for the Doctor of Philosophy degree. In addition, the candidate for the Doctor of Education degree must arrange with his or her advisory committee to engage in an internship appropriate to his or her field of professional service.



AGRICULTURAL ECONOMICS  
AGRICULTURAL MECHANIZATION  
AGRONOMY  
ANIMAL AND FOOD INDUSTRIES  
ANIMAL PHYSIOLOGY  
ANIMAL SCIENCE  
APPLIED ECONOMICS  
DAIRY SCIENCE  
ENTOMOLOGY  
ENVIRONMENTAL SCIENCE  
EXPERIMENTAL STATISTICS  
FOOD SCIENCE  
GENETICS  
HORTICULTURE  
NUTRITION  
PLANT PATHOLOGY  
PLANT PHYSIOLOGY  
POULTRY SCIENCE  
WILDLIFE BIOLOGY

# College Of Agricultural Sciences



AGRICULTURAL ECONOMICS

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

Major  
Agricultural Economics  
Applied Economist

Degrees  
M. Ag., M.S.  
Ph.D.

Graduate work in agricultural economics is of increasing importance since it enables the student to attain a higher degree of specialized

\*Jointly administered by the College of Agricultural Sciences and the College of Education. The M. Ag. Ed. degree is awarded by the College of Education.

\*\*Jointly administered by the College of Agricultural Sciences and the College of Engineering. The M.S. and Ph.D. degrees are awarded by the College of Engineering.

Jointly administered by the College of Agricultural Sciences and the College of Industrial Management and Textile Science. The Ph.D. degree is awarded by the College of Agricultural Sciences.



## COLLEGE OF AGRICULTURAL SCIENCES

L. P. Anderson, Dean

The College of Agricultural Sciences awards advanced degrees in the following areas of study:

Agricultural Economics	Dairy Science
Agricultural Education*	Entomology
Agricultural Engineering**	Horticulture
Agricultural Mechanization	Nutrition
Agronomy	Plant Pathology
Animal and Food Industries	Plant Physiology
Animal Physiology	Poultry Science
Animal Science	Wildlife Biology
Applied Economics†	

In addition to the M.S. and Ph.D. degrees, the College of Agricultural Sciences offers two professional degrees, Master of Agriculture and Master of Nutritional Sciences. These post-baccalaureate degree programs are designed primarily to meet the continuing education needs of individuals whose interests lie outside a research-oriented profession.

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

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

### AGRICULTURAL ECONOMICS

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

Major	Degrees
Agricultural Economics	M.Ag., M.S.
Applied Economics†	Ph.D.

Graduate work in agricultural economics is of increasing importance since it enables the student to attain a higher degree of specialized

\*Jointly administered by the College of Agricultural Sciences and the College of Education. The M.Ag.Ed. degree is awarded by the College of Education.

\*\*Jointly administered by the College of Agricultural Sciences and the College of Engineering. The M.S. and Ph.D. degrees are awarded by the College of Engineering.

†Jointly administered by the College of Agricultural Sciences and the College of Industrial Management and Textile Science. The Ph.D. degree is awarded by the College of Agricultural Sciences.



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 addition to applicants with baccalaureate degrees in agricultural economics and related programs, the department encourages applications from students who have a sound 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 graduate program is placed on the economics of agricultural production and marketing, economic development, analysis of programs and policies affecting agriculture, and statistical techniques used in solving economic problems of the agricultural industry.

AG EC 602 PRODUCTION ECONOMICS  
3 cr. (3 and 0) F

AG EC 603 LAND ECONOMICS  
3 cr. (3 and 0) S

AG EC 609 AGRIBUSINESS ORGANIZATION  
3 cr. (3 and 0)

AG EC 613 RURAL PROPERTY APPRAISAL  
3 cr. (3 and 0)

AG EC 652 AGRICULTURAL POLICY  
3 cr. (3 and 0) F,S

AG EC 656 PRICES  
3 cr. (3 and 0) F,S

AG EC 660 AGRICULTURAL FINANCE  
3 cr. (3 and 0) F,S

AG EC 719 PROFESSIONAL PROBLEMS IN AGRIBUSINESS MANAGEMENT  
3 cr. (3 and 0) F

Concepts and principles of agribusiness firm management; decision theory, information systems, systems analysis and organization theory applied to the organization, administration, and management of agriculturally-related businesses.

AG EC 791 SELECTED TOPICS IN AGRICULTURAL ECONOMICS  
1-3 cr. (1-3 and 0)

Students working toward Master of Agriculture degree in Department of Agricultural Economics and Rural Sociology study selected topics under guidance of major professor. Course may be repeated for maximum of six credits.

**AG EC 802    ADVANCED PRODUCTION ECONOMICS**

3 cr. (3 and 0)

Production economics theory in a quantitative framework. Technical and economic factor-product, factor-factor, and product-product relationships in single and multi-product firms under conditions of perfect and imperfect competition in both factor and product markets. **Prerequisite:** AG EC 808 or permission of instructor.

**AG EC 805    SEMINAR IN MARINE RESOURCES MANAGEMENT AND POLICY**

3 cr. (3 and 0)

Economic, institutional and legal aspects of the control and management of common-property marine resources. Management systems for coastal zone and continental shelf resources.

**AG EC 806    APPLIED REGIONAL ECONOMICS**

3 cr. (3 and 0) S

Theories of economic growth and development and their application to areas or regions. Methods of regional economic analysis emphasizing macro- and microeconomic aspects.

**AG EC 807    MARKET STRUCTURE IN AGRICULTURAL INDUSTRIES**

3 cr. (3 and 0) S

Market structure and other approaches related to agricultural marketing. Individual assignments in the student's field of interest required. **Prerequisite:** Permission of instructor.

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**AG EC 808    APPLIED QUANTIFICATIONS IN AGRICULTURAL ECONOMICS**

3 cr. (3 and 0) F

Mathematical tools needed for concise description of agricultural economic principles. Microeconomic theory under assumptions of perfect competition. Relations among agricultural demand, supply, cost, revenue, and productivity. **Prerequisite:** Permission of instructor.

**AG EC 809    ADVANCED NATURAL RESOURCE ECONOMICS**

3 cr. (3 and 0)

Applications of economic theory to problems of natural resource management. Epistemological considerations, rent theory, public and private investment criteria, benefit-cost analysis and general equilibrium management models. **Prerequisite:** AG EC 802 or permission of instructor.

**AG EC 810    WATER AND MARINE RESOURCES MANAGEMENT AND POLICY**

3 cr. (3 and 0)

Economic, institutional and legal aspects of control and management of natural resources; concepts of economic science applied to public policy questions related to land and water resources. Specialized background in economics not necessary. **Prerequisite:** Permission of instructor.

**AG EC 814    CONTEMPORARY PUBLIC POLICY**

3 cr. (3 and 0) F

Contemporary public policy, including price and resource policy, affecting rural areas. Public policy, or the lack thereof, related to programs designed to implement public policy.

**AG EC 827    ADVANCED AGRICULTURAL CONSUMPTION AND DEMAND**  
3 cr. (3 and 0)

Advanced analysis of individual and aggregate consumption decisions concerning agricultural products, emphasizing agricultural marketing applications; market interdependencies; policy applications of empirical work. **Prerequisite:** EX ST 803 or its equivalent.

**AG EC 851    SEMINAR IN RESEARCH METHODOLOGY**  
1 cr. (1 and 0)

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

**AG EC 881    INTERNSHIP IN COMMUNITY AND RESOURCE DEVELOPMENT**  
1-6 cr.

Supervised employment in an agency dealing with socio-economic aspects, community development and/or natural resource management. Monthly reports covering student's experience required. **Prerequisite:** 18 semester hours graduate credit.

**AG EC 891    MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**AG EC 904    SEMINAR IN RESOURCE ECONOMICS**  
3 cr. (3 and 0)

Special problems and recent periodical literature relating to the control, management, development and use of land and water resources in the United States and in other parts of the world. **Prerequisite:** AG EC 403/603.

**AG EC 906    SEMINAR IN AREA ECONOMIC DEVELOPMENT**  
3 cr. (3 and 0)

Recent research developments in economic development. Review of research publications, journal articles, and other literature. Objectives, analytical techniques, and procedures used in area or regional development efforts. **Prerequisite:** AG EC 806.

**AG EC 907    AGRICULTURAL MARKETING PROBLEMS**  
3 cr. (3 and 0)

Theory and research related to consumer behavior. Economic consequences of individuals' and firms' decisions upon supply and demand. General interdependency among economic variables. **Prerequisite:** AG EC 807.

**AG EC 991    DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

**CRD 611    REGIONAL IMPACT ANALYSIS**  
3 cr. (3 and 0)

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

**AGRICULTURAL MECHANIZATION**

B. K. Webb, Head, Department of Agricultural Engineering

**Major**

Agricultural Mechanization

**Degree**

M.Ag.

This program prepares individuals with agricultural and related backgrounds for positions of leadership in technical services, mechanized production and other businesses serving modern agriculture. Students with undergraduate backgrounds in agricultural mechanization, other agricultural curriculums or related curriculums from non-agricultural colleges and universities may apply.

The student's program will be arranged to include courses in the agricultural mechanization specialty and in supporting areas. Emphasis is placed on developing a coherent program to satisfy student objectives.

AG M 602 DRAINAGE, IRRIGATION, AND WASTE MANAGEMENT  
3 cr. (2 and 3)

AG M 606 MECHANICAL AND HYDRAULIC SYSTEMS  
3 cr. (2 and 3)

AG M 652 FARM POWER  
3 cr. (2 and 3)

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

AG M 712 FARM MACHINERY MANAGEMENT  
3 cr. (2 and 3)

Selection, functional analysis, and maximum utilization of existing and developing farm machinery; computer applications to programming of field operations; available capital and labor, machine size, critical field operations, growing degree days, weather; maintenance equipment, procedures, and scheduling.

AG M 733 ANALYSIS OF AGRISTRUCTURES  
3 cr. (3 and 0)

Materials and their function in farm buildings, aesthetic values and rational selection of individual components; farmstead planning, space and environmental considerations, crop processing, materials handling, and waste disposal.

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

Selected topics not covered in other course offerings. Performance measured by oral or written reports or examinations; may be repeated for maximum of six credits.

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

Independent analysis through literature review and laboratory or field research. Requires written documentation; may be repeated for a maximum of six credits.

## AG M 851 SIMULATION OF AGRICULTURAL SYSTEMS

3 cr. (3 and 0)

Synthesis and analysis of agricultural systems via computer simulation; continuous and discrete systems; philosophy of system simulation and optimization. Models will be used to teach working techniques and each student will build a model of a system; computer background not required. **Prerequisite:** MTH SC 106 or permission of instructor.

**AGRONOMY**

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

**Major**

Agronomy

**Degrees**

M.Ag., M.S., Ph.D.

Graduate programs in agronomy are arranged to allow concentration in either crop science or soil science with a supporting minor area. Research activities in soil science include soil chemistry and physics, soil genesis, soil microbiology and fertility. Research in crop science includes crop physiology, weed science, plant breeding and genetics. Laboratory, greenhouse and field facilities are available.

Students with undergraduate backgrounds in agriculture, biology, or other sciences may apply.

## AGRON 601 FERTILIZERS

3 cr. (3 and 0) F

## AGRON 602 LAND POLLUTION CONTROL

3 cr. (3 and 0) S (odd numbered years)

## AGRON 603 SOIL GENESIS AND CLASSIFICATION

2 cr. (1 and 3) F

## AGRON 604 SOILS AND LAND USE

2 cr. (1 and 3) F

## AGRON 605 PLANT BREEDING

3 cr. (2 and 2) S

## AGRON 607 PRINCIPLES OF WEED CONTROL

3 cr. (2 and 2) F

## AGRON 621 FIELD CROPS-MONOCOTS AND SPECIALTY CROPS

3 cr. (3 and 0) F

## AGRON 622 FIELD CROPS-DICOTS

3 cr. (3 and 0) S

## AGRON 623 FIELD CROPS-FORAGES

3 cr. (3 and 0) S

## AGRON 624 ADVANCED FIELD CROPS LABORATORY

1 cr. (0 and 2) S

- AGRON 625 SEED SCIENCE AND TECHNOLOGY  
3 cr. (2 and 0)
- AGRON 652 SOIL FERTILITY AND MANAGEMENT  
2 cr. (2 and 0) S
- AGRON 653 SOIL FERTILITY LABORATORY  
1 cr. (0 and 3) S
- AGRON 655 SEMINAR  
1 cr. (1 and 0)
- AGRON 656 SEMINAR  
1 cr. (1 and 0)
- AGRON 675 SOIL PHYSICS AND CHEMISTRY  
3 cr. (2 and 3) S
- AGRON 690 SOIL ORGANISMS IN CROP PRODUCTION  
3 cr. (2 and 3)
- AGRON 801 CROP PHYSIOLOGY AND NUTRITION  
3 cr. (3 and 0) F (odd numbered years)  
Basic concepts and physiologic aspects of growth and culture applied to crop management practices.
- AGRON 802 PEDOLOGY AND SOIL CLASSIFICATION  
3 cr. (2 and 3) F (odd numbered years)  
Soil genesis, soil morphology, and soil classification; soil formation including parent material, topography, climate and organisms; classification of South-eastern soils.
- AGRON 804 THEORY AND METHODS OF PLANT BREEDING  
3 cr. (3 and 0) F (even numbered years)  
Concepts and principles of plant breeding and genetics as applied to development and maintenance of improved crop varieties; theoretical considerations of various breeding methods.
- AGRON 805 SOIL FERTILITY  
3 cr. (3 and 0) S (even numbered years)  
Essential nutrients in the soil-plant system and mechanisms of retention and transport; supplies and availability; reactions and interactions; deficiency diagnosis and remedies; concepts and techniques for evaluating soil fertility problems.
- AGRON 806 SPECIAL PROBLEMS  
1-3 cr. (0 and 3-9)  
Research not related to a thesis.
- AGRON 807 SOIL PHYSICS  
4 cr. (3 and 3) F (even numbered years)  
Principles and applications of transport of water and solutes in soils emphasizing unsaturated flow phenomenon. **Prerequisite:** MTH SC 108 or equivalent.

**AGRON 808 SOIL CHEMISTRY**

3 cr. (2 and 3) F (odd numbered years)

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

**AGRON 812 CROP ECOLOGY AND LAND USE**

3 cr. (3 and 0) F (even numbered years)

Concepts and factors affecting adaptation and distribution of crop plants; microclimate and crop response to environmental factors with modifications of microclimate by agricultural operations; interactions among crop plants and between weeds and crop plants under field conditions.

**AGRON 820 PESTICIDE RESIDUES IN THE ENVIRONMENT**

3 cr. (3 and 0) S (odd numbered years)

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

**AGRON 825 SEMINAR**

1 cr. (1 and 0) F.S

Special topics and original research in agronomy. Credit may be earned for more than one semester by doctoral candidates.

**AGRON 891 MASTER'S THESIS RESEARCH**

Credit to be arranged.

**AGRON 991 DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged.

**ANIMAL AND FOOD INDUSTRIES**

L. T. Frobish, Head, Department of Animal Science

**Major**

Animal and Food Industries

**Degree**

M.S.

Students may concentrate in animal science, dairy science, food science, or poultry science. See these departmental listings for course descriptions.

**ANIMAL PHYSIOLOGY**

J. F. Dickey, Program Coordinator, Department of Dairy Science

**Major**

Animal Physiology

**Degree**

Ph.D.

The graduate program in animal physiology uses the facilities of the departments of Animal Science; Dairy Science; Entomology, Fisheries and Wildlife; Food Science; and Poultry Science. It includes faculty from these departments plus the Department of Zoology.

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

Students enrolling in animal physiology should have a strong background in the biological sciences and at least one course in organic chemistry.

**AN PH 660 SYSTEMS PHYSIOLOGY II**

4 cr. (3 and 3) S

**AN PH 801 ELECTRON MICROSCOPY OF BIOLOGICAL SPECIMENS**

3 cr. (1 and 6) S,F

Concepts and practice in preparing biological specimens for electron microscopy: fixing, embedding, thin-sectioning, staining, operating microscope and photographing, developing, printing, and interpreting micrographs. Each student must achieve proficiency with a selected specimen, including writing brief research proposal, preparing specimen, studying specimen with electron microscope, and interpreting micrographs. **Prerequisite:** Permission of instructor.

**AN PH 806 EXPERIMENTAL ANIMAL PHYSIOLOGY**

3 cr. (1 and 6) F

Demonstration and practice of research methodology in animal physiology; scientific approach for using animals or specific organs of intact animals as experimental units; selection and use of animal techniques and practices; surgical procedures for altering physiological and endocrinological activities with large and small animals. **Prerequisites:** ZOO 459/659 and AN PH 660 or permission of instructor.

**AN PH 807 SPECIAL PROBLEMS IN ANIMAL PHYSIOLOGY**

1-3 cr. (1-3 and 0) F, S, SS

Research not related to a thesis. May include a comprehensive review of related literature.

**AN PH 808 MAMMALIAN AND AVIAN ENDOCRINOLOGY**

3 cr. (3 and 0) S (odd numbered years)

Advanced concepts of the interrelationships of the nervous and endocrine systems as they influence growth and development, body metabolism, body regulatory mechanism, behavior, reproduction in mammals and birds, and lactation in mammals. The integrating actions of hormones as they affect production will be emphasized. **Prerequisites:** AN PH 660 and ZOO 675 or permission of course coordinator.

**AN PH 812 DIGESTIVE-METABOLIC, EXCRETORY AND RESPIRATORY PHYSIOLOGY**

5 cr. (4 and 3) F (even numbered years)

Development of advanced concepts of mechanisms and functions of gastrointestinal tract (mastication, salivation, digestion, absorption, metabolism, excretion), kidney (filtration, secretion, reabsorption) and respiratory systems (transport, exchange and utilization of gases), and the action of hormones and pharmacologic agents on these systems. **Prerequisites:** ZOO 459/659 and AN PH 660 or permission of course coordinator.



AN PH 814 MEMBRANE, CARDIOVASCULAR  
AND NEURO-MUSCULAR PHYSIOLOGY  
5 cr. (4 and 3) S (odd numbered years)

Development of advanced concepts in membrane physiology (permeability, action potentials, specialized functions), cardiovascular physiology (functions of the heart, blood and vascular system in maintaining acid-base balance, immunity, homeostasis, circulation), and neuro-muscular physiology (functions of the nervous system, special senses, reflexes, control of muscular activity), and the action of several pharmacologic agents on muscle and nerve functions. **Prerequisites:** ZOOL 459/659 and AN PH 660 or permission of course coordinator.

AN PH 851 ANIMAL PHYSIOLOGY SEMINAR I  
1 cr. (1 and 0) F

Current research and developments in animal physiology through related literature and student and faculty participation.

AN PH 852 ANIMAL PHYSIOLOGY SEMINAR II  
1 cr. (1 and 0) S

Continuation of AN PH 851.

AN PH 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

*The following courses offered by various departments represent possible electives for the student in animal physiology. Descriptions for all 800-level courses can be found under the respective department headings.*

BIOCH 606 PHYSIOLOGICAL CHEMISTRY  
3 cr. (3 and 0)

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

BIOCH 623 PRINCIPLES OF BIOCHEMISTRY  
3 cr. (3 and 0)

BIOCH 624 PRINCIPLES OF BIOCHEMISTRY  
3 cr. (3 and 0)

BIOCH 625 GENERAL BIOCHEMISTRY LABORATORY  
1 cr. (0 and 3)

BIOCH 626 GENERAL BIOCHEMISTRY LABORATORY  
1 cr. (0 and 3)

BIOCH 815 LIPIDS AND BIOMEMBRANES  
3 cr. (3 and 0)

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

BIOCH 819 REGULATION OF INTERMEDIARY METABOLISM  
3 cr. (3 and 0)

- BIOCH 824 CELLULAR REGULATION AT THE MOLECULAR LEVEL  
3 cr. (3 and 0)
- DY SC 653 ANIMAL REPRODUCTION  
3 cr. (3 and 0)
- DY SC 655 REPRODUCTIVE MANAGEMENT  
1 cr. (0 and 3)
- DY SC 661 PHYSIOLOGY OF LACTATION  
2 cr. (2 and 0)
- DY SC 803 PHYSIOLOGY OF REPRODUCTION AND MILK SECRETION  
3 cr. (3 and 0)
- ENT 670 INSECT PHYSIOLOGY  
3 cr. (2 and 3)
- ENT 870 ADVANCED INSECT PHYSIOLOGY  
3 cr. (2 and 3)
- MICRO 614 BASIC IMMUNOLOGY  
3 cr. (2 and 3)
- MICRO 811 BACTERIAL CYTOLOGY AND PHYSIOLOGY  
4 cr. (4 and 0)
- PS 600 AVIAN PHYSIOLOGY  
4 cr. (3 and 3)
- ZOOL 605 ANIMAL HISTOLOGY AND HISTOLOGY TECHNIQUES  
4 cr. (3 and 3)
- ZOOL 650 COMPARATIVE VERTEBRATE EMBRYOLOGY  
4 cr. (3 and 3)
- ZOOL 657 COMPARATIVE PHYSIOLOGY  
4 cr. (3 and 3)
- ZOOL 658 CELL PHYSIOLOGY  
4 cr. (3 and 3)
- ZOOL 659 SYSTEMS PHYSIOLOGY I  
4 cr. (3 and 3)
- ZOOL 670 ANIMAL BEHAVIOR  
3 cr. (3 and 0)
- ZOOL 671 ANIMAL BEHAVIOR LAB  
1 cr. (0 and 3)
- ZOOL 675 VERTEBRATE ENDOCRINOLOGY  
3 cr. (3 and 0)

ZOOL 680 ANALYSIS OF DEVELOPMENT  
3 cr. (3 and 0)

## ANIMAL SCIENCE

L. T. Frobish, Head, Department of Animal Science

Major	Degrees
Animal Science	M.Ag.
Animal and Food Industries	M.S.
Animal Physiology	Ph.D.
Nutrition	M.S., Ph.D.

AN SC 601 BEEF PRODUCTION  
3 cr. (3 and 0)

AN SC 603 BEEF PRODUCTION LABORATORY  
1 cr. (0 and 3)

AN SC 608 PORK PRODUCTION  
3 cr. (3 and 0)

AN SC 610 PORK PRODUCTION LABORATORY  
1 cr. (0 and 3)

AN SC 652 ANIMAL BREEDING  
3 cr. (3 and 0)

AN SC 802 TOPICAL PROBLEMS  
1-3 cr. (1-3 and 0)

Animal science experiments and interpretation of their results.

AN SC 803 MEAT TECHNOLOGY  
3 cr. (3 and 0)

Biochemistry, histology and microbiology of fresh, frozen, cured, smoked and processed meats; quality of meats and meat products, processing methods, nutritive value, and research techniques. **Prerequisites:** AN SC 353 and 355.

AN SC 804 METHODS IN ANIMAL BREEDING  
3 cr. (3 and 0)

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

AN SC 805 NUTRITION OF MEAT ANIMALS  
3 cr. (3 and 0)

Metabolism of carbohydrates, lipids, proteins, inorganic elements, and vitamins in the nutrition of beef cattle, swine and sheep; nutritional requirements of meat animals; properties and functions of nutrients in relation to practical production situations; common nutritional aberrations. **Prerequisite:** NUTR 401/601 or equivalent.

AN SC 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

**APPLIED ECONOMICS**

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

**Major**  
Applied Economics

**Degree**  
Ph.D.

The graduate program in applied economics utilizes the facilities and faculty of the Department of Agricultural Economics and Rural Sociology in the College of Agricultural Sciences and the Department of Economics in the College of Industrial Management and Textile Science. Students may carry out their dissertation research under the direction of a faculty member from either department.

**DAIRY SCIENCE**

J. H. Martin, Head, Department of Dairy Science

**Major**  
Dairy Science  
Animal and Food Industries  
Animal Physiology  
Nutrition

**Degrees**  
M.Ag.  
M.S.  
Ph.D.  
M.S., Ph.D.

DY SC 600	CULTURED DAIRY PRODUCTS 3 cr. (2 and 3)
DY SC 602	DAIRY MANUFACTURERS 3 cr. (2 and 3)
DY SC 603	LABORATORY TECHNIQUES 3 cr. (2 and 3)
DY SC 604	PLANT MANAGEMENT 3 cr. (2 and 3)
DY SC 606	DAIRY TECHNOLOGY 3 cr. (2 and 3)
DY SC 607	MARKET MILK 3 cr. (2 and 3)
DY SC 652	DAIRY CATTLE FEEDING AND MANAGEMENT 3 cr. (2 and 3)
DY SC 653	ANIMAL REPRODUCTION 3 cr. (3 and 0)
DY SC 655	REPRODUCTIVE MANAGEMENT 1 cr. (0 and 3)
DY SC 656	ANIMAL REPRODUCTIVE MANAGEMENT 1 cr. (0 and 3)

DY SC 661 PHYSIOLOGY OF LACTATION  
2 cr. (2 and 0)

DY SC 801 TOPICAL PROBLEMS  
1-3 cr. (1-3 and 0)

Problems in dairying not covered by thesis research. Credit varies with problems selected.

DY SC 803 PHYSIOLOGY OF REPRODUCTION AND MILK SECRETION  
3 cr. (3 and 0)

Development of advanced concepts of steroidogenesis, gametogenesis, fertilization placentation, embryogenesis, embryonic-endometrial relationships, parturition and lactation, and the influence of hormones on these processes. Students will evaluate the most recent scientific literature in these areas for information, experimental methods, and validity of authors' conclusions, and will select a problem, review related literature, and write a research proposal for solving the problem. **Prerequisites:** DY SC 453/653 and 461/661 or permission of instructor.

DY SC 808 INDUSTRIAL DAIRY SCIENCE  
3 cr. (3 and 0)

Managerial training for operating dairy and food plants; managerial policy and decision making.

DY SC 820 DAIRY SCIENCE GRADUATE SEMINAR  
1 cr. (1 and 0)

Ongoing research, evaluation of research needs, research techniques, critical reviews, and discussions of published research in all areas of dairy science. Relevant to all dairy science disciplines.

DY SC 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

## ENTOMOLOGY

S. B. Hays, Head, Department of Entomology, Fisheries and Wildlife

**Major**  
Entomology

**Degrees**  
M.Ag., M.S., Ph.D.

Facilities of the Agricultural Experiment Station on campus and at four substations located in various parts of the state are available for graduate student research. Teaching and research laboratories, greenhouses, and other facilities are equipped to train students in economic entomology, insect ecology, insect pathology, insect physiology, medical and veterinary entomology, pest management, and the traditional fields of taxonomy and morphology.

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

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

ENTOMOLOGY

- ENT 603 FIELD CROP INSECTS  
3 cr. (2 and 3)
- ENT 604 STRUCTURAL, INDUSTRIAL AND HOUSEHOLD INSECTS  
3 cr. (2 and 3)
- ENT 605 INSECT MORPHOLOGY  
4 cr. (3 and 3)
- ENT 610 INSECT TAXONOMY  
3 cr. (1 and 6)
- ENT 612 FIELD AND MUSEUM ENTOMOLOGY  
3 cr. (0 and 9)
- ENT 620 TOXICOLOGY OF INSECTICIDES  
3 cr. (2 and 3)
- ENT 655 MEDICAL AND VETERINARY ENTOMOLOGY  
3 cr. (2 and 3)
- ENT 668 INTRODUCTION TO RESEARCH  
2 cr. (1 and 3)
- ENT 669 AQUATIC INSECTS  
3 cr. (1 and 6)
- ENT 670 INSECT PHYSIOLOGY  
3 cr. (2 and 3)
- ENT 680 INSECT PATHOLOGY  
3 cr. (2 and 3)
- ENT 808 TAXONOMY OF IMMATURE INSECTS  
3 cr. (1 and 6)  
Identification of immature insects emphasizing the Holometabola. Identified collection required.
- ENT 809 RECENT ADVANCES IN ENTOMOLOGY  
1 cr. (1 and 0)  
Current literature in entomology; needs and changes in future research.
- ENT 812 ENTOMOLOGICAL HISTORY AND LITERATURE  
1 cr. (1 and 0)  
Literature related to development of the science of entomology. Reading in the available journals, indexing and abstracting journals required.
- ENT 840 INSECT ECOLOGY  
3 cr. (2 and 3)  
Principles of insect ecology, population dynamics and natural regulating mechanisms of insect populations; effect of environment on distribution and abundance of insects.

ENT 853 APPLIED SYSTEMATICS  
3 cr. (2 and 3)

Application of evolutionary principles to resolution of contemporary zoological problems; legal issues and technical skills for efficient operation of international zoological information storage and retrieval system. **Prerequisite:** A taxonomic course in entomology or zoology or permission of instructor.

ENT 856 MEDICAL ENTOMOLOGY  
3 cr. (2 and 3)

Disease vectors of animals emphasizing insects and related Arthropod disease carriers. **Prerequisite:** ENT 301 or permission of instructor.

ENT 860 INSECT PEST MANAGEMENT  
3 cr. (3 and 0)

Application of ecological principles to the management or control of insect populations; major factors influencing insect population fluctuations; integrated systems including biological, cultural, physical, chemical and other techniques forming a unified multi-faceted approach based on applied ecology.

ENT 861 INSECT TOXICOLOGY  
3 cr. (2 and 3)

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

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

Insect toxicology, insect physiology, medical entomology and biological control of insects through research not related to a thesis.

ENT 870 ADVANCED INSECT PHYSIOLOGY  
3 cr. (2 and 3)

Metabolism, excretion, regulatory mechanisms, endocrine system, pheromones, nervous system, insect immunity, defensive secretions, and chemicals controlling insect behavior.

ENT 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

ENT 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## ENVIRONMENTAL SCIENCE

R. F. Borgman, Program Coordinator, Department of Food Science

Advanced degrees are not awarded in environmental science. Courses are offered to provide a minor or electives for students in other areas.

EN SC 631 PUBLIC HEALTH ADMINISTRATION  
3 cr. (3 and 0)

EN SC 671 MAN AND HIS ENVIRONMENT  
2 cr. (2 and 0)

EN SC 672 ENVIRONMENTAL PLANNING AND CONTROL  
2 cr. (2 and 0)

### EXPERIMENTAL STATISTICS

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

Advanced degrees are not awarded in experimental statistics. A minor is offered at the master's and doctoral levels. Courses are offered as support for students majoring in other areas.

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 must demonstrate competence in the theoretical basis as well as the application of statistics.

EX ST 662 STATISTICS APPLIED TO ECONOMICS  
3 cr. (3 and 0) S

EX ST 801 STATISTICAL METHODS  
4 cr. (3 and 3) F, S, SS

Role and application of statistics in research; estimation, test of significance, analysis of variance, multiple comparison techniques, basic designs, mean square expectations, variance components analysis, simple and multiple linear regression and correlation, and non-parametric procedures. **Prerequisite:** Permission of instructor.

EX ST 803 REGRESSION AND LEAST SQUARES ANALYSIS  
3 cr. (3 and 0) F

Regression analysis; simple and multiple linear, curvilinear and multiple curvilinear; curve fitting; least squares and computer techniques for fitting of constants and analysis of planned experiments. **Prerequisite:** EX ST 801.

EX ST 804 SAMPLING  
3 cr. (3 and 0) F

Principles of scientific sampling; finite population sampling; simple random, stratified, multistage, and systematic sampling; optimum allocation; methods of obtaining, processing and reporting survey information. Sampling as related to the environment, natural resources, and social and economic problems. **Prerequisite:** EX ST 801.

EX ST 805 DESIGN AND ANALYSIS OF EXPERIMENTS  
3 cr. (3 and 0) S

Review of the basic designs and analysis; data transformations; single degree of freedom, orthogonality and responses in ANOVA; covariance; response surfaces; incomplete blocks; introduction to least squares analysis of experiments; uses of standard computer programs for selected analyses. **Prerequisite:** EX ST 801.

### FOOD SCIENCE

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

#### Major

Animal and Food Industries  
Animal Physiology  
Nutrition

#### Degrees

M.S.  
Ph.D.  
M.N.S., M.S., Ph.D.



- FD SC 601 FOOD CHEMISTRY I  
4 cr. (3 and 3)
- FD SC 602 FOOD CHEMISTRY II  
4 cr. (3 and 3)
- FD SC 603 FOOD PRESERVATION AND PROCESSING I  
3 cr. (3 and 0)
- FD SC 604 FOOD PRESERVATION AND PROCESSING II  
3 cr. (3 and 0)
- FD SC 605 FOOD PRESERVATION AND PROCESSING LABORATORY I  
1 cr. (0 and 3)
- FD SC 606 FOOD PRESERVATION AND PROCESSING LABORATORY II  
1 cr. (0 and 3)
- FD SC 622 QUALITY ASSURANCE AND SENSORY EVALUATION  
2 cr. (2 and 0)
- FD SC 624 QUALITY ASSURANCE AND SENSORY EVALUATION  
LABORATORY  
1 cr. (0 and 3)
- FD SC 664 FOOD PACKAGING SYSTEMS  
3 cr. (3 and 0)
- FD SC 666 FOOD PACKAGING SYSTEMS LABORATORY  
1 cr. (0 and 3)
- FD SC 801 TOPICAL PROBLEMS IN FOOD SCIENCE  
1-3 cr. (1-3 and 0)

Topics in food science not covered in other courses or by thesis research.  
Cumulative credit not to exceed three semester hours.

- FD SC 802 FOOD ENZYMOLOGY  
2 cr. (2 and 0)

Production, utilization and application of food enzymes in the food industry; effect of food enzymes on color, texture and flavor of foods and food products; health and legal aspects of use of enzymes in foods; current topics in food enzymology. **Prerequisite:** FD SC 401/601 or permission of instructor.

- FD SC 803 FOOD FERMENTATIONS  
2 cr. (2 and 0)

Processes for production of fermented beverages and food products; methods to control stability and quality of these products. **Prerequisite:** MICRO 407/607 or permission of instructor.

- FD SC 804 THERMAL PROCESSING OF PACKAGED FOODS  
3 cr. (3 and 0)

Mathematical methods and models used to design and evaluate heat processing of packaged foods; prediction of shelf life and nutrient loss; comparison with other methods of preservation. **Prerequisite:** Permission of instructor.

FD SC 805 FOOD RHEOLOGY  
2 cr. (2 and 0)

Physical and rheometric characteristics of foods and their modification by micro- and macromolecular constituents and chemical environments; experimental observations, measurement techniques, psychorheology, texture profiles of foods, and mathematical models. **Prerequisite:** Permission of instructor.

FD SC 806 CHEMISTRY OF FOOD COLORS AND PIGMENTS  
2 cr. (2 and 0)

Chemical, physical and biological properties of natural and artificial food colorants and pigments in raw and processed foods and food products; regulation of color additives in foods. **Prerequisite:** FD SC 401/601 or permission of instructor.

FD SC 807 FOOD COLLOIDS  
2 cr. (2 and 0)

Colloidal behavior and interaction of food constituents and added ingredients in dispersions created through food manufacture; functional properties of naturally occurring food components in the formation and stabilization of food batters, emulsions, foams and microencapsulated substances. **Prerequisite:** FD SC 401/601 or permission of instructor.

FD SC 808 FOOD FLAVORS  
2 cr. (2 and 0)

Natural and artificial flavor compounds and their interaction and fate in food before, during and after processing and storage. **Prerequisite:** FD SC 401/601 or permission of instructor.

FD SC 851 FOOD SCIENCE SEMINAR  
1 cr. (1 and 0)

A review of current research and related developments in food science by faculty, students and invited lecturers.

FD SC 852 FOOD SCIENCE SEMINAR  
1 cr. (1 and 0)

Continuation of FD SC 851.

FD SC 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

### GENETICS

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

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

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

GEN 651 ADVANCED GENETICS  
3 cr. (3 and 0) F

GEN 661 BIOMETRICAL GENETICS  
3 cr. (3 and 0) S

GEN 701 MODERN DEVELOPMENTS IN GENETICS  
3 cr. (3 and 0)

Contemporary developments in genetics for secondary school teachers; genetic approaches to the problems of health and behavior; methods and equipment used to illustrate principles of genetics in the theory and laboratory. **Prerequisite:** A genetics course or the equivalent in biology courses.

GEN 801 CYTOGENETICS  
3 cr. (2 and 3) S (even numbered years)

Classical and contemporary problems of chromosome structure, behavior and transmission; recombination, interspecific hybridization, euchromatin and heterochromatin, polyploidy, mutable genetic systems; structural and numerical aberrations of chromosomes and their effects upon breeding systems of plants and animals. **Prerequisite:** GEN 302 or equivalent.

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

Research not related to a thesis.

## HORTICULTURE

E. T. Sims, Jr., Acting Head, Department of Horticulture

### Major

Horticulture  
Plant Physiology

### Degrees

M.Ag., M.S.  
Ph.D.

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

The Master of Science and Master of Agriculture degrees are offered in the areas of pomology, olericulture, floriculture, ornamental horticulture, turf, postharvest physiology and handling, horticultural products technology, and hortitherapy.

The department participates in an interdepartmental program awarding the Doctor of Philosophy degree with a major in plant physiology. This program offers opportunities for doctoral research in horticulture and is described on page 73.

HORT 606 NURSERY TECHNOLOGY  
3 cr. (2 and 3) S

HORT 607 LANDSCAPE DESIGN  
3 cr. (2 and 3) F

HORT 610 FLORICULTURE  
3 cr. (2 and 3) S

HORTICULTURE

- HORT 612 TURF MANAGEMENT  
3 cr. (2 and 3) F
- HORT 613 ADVANCED TURFGRASS CULTURE  
3 cr. (3 and 0) S
- HORT 652 COMMERCIAL POMOLOGY  
3 cr. (2 and 3) F
- HORT 654 SUBTROPICAL AND TROPICAL HORTICULTURE  
3 cr. (3 and 0)
- HORT 655 SMALL FRUIT AND NUT CROPS  
4 cr. (3 and 3) S
- HORT 656 VEGETABLE CROPS  
3 cr. (3 and 0) S (odd numbered years)
- HORT 661 PROBLEMS IN LANDSCAPE DESIGN  
3 cr. (2 and 3) F
- HORT 662 LANDSCAPE DESIGN IMPLEMENTATION  
3 cr. (2 and 3) S
- HORT 664 POSTHARVEST HORTICULTURE  
3 cr. (2 and 2) F
- HORT 670 HORTITHERAPY  
2 cr. (2 and 0)
- HORT 671 INTERNSHIP  
1-6 cr. (0 and 2-12)
- HORT 673 HORTITHERAPY LAB  
1 cr. (0 and 2)
- HORT 801 PROBLEMS IN SMALL FRUIT PRODUCTION  
3 cr. (3 and 0) F (odd numbered years)  
Problems in producing blueberries, strawberries, brambles and grapes.
- HORT 802 RESEARCH SYSTEMS IN HORTICULTURE  
3 cr. (2 and 3) F  
Current trends, developments, and techniques in horticultural research.  
**Prerequisites:** CH 223, 227 or CH 201 and PHYS 207, or BIOCH 210.
- HORT 803 EXPERIMENTAL OLERICULTURE  
3 cr. (3 and 0) F (even numbered years)  
Sources of information on research developments in vegetable crops.
- HORT 804 SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICULTURE  
3 cr. (3 and 0) S (odd numbered years)  
Research and current developments in ornamental horticulture covered in scientific periodicals.

**HORT 805**      **PHYSIOCHEMICAL PROCEDURES FOR DETERMINING QUALITY IN HORTICULTURAL CROPS**

3 cr. (2 and 3) F (even numbered years)

Titration, organoleptic evaluations, refractory, colorimetry, and quality evaluations with succulometers and texturometers; effect of acids, sugars, salts, and other chemical constituents on quality of horticultural crops.

**HORT 806**      **POSTHARVEST PHYSIOLOGY AND HANDLING OF HORTICULTURAL CROPS**

3 cr. (3 and 0) S (even numbered years)

Principles, developments, and research findings dealing with physiological and biochemical changes and processes occurring in horticultural plant organs after harvest; biological aspects of methods and practices relating to harvesting, handling, transportation, and storage of horticultural commodities for fresh market.

**Prerequisite:** BOT 421/621 or equivalent.

**HORT 807**      **POMOLOGY**

3 cr. (3 and 0) S (odd numbered years)

Growth and development of deciduous fruits emphasizing peach and apple.

**Prerequisite:** HORT 352.

**HORT 808**      **SPECIAL INVESTIGATIONS IN HORTICULTURE**

2 cr. (2 and 0) S, SS

Research not related to a thesis. **Prerequisite:** HORT 802 or 805.

**HORT 809**      **SEMINAR I**

1 cr. (1 and 0) F

Current topics in horticulture prepared and presented by the student.

**HORT 810**      **SEMINAR II**

1 cr. (1 and 0) S

Continuation of HORT 809.

**HORT 811**      **QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT**

2 cr. (1 and 3) S (even numbered years)

Principles and application of quantitative morphology and crop production analysis; techniques for visually detecting minute daily changes in plant development; graphic and statistical evaluation of the influence of specific environmental factors and their interactions on plant development; practical and theoretical applications of derived systems of observation and analysis.

**HORT 870**      **PRACTICUM IN HORTITHERAPY**

3 cr. (1 and 4) S

Practicum in developing, evaluating and reporting on a hortitherapy project.

**Prerequisite:** HORT 470/670 or permission of instructor.

**HORT 891**      **MASTER'S THESIS RESEARCH**

Credit to be arranged. F, S, SS

**HORT 991**      **DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged. F, S, SS

**NUTRITION**

R. F. Borgman, Program Coordinator, Department of Food Science

**Major**

Nutrition

**Degrees**

M.N.S., M.S., Ph.D.

The M.S. and Ph.D. degree programs in nutrition are interdepartmental with course work and curricula developed and offered by the departments of Animal Science, Dairy Science, Food Science and Poultry Science. Applicants should have a strong background in the biological and physical sciences. Students with deficiencies may be admitted if their deficiencies are corrected by completing appropriate courses. A student's program of study will include a core of basic courses in nutrition, biochemistry, statistics and physiology. Additional course work may be taken in areas of special interest as approved by the advisory committee.

A student must complete an original research project and submit a thesis or dissertation. The subject area of the research project will involve the use of human, laboratory animal or domestic animal models.

The Master of Nutritional Sciences degree program is a graduate program in human nutrition offered through the Department of Food Science for the student with career aspirations in clinical dietetics, public health or community nutrition. Applicants should have a strong background in the biological sciences. Those with background deficiencies may be admitted by completing undergraduate course work to correct deficiencies. The student's program of study will include a core of courses in human nutrition in addition to course work in statistics, biochemistry and physiology. An experimental education practicum will be completed in lieu of a thesis.

NUTR 601 FUNDAMENTALS OF NUTRITION

3 cr. (3 and 0)

NUTR 625 NUTRITION AND DIETETICS

3 cr. (3 and 0)

NUTR 651 HUMAN NUTRITION

3 cr. (3 and 0)

NUTR 652 CLINICAL NUTRITION

3 cr. (3 and 0)

NUTR 701 THERAPEUTIC NUTRITION

3 cr. (3 and 0)

Interrelationship of pathological, physiological, and metabolic alterations produced by various disease states and body nutrient status; application of current practices in nutritional therapy and dietary management in treatment of diseases.

NUTR 702 PUBLIC HEALTH NUTRITION

3 cr. (3 and 0)

Improvement of dietary practices of the general population; application of nutritional principles to problems of disease and infection.

**NUTR 703 NUTRITION EDUCATION**

3 cr. (3 and 0)

Methods of instruction appropriate for varied age and educational levels; preparation and use of visual aids; cultural patterns in food use as related to nutrition improvement programs for various population groups.

**NUTR 704 FOOD SERVICE SYSTEMS**

3 cr. (3 and 0)

Volume feeding systems and their relationship to food quality, food acceptance, sanitation and materials selection; physical plant layout, management structure, food flow dynamics and computer-assisted diet formulation and accounting in various feeding systems.

**NUTR 705 NUTRITION PRACTICUM**

1-6 cr. (0 and 1-6)

Supervised training in outlining important aspects of practical nutrition situations and preparing plans to make improvements or changes.

**NUTR 706 NUTRITION FOR TEACHERS**

3 cr. (3 and 0)

Principles of nutrition applied to nutrition education. **Prerequisite:** Permission of instructor.

**NUTR 801 TOPICAL PROBLEMS IN NUTRITION**

1-3 cr. (1-3 and 0)

Topics not covered in other courses or by thesis research. Credit varies with problems selected.

**NUTR 808 MONOGASTRIC NUTRITION**

3 cr. (3 and 0) F

Basic concepts and current research related to nutrient requirement and metabolism of poultry, swine, and other monogastric species. **Prerequisites:** NUTR 401/601 or 451/651 or PS 451/651.

**NUTR 809 RUMINANT NUTRITION**

3 cr. (3 and 0) F

Microbiological, biochemical, and physiological processes involved in the synthesis of amino acids, proteins, and B-vitamins; relation of these processes to utilization of proteins, lipids, and fibrous and non-fibrous feed ingredients; properties and functions of nutrients, non-protein nitrogen compounds, and growth-promoting substances for dairy cattle, beef cattle, and sheep. **Prerequisite:** NUTR 401/601 or permission of instructor.

**NUTR 812 NUTRITION OF CARBOHYDRATES AND LIPIDS**

3 cr. (3 and 0) S

Energy utilization; metabolism of carbohydrates including those digestible; metabolism of lipids; diseases associated with abnormalities in metabolism. **Prerequisite:** General biochemistry and a course in nutrition.

**NUTR 813 NUTRITION TECHNIQUES WITH LARGE ANIMALS**

2 cr. (1 and 3) S

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

NUTRITION

NUTR 814 NUTRITION TECHNIQUES WITH LABORATORY ANIMALS  
2 cr. (1 and 3) F

Nutritional techniques employing small laboratory animals; metabolism and nutrient deficiencies.

NUTR 816 AMINO ACIDS AND PROTEIN NUTRITION  
2 cr. (2 and 0) F

Nutrition of amino acids, non-protein nitrogen, and proteins related to humans and domestic animals; essentiality, interrelationships, and metabolism of amino acids.

NUTR 818 VITAMINS AND MINERALS  
4 cr. (3 and 3) S

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

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

Current research and developments in nutrition. Topics, selected by the instructor and students, will come from student research and nutrition literature.

NUTR 852 NUTRITION SEMINAR II  
1 cr. (1 and 0) S

Continuation of NUTR 851.

NUTR 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

NUTR 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

*The following courses offered by the various departments represent possible electives for the student in nutrition. Descriptions for all 800-level courses can be found under the respective department headings.*

AN SC 805 NUTRITION OF MEAT ANIMALS  
3 cr. (3 and 0)

BIOCH 606 PHYSIOLOGICAL CHEMISTRY  
3 cr. (3 and 0) S

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

BIOCH 815 LIPIDS AND BIOMEMBRANES  
3 cr. (3 and 0)

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

BIOCH 822 ENZYMES  
3 cr. (3 and 0)



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

## PLANT PATHOLOGY

O. J. Dickerson, Head, Department of Plant Pathology and Physiology

<b>Major</b>	<b>Degrees</b>
Plant Pathology	M.Ag., M.S., Ph.D.

Graduate training in plant pathology is designed to understand the principles and techniques used to diagnose plant problems, to engage in research involving causal agents and host-pathogen interactions, and to teach plant pathology. Facilities are available on campus and at four branch stations in South Carolina. Current research interest includes virology; nematology; diseases of ornamental, fruit, field crops, and vegetables; epidemiology; physiological results of stress; and chemical control of causal agents.

Undergraduate study in a crop science or biology generally provides a good background for graduate work in plant pathology.

PL PA 601 PLANT PATHOLOGY  
3 cr. (2 and 2) F, S

PL PA 651 BACTERIAL PLANT PATHOGENS  
3 cr. (2 and 3) S (odd numbered years)

PL PA 656 PLANT VIROLOGY  
3 cr. (3 and 0) S (even numbered years)

PL PA 658 PLANT PARASITIC NEMATODES  
3 cr. (2 and 3) F (odd numbered years)

PL PA 700 INTERNSHIP IN PLANT PATHOLOGY  
1-5 cr. (0 and 8-40) F

Professional employment under competent supervision in an approved agency dealing with vocational or occupational aspects of plant pathology. Weekly and terminal reports required; graded on pass/fail basis. **Prerequisites:** Graduate standing for at least one semester, PL PA 401/601 and permission of graduate program coordinator.

PL PA 800 ADVANCED PLANT PATHOLOGY I  
3 cr. (3 and 0) F (odd numbered years)

Economic and social significance and history of plant pathology, host-parasite interactions (host defense mechanisms, mycotoxins, pathotoxins, mycoplasmas), ecology (mycorrhizae, pollution, soil-borne plant pathogens) and disease loss and appraisal. Selected pathogens used to illustrate concepts and principles; outside assignments introduce topics not covered in class. **Prerequisite:** PL PA 401/601.

PL PA 801 ADVANCED PLANT PATHOLOGY II  
3 cr. (3 and 0) S (even numbered years)

Epidemiology and control of plant diseases, including practical and theoretical

coverage of chemical, physical, and biological means of plant disease control.  
**Prerequisites:** PL PA 401/601 and organic chemistry.

PL PA 803 FUNGAL PLANT PATHOGENS

4 cr. (3 and 3) F (even numbered years)

Plant diseases and their causative fungi; isolation, cultural features, morphological characteristics and identification of plant pathogenic fungi. **Prerequisites:** BIOL 103, PL PA 401/601 or permission of instructor.

PL PA 804 PHYSIOLOGICAL PLANT PATHOLOGY

3 cr. (3 and 0) F (even numbered years)

Interaction of pathogen and host in development of plant diseases; factors influencing infection; development of pathogen within host. **Prerequisites:** BOT 421/621; PL PA 401/601; organic chemistry.

PL PA 805 SPECIAL PROBLEMS IN PLANT PATHOLOGY

Credit to be arranged. F, S, SS

Research not related to a thesis. **Prerequisite:** Permission of instructor.

PL PA 807 SEMINAR

1 cr. (1 and 0) F

Areas of plant pathology and plant physiology not covered by formal courses. Relevant literature will be reviewed and material will be organized and presented by students.

PL PA 808 TECHNIQUES AND METHODS IN PLANT PATHOLOGY I

1 cr. (0 and 3) F (even numbered years)

Research techniques and methods. **Prerequisites:** PL PA 401/601 or concurrent registration in PL PA 401/601.

PL PA 809 TECHNIQUES AND METHODS IN PLANT PATHOLOGY II

1 cr. (0 and 3) S (odd numbered years)

Continuation of PL PA 808 emphasizing separation science techniques and qualitative and quantitative analysis. **Prerequisites:** Organic chemistry, PL PA 401/601 and 808, or permission of instructor.

PL PA 811 PLANT DISEASE DIAGNOSIS I

1 cr. (0 and 3) SS (odd numbered years)

Procedures used in diagnosis of plant diseases, especially spring and early summer diseases. Students will practice diagnosing all types of diseases of cultivated and wild plants. **Prerequisite:** PL PA 401/601 or permission of instructor.

PL PA 812 PLANT DISEASE DIAGNOSIS II

1 cr. (0 and 3) SS (even numbered years)

A continuation of PL PA 811 emphasizing mid-summer diseases. **Prerequisites:** PL PA 401/601 or permission of instructor.

PL PA 891 MASTER'S THESIS RESEARCH

Credit to be arranged.

PL PA 991 DOCTORAL DISSERTATION RESEARCH

Credit to be arranged.

**PLANT PHYSIOLOGY**

N. D. Camper, Program Coordinator, Department of Plant Pathology and Physiology

<b>Major</b>	<b>Degree</b>
Plant Physiology	Ph.D.

The graduate program in plant physiology is interdisciplinary. Students may select courses and a major area of study from the Departments of Agronomy and Soils, Horticulture, and Plant Pathology and Physiology in the College of Agricultural Sciences, and the Department of Botany in the College of Sciences.

*The following courses offered by various departments represent possible electives for the student in plant physiology. Descriptions for all 800-level courses can be found under the respective department headings.*

**AGRON 690 SOIL ORGANISMS AND CROP PRODUCTION**

3 cr. (2 and 3)

**AGRON 801 CROP PHYSIOLOGY AND NUTRITION**

3 cr. (3 and 0)

**AGRON 805 SOIL FERTILITY**

3 cr. (3 and 0)

**AGRON 812 CROP ECOLOGY AND LAND USE**

3 cr. (3 and 0)

**AGRON 820 PESTICIDE RESIDUES IN THE ENVIRONMENT**

3 cr. (3 and 0)

**AGRON 991 DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged.

**BOT 821 INORGANIC PLANT METABOLISM**

4 cr. (3 and 3)

**BOT 822 ORGANIC PLANT METABOLISM**

3 cr. (3 and 0)

**BOT 823 PLANT GROWTH & DEVELOPMENT**

3 cr. (3 and 0)

**BOT 824 MODE OF ACTION OF GROWTH SUBSTANCES**

4 cr. (3 and 3)

**BOT 826 PHYSIOLOGY OF THE FUNGI**

3 cr. (3 and 0)

**BOT 861 PLANT CELL BIOLOGY**

3 cr. (3 and 0)

- BOT 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.
- HORT 802 RESEARCH SYSTEMS IN HORTICULTURE  
3 cr. (2 and 3)
- HORT 803 EXPERIMENTAL OLERICULTURE  
3 cr. (3 and 0)
- HORT 805 PHYSIOCHEMICAL PROCEDURES FOR DETERMINING QUALITY  
IN HORTICULTURAL CROPS  
3 cr. (2 and 3)
- HORT 806 POSTHARVEST PHYSIOLOGY AND HANDLING OF  
HORTICULTURAL CROPS  
3 cr. (3 and 0)
- HORT 811 QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT  
2 cr. (1 and 3)
- HORT 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.
- PL PA 804 PHYSIOLOGICAL PLANT PATHOLOGY  
3 cr. (3 and 0)
- PL PA 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

**POULTRY SCIENCE**

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

<b>Major</b>	<b>Degrees</b>
Poultry Science	M.Ag.
Animal and Food Industries	M.S.
Animal Physiology	Ph.D.
Nutrition	M.S., Ph.D.

- PS 600 AVIAN PHYSIOLOGY  
4 cr. (3 and 3)
- PS 601 ANIMAL ENVIRONMENTAL TECHNOLOGY  
2 cr. (2 and 0) F (even numbered years)
- PS 603 ANIMAL ENVIRONMENTAL TECHNOLOGY LABORATORY  
1 cr. (0 and 3) F (even numbered years)
- PS 605 TOPICAL PROBLEMS  
1-3 cr. (0 and 3-9)
- PS 651 POULTRY NUTRITION  
2 cr. (2 and 0) S (even numbered years)

- PS 654 LEAST COST FEED FORMULATION  
2 cr. (1 and 2)
- PS 655 POULTRY PRODUCTS GRADING AND TECHNOLOGY  
3 cr. (2 and 3) F (odd numbered years)
- PS 658 AVIAN MICROBIOLOGY AND PARASITOLOGY  
4 cr. (3 and 3) F (even numbered years)
- PS 659 MANAGEMENT OF EGG, BROILER, AND TURKEY ENTERPRISES  
3 cr. (2 and 3) F (even numbered years)
- PS 660 SEMINAR  
1 cr. (1 and 0)
- PS 804 POULTRY PATHOLOGY  
3 cr. (1 and 6) S (odd numbered years)  
Etiological agents, prophylaxis and treatment of poultry diseases. Laboratory work includes experiments in bacteriology, virology, protozoology, and immunology procedures emphasizing isolation and identification of disease producing agents.  
**Prerequisite:** PS 458/658 or permission of instructor.
- PS 805 SEMINAR  
1 cr. (1 and 0) F  
Report on special topics or original research by students, staff and visiting speakers.
- PS 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

## WILDLIFE BIOLOGY

S. B. Hays, Head, Department of Entomology, Fisheries and Wildlife

Major  
Wildlife Biology

Degree  
M.S.

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

- WB 612 WILDLIFE MANAGEMENT  
3 cr. (2 and 3)
- WB 616 FISHERY BIOLOGY  
3 cr. (2 and 3)
- WB 660 BIOLOGY OF MARINE ORGANISMS  
3 cr. (2 and 3)

- WB 662      AQUATIC PRODUCTIVITY  
3 cr. (3 and 0)
- WB 809      WILDLIFE BIOLOGY SEMINAR I  
1 cr. (1 and 0)  
Current literature regarding problems encountered in applied wildlife biology.
- WB 810      WILDLIFE BIOLOGY SEMINAR II  
1 cr. (1 and 0)  
Continuation of WB 809.
- WB 815      PRINCIPLES OF WILDLIFE BIOLOGY  
3 cr. (2 and 3) SS and alternate years  
Theories and principles applicable to wildlife biology emphasizing upland game species.
- WB 816      APPLIED WILDLIFE BIOLOGY  
3 cr. (2 and 3)  
Techniques and practices involved in management of wildlife species emphasizing upland game.
- WB 818      ECOLOGY AND MANAGEMENT OF WETLAND WILDLIFE  
3 cr. (2 and 3)  
Identification, ecology and management of waterfowl and marshland furbearers emphasizing economically important species. Laboratory work includes demonstration and application of relevant wetland management techniques, current literature topics and field trips. **Prerequisites:** ZOO 411/611, WB 412/612, or permission of instructor.
- WB 840      IMPOUNDMENT AND STREAM MANAGEMENT  
3 cr. (2 and 3)  
Principles and techniques of managing ponds and streams for sport fishing and/or commercial fishing emphasizing trout streams, farm ponds, and reservoirs. Laboratory work includes demonstration and application of management techniques and field trips to observe other management practices. **Prerequisite:** ZOO 410/610 and ZOO 463/663 or permission of instructor.
- WB 850      AQUACULTURE  
3 cr. (3 and 0)  
Basic aquacultural techniques applied to freshwater and marine organisms; past and present culture of finfishes and shellfishes around the world; principles underlying fish production; water quality, feeding, and nutrition as they influence production of cultured aquatic organisms. **Prerequisite:** WB 416/616 or ZOO 463/663.
- WB 852      PARASITES AND DISEASES OF MARINE ANIMALS  
3 cr. (2 and 3)  
Major groups of symbionts as causative agents of disease in marine organisms; systematics, life cycles, and physiology as they contribute to the intimate host-symbiont relationship. A special problem will be completed. **Prerequisite:** ZOO 456/656.
- WB 856      DIRECTED STUDIES & FIELD WORK IN MARINE BIOLOGY  
4 cr. (2 and 6)

Selected topics for study and investigation while in summer residence at the South Carolina Marine Resources Institute at Charleston; systematics and morphology of marine organisms and experimental investigations dependent upon interests of the student. **Prerequisite:** Permission of instructor(s).

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

Research not related to a thesis. Credit varies with problems selected. **Prerequisite:** Permission of instructor.

WB 891      MASTER'S THESIS RESEARCH  
Credit to be arranged.

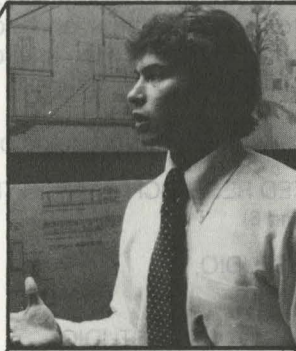


COLLEGE OF ARCHITECTURE

Richard E. McClure, Dean

# College Of Architecture

ARCHITECTURE  
BUILDING SCIENCE  
CITY AND REGIONAL PLANNING  
VISUAL STUDIES



The following courses are offered:

CA 812	DIRECTED STUDIES	3 cr. (1-3)
CA 820	VISUAL STUDIES	3 cr. (0-3)
CA 842	BUILDING SCIENCE	1-3 cr. (0-3 and 3-18)
CA 850	ARCHITECTURAL STUDIO	1-3 cr. (0-3 and 3-18)
CA 860	PLANNING STUDIO	1-3 cr. (0-3 and 3-18)
CA 880	VISUAL ARTS STUDIO	1-3 cr. (0-3 and 3-18)





## COLLEGE OF ARCHITECTURE

Harlan E. McClure, Dean

The College of Architecture offers professional degree programs leading to the Master of Architecture, Master of City and Regional Planning, and the Master of Fine Arts in visual studies.

Clemson University is the only institution in South Carolina offering studies in architecture and environmental design at its several levels.

As an enrichment to its graduate offerings, the Clemson Architectural Foundation in collaboration with the College maintains an overseas center in Genoa, Italy, and each graduate student is expected to spend the period of one semester and a summer in that facility. The activities there include regular classes, coordinated field trips, and lectures by visiting professors, as well as participation by critics from the environmental design professions in other Italian universities.

The following courses are included in the overseas program:

CA 612 DIRECTED RESEARCH IN ARCHITECTURAL HISTORY  
3 cr. (1 and 6)

CA 620 VISUAL STUDIO  
3 cr. (0 and 9)

CA 642 BUILDING SCIENCE STUDIO  
1-9 cr. (0-3 and 3-18)

CA 850 ARCHITECTURAL STUDIO  
1-9 cr. (0-3 and 3-18)

Studio problems in architectural and urban design in the framework of a dense and ancient urban area. Field trips and related lectures will be an adjunctive structured resource in the conduct to these intensive programs. Particularly for M.Arch. degree candidates; may be substituted for CA AR 853, 854, 857 if nine credits are taken. **Prerequisite:** Graduate student status in the College of Architecture.

CA 860 PLANNING STUDIO  
1-9 cr. (0-3 and 3-18)

Studio planning problems programmed to coordinate with concurrent work undertaken by colleagues in CA 850. Specialist lectures from other Italian universities will be scheduled. Particularly for Master of City and Regional Planning degree candidates; may be substituted for CA PL 854, 863, or 865 with approval of credit hours by major advisor. **Prerequisite:** Acceptance in the Master of City and Regional Planning degree program.

CA 880 VISUAL ARTS STUDIO  
1-9 cr. (0-3 and 3-18)

Intensive graduate work in the visual arts studio. Adjunct lectures and gallery tours will be scheduled with leading Italian artists, art critics, and historians; field work required. Primarily for Master of Fine Arts candidates; may be substituted for a graduate visual arts studio. **Prerequisite:** Graduate student status in the College of Architecture.

## ARCHITECTURE

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

**Major**  
Architecture

**Degree**  
M.Arch.

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

The graduate program comprises at least one to two years of professional architectural curriculum. Applicants who have completed an undergraduate degree in design or its equivalent will enter at the fifth-year level (the 4-2 program) and work toward the Master of Architecture as the first professional degree. Applicants possessing an undergraduate professional degree in architecture will enter at the sixth-year level (the 5-1 program) and work toward the Master of Architecture as the second professional degree.

### Admission Requirements:

The following requirements for admission to the graduate program in architecture apply only to students in the 4-2 program:

1. Attainment of a B.A. or B.S. degree in design or equivalent.
2. Attainment of a satisfactory academic record in the last 60 major\* credit (semester) hours.
3. Completion of a counseling review with the Dean of the College of Architecture and the Head of the Department of Architectural Studies, including a portfolio of previous creative efforts.
4. Letters of recommendation from three of the following: the dean of the undergraduate school, an undergraduate teacher, an employer, or a personal acquaintance.
5. Completion of the Graduate Record Examination.
6. Work experience in an approved architectural office.

### Requirements for Degree Candidacy:

1. (a) 4-2 Program: Thirty (30) semester hours in the student's prescribed professional curriculum in the graduate program with a minimum grade point ratio of 3.00.

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

(b) 5-1 Program: Eighteen (18) semester hours in the student's prescribed professional curriculum in the graduate program with a minimum grade point ratio of 3.00.

2. Work experience of a minimum of 1,000 hours in an architectural office. The majority of these hours should be obtained prior to application to the Graduate School.

**Requirements for Awarding of a Degree:**

1. (a) 4-2 Program: A minimum of 48 semester hours of credit with a grade point ratio of 3.00 or above average in the student's professional curriculum, excluding a thesis or a terminal project.

(b) 5-1 Program: A minimum of 27 semester hours of credit with a grade point ratio of 3.00 or above average in the student's professional curriculum, excluding a thesis or a terminal project.

2. (a) 4-2 Program: Satisfactory completion of a thesis or a terminal project, each of 12 credit hours, while in residence as a full-time student.

(b) 5-1 Program: Satisfactory completion of a thesis or a terminal project, each of 9 credit hours, while in residence as a full-time student.

CA AR 624 FURNITURE DESIGN/INDUSTRIAL PRODUCT DESIGN  
3 cr. (1 and 4)

CA AR 625 ENERGY CRITERIA ON ARCHITECTURAL DESIGN  
3 cr. (3 and 0)

CA AR 681 ARCHITECTURAL OFFICE PRACTICE  
3 cr. (3 and 0)

CA AR 685 HEALTH CARE DELIVERY SYSTEMS AND HEALTH CARE FACILITIES SEMINAR  
3 cr. (3 and 0)

CA AR 688 HEALTH CARE FACILITIES PROGRAMMING TECHNIQUES  
3 cr. (2 and 3)

CA AR 801 PROFESSIONAL PRACTICE SEMINAR  
3 cr. (3 and 0)

Emerging methods of architectural practice and management of the firm.  
**Prerequisite:** CA AR 481/681.

CA AR 853 ARCHITECTURAL DESIGN  
6-9 cr. (0 and 18-27)

City planning design and development of complex building structures. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program will enroll for nine credit hours.

CA AR 854 ARCHITECTURAL DESIGN  
6-9 cr. (0 and 18-27)

Architectural and planning research and design of complex buildings and urban groupings. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program will enroll for nine credit hours. **Prerequisite:** CA AR 853.

CA AR 857 ARCHITECTURAL DESIGN  
9 cr. (0 and 27)

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

CA AR 858 PRELIMINARY THESIS OR TERMINAL PROJECT  
3 cr. (1 and 6)

Preliminary analysis of data to determine most advisable form of terminal presentation within thesis or non-thesis options for Master of Architecture degree. **Prerequisites:** CA AR 853 and 854 or CA 850 substituting for CA AR 853 or CA AR 854.

CA AR 859 TERMINAL PROJECT  
1-12 cr. (0 and 3-36)

Special project in lieu of architectural thesis. Approval of department faculty required; may be repeated for no more than 12 credits. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program will enroll for nine credit hours. **Prerequisites:** CA AR 858 plus CA AR 857 and/or CA 850.

CA AR 886 HEALTH CARE FACILITIES COMPONENTS AND FUNCTIONS  
3 cr. (2 and 3)

Components and service functions of physical and mental health care delivery systems and facilities.

CA AR 890 DIRECTED STUDIES  
1-5 cr.

Special topics not covered in other courses emphasizing field studies, research activities, and current developments in architecture and planning. **Prerequisite:** Permission of faculty advisor, and department head or dean.

CA AR 891 ARCHITECTURAL THESIS  
1-12 cr.

Each student will select and have approved by his or her major advisor an individual thesis problem of appropriate scope, and conduct his or her own comprehensive research. Under approved special circumstances, the thesis may be a team effort. The solution will be presented in oral, written and visual form. May be repeated for no more than 12 credits. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program will enroll for nine credit hours. **Prerequisite:** CA AR 854.

## BUILDING SCIENCE

R. E. Knowland, Head, Department of Building Science

Advanced degrees are not awarded in building science. Courses are offered to provide electives for students in other areas.

CA BS 632 CONSTRUCTION MANAGEMENT V  
3 cr. (3 and 0)

CA BS 661 CONSTRUCTION ECONOMIC SEMINAR  
3 cr. (3 and 0)

CA BS 671	ARCHITECTURAL STRUCTURES 3 cr. (3 and 0)
CA BS 672	ARCHITECTURAL STRUCTURES 3 cr. (3 and 0)
CA BS 675	BUILDING EQUIPMENT AND SYSTEMS 3 cr. (3 and 0)
CA BS 676	DESIGN FOR NATURAL HAZARDS 3 cr. (3 and 0)

### **CITY AND REGIONAL PLANNING**

E. L. Falk, Head, Department of City and Regional Planning

<b>Major</b>	<b>Degree</b>
City and Regional Planning	M.C.R.P.

The two-year professional master of city and regional planning curriculum consists of a core and an elective concentration. The core provides the student with the common basic skills and knowledge needed to succeed as a professional planner. The elective concentration facilitates either (1) the generalist capabilities or (2) the development of a planning specialty. Where appropriate, specialty concentrations are aligned with doctoral programs to assist qualified students in preparing for academic or research careers in addition to their professional training.

The Overseas Center for Urban Studies in Genoa, Italy, provides a unique core element in the planning studies program. It provides a semester in an interdisciplinary program of fine arts, design, and planning studies.

#### **Admission Requirements:**

1. A bachelor's degree from an accredited college or university.
2. A satisfactory academic record in the last 60 major\* credit hours of undergraduate work.
3. A counseling review with the Dean of the College of Architecture and the Head of the Department of Planning Studies. This review is for acceptance as well as counseling in the case of applicants from outside the College of Architecture.
4. Letter of recommendation from any three of the following: the dean of the undergraduate school, an undergraduate teacher, an employer or a personal acquaintance.
5. Completion of the Graduate Record Examination.

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

### Requirements for Degree Candidacy:

The two-year Master of City and Regional Planning degree requires a minimum of 60 semester hours. Ten three-semester-hour courses make up the core curriculum. Of the seven approved three-semester-hour electives, at least four are required to complete an optional concentration. In addition, each student is required to complete an internship (or equivalent) and terminal paper (or thesis). Typical optional concentrations include urban design, planning implementation, health and social services, planning methods and quantitative analysis, local government finance, transportation planning, regional and natural resource economics, urban economics, public administration, environmental planning, recreation planning, rural planning, and community development.

### Requirements for Awarding of a Degree:

#### 1. Thesis Option\*\*

(a) A minimum of 54 hours of course work with a B average in the student's prescribed professional curriculum including the thesis.

(b) Satisfactory completion of a six-semester-hour planning thesis. Only those students who have been approved by the planning faculty and have performed satisfactorily on the written comprehensive examination will be permitted this option.

(c) The final oral examination requires satisfactory answers to questions concerning the student's thesis and concentration area.

#### 2. Non-Thesis Option\*\*

(a) A minimum of 57 hours of course work with a B average in the student's prescribed professional curriculum.

(b) Satisfactory completion of an approved three-semester-hour terminal paper. Students must perform satisfactorily on a written comprehensive examination covering the core planning courses before being permitted to write the terminal paper.

(c) The final oral examination requires satisfactory answers to questions concerning the student's terminal paper and concentration area.

CA PL 611 INTRODUCTION TO CITY AND REGIONAL PLANNING  
3 cr. (3 and 0)

CA PL 621 URBAN SOCIAL STRUCTURE  
3 cr. (3 and 0)

CA PL 672 IMPLEMENTATION OF THE LOCAL PLANNING PROCESS  
3 cr. (3 and 0)

CA PL 673 GOVERNMENT AND PLANNING LAW  
3 cr. (3 and 0)

CA PL 683 SEMINAR ON PLANNING COMMUNICATION  
3 cr. (3 and 0)

\*\*Upon approval of the majority of the faculty, either a thesis or a terminal paper of up to nine semester hours may be permitted with a corresponding reduction in the required course work.

CA PL 812 CITY AND REGIONAL PLANNING THEORY  
3 cr. (3 and 0)

Urban theory as a planning experience during the evolution of human settlements; historical background considered as a basic knowledge for understanding living standards, yielding ideas for improving standards through planning proposals. **Prerequisite:** Permission of instructor or department head.

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

Operations, structure and review procedures between local, state and multi-state agencies and the federal government; techniques of regional delineation and areal problems in governmental planning operations. **Prerequisite:** Permission of instructor and department head.

CA PL 822 URBAN SYSTEMS AND DESIGN  
3 cr. (3 and 0)

Translation of the intricate mathematical exploration patterns of the complex needs of a city and their inter-relationships into a possible range of built forms. Focus is on the translation area with its constituent spatial and non-spatial characteristics. **Prerequisite:** Permission of instructor or department head.

CA PL 823 SOCIAL POLICY PLANNING AND DELIVERY SYSTEMS  
3 cr. (3 and 0)

Concepts of planning social service delivery systems: basic principles, role of the public sector (at national, state, and local levels), components of delivery systems, and methods for planning and evaluation. **Prerequisite:** Permission of instructor.

CA PL 853 COMPARATIVE STUDIES IN PLANNING METHODS AND  
ANALYSIS  
3 cr. (0 and 9)

Simulated office procedures with projects aimed at developing skills in the three main sectors of the planning process — survey, analysis and creative planning — emphasizing plans for physical development.

CA PL 854 PLANNING AND BUILT FORM STUDIES: STUDIO  
3 cr. (0 and 9)

Theoretical course work applied to simulated real life project exercises.

CA PL 858 PRELIMINARY PLANNING THESIS  
3 cr. (0 and 9)

Preliminary analysis of data to determine most advisable form of terminal presentation within thesis or non-thesis options for Master of City and Regional Planning degree. **Prerequisite:** Permission of faculty.

CA PL 859 PLANNING TERMINAL PROJECT  
3 cr. (0 and 9)

Student selects, with approval of adviser, and conducts research on an individual planning problem of suitable scope. Oral, written, and, where appropriate, visual presentation of thesis required. Student must enroll during final semester.

## CA PL 862 CITIZEN PARTICIPATION IN PLANNING

3 cr. (3 and 0)

Methods and validity of citizen participation in city and regional planning process. **Prerequisite:** Permission of instructor.

## CA PL 863 URBAN AND METROPOLITAN PLANNING STUDIES: STUDIO

3-6 cr. (0 and 9-18)

Projects pertaining to land use, transportation, urban design, public facilities, public services, capital improvement program, etc., accomplished through individual or small group activity under guidance of planning faculty.

## CA PL 865 ADVANCED LAND USE AND BUILT FORM STUDIES: STUDIO

3-9 cr. (0 and 9-27)

Continuation of CA PL 863; may include terminal paper on one or more of items listed in CA PL 863.

## CA PL 871 SEMINAR ON PLANNING AND MANAGEMENT OF CHANGE

3 cr. (3 and 0)

Potentials of planning and management approaches emphasizing relationship and integration among various implementing techniques and instruments, importance of public-private sector partnerships, and potential impact of various policies and programs. New towns will be considered. **Prerequisites:** CA PL 672 and permission of instructor or department head.

## CA PL 881 QUANTITATIVE METHODS FOR URBAN PLANNING AND POLICY

3 cr. (3 and 0)

Conceptual foundations of quantitative methods; survey of quantitative techniques in relation to major tasks of urban planning process.

## CA PL 882 SEMINAR IN MATHEMATICAL MODELING FOR URBAN AND REGIONAL PLANNING

3 cr. (3 and 0)

Mathematical models for analysis of urban systems; predictive and estimating models, optimizing models, simulation and evaluation. Theoretical knowledge is applied to development of operational empirical models.

## CA PL 883 TECHNIQUES FOR ANALYZING DEVELOPMENT IMPACTS

3 cr. (3 and 0)

Models and techniques for analyzing development impacts in urban areas and regions; economic, social, physical, energy, and fiscal impact methods. Operational knowledge of these techniques will be developed. **Prerequisites:** CA PL 881, CA PL 865, and permission of instructor.

## CA PL 884 PUBLIC SERVICES AND FACILITIES PLANNING

3 cr. (3 and 0)

Approaches, concepts and operations of public services and facilities; potential impact on various parts of the community and its inhabitants. **Prerequisite:** Permission of instructor or department head.



## CA PL 885 CITY AND REGIONAL FINANCIAL PLANNING

3 cr. (3 and 0)

Concepts and functions of budgetary processes — operating budget, capital improvement program, and revenue sources — for local, regional, state and federal funding of public activities. **Prerequisite:** Permission of instructor or department head.

## CA PL 889 SELECTED TOPICS IN PLANNING

3 cr. (3 and 0)

Topics not covered in other courses, emphasizing current literature and results of current research. May be repeated for credit. **Prerequisite:** Permission of instructor.

## CA PL 890 DIRECTED STUDIES IN CITY AND REGIONAL PLANNING

1-5 cr. (0 and 1-5)

Student pursues individual professional interests under guidance of city and regional planning program graduate faculty.

## CA PL 891 PLANNING THESIS

3-9 cr.

Student, working individually, programs a planning problem of appropriate scope and conducts research. Oral, written, and, where appropriate, visual presentation of thesis required. **Prerequisite:** Permission of faculty.

## CA PL 893 CITY AND REGIONAL PLANNING INTERNSHIP

6 cr. (0 and 6)

Twelve weeks of supervised professional employment in an approved planning office or agency. Monthly reports covering student's experience required. Graded on pass/fail basis. **Prerequisite:** Two semesters of city and regional planning or equivalent.

**VISUAL STUDIES**

J. T. Acorn, Head, Department of History and Visual Studies

**Major**

Visual Studies

**Degree**

M.F.A.

The Master of Fine Arts degree is the terminal degree within the areas of visual arts. The program offers maximum opportunity for a student to pursue his or her individual direction within these areas. Interdisciplinary projects are encouraged within the department and the college. The primary goal of the program is the development of each student to a high degree of professional competence.

**Admission Requirements:**

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

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

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

3. A portfolio/documentation of candidate's creative work in one or more of the following: ceramics, cinematography, painting, sculpture, printmaking, graphic design, drawing, photography, multimedia. This portfolio, which may include slides, photographs, films, other documentation, or the original work, will be reviewed by the admissions committee, composed of members of the faculty of the Department of History and Visual Studies. Upon acceptance of the past accomplishments of the candidate, a personal interview will be arranged.

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

#### Requirements for Degree Candidacy:

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

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

#### Requirements for Awarding of a Degree:

1. A minimum of 45 credit hours with a B average or above in the student's professional curriculum. Included in this are 33 hours of studio art and 12 hours in history of art and architectural history.

2. Completion of a 15-credit-hour thesis culminating in satisfactory completion of a written documentary of the "thesis show" and an oral examination by the Graduate Committee.

CA VA 605 DRAWING  
3 cr. (0 and 9)

CA VA 607 PAINTING  
3 cr. (0 and 9)

CA VA 609 SCULPTURE  
3 cr. (0 and 9)

CA VA 611 PRINTMAKING  
3 cr. (0 and 9)

CA VA 613 PHOTOGRAPHY  
3 cr. (0 and 9)

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

- CA VA 615 GRAPHIC DESIGN  
3 cr. (0 and 9)
- CA VA 617 CERAMIC ARTS  
3 cr. (0 and 9)
- CA VA 690 DIRECTED STUDIES  
1-5 cr.
- CA VA 850 VISUAL ARTS STUDIO  
3 cr. (0 and 9)  
Concentrated and advanced work in ceramics, drawing, painting, printmaking, sculpture, photography, graphic design or multimedia. **Prerequisite:** MFA majors only.
- CA VA 851 VISUAL ARTS STUDIO  
3-6 cr.  
Continuation of CA VA 850. May be repeated for maximum of six credits. **Prerequisites:** CA VA 850; MFA majors only.
- CA VA 870 VISUAL ARTS STUDIO  
6 cr. (1 and 15)  
Advanced theory; directed research in art criticism; applied work in ceramic arts, drawing, painting, sculpture, photography, graphic design, or multimedia. **Prerequisites:** CA VA 851; MFA majors only.
- CA VA 871 VISUAL ARTS STUDIO  
3-6 cr.  
Continuation of CA VA 870. May be repeated for maximum of six credits. **Prerequisites:** CA VA 870; MFA majors only.
- CA VA 880 VISUAL ARTS STUDIO  
3-15 cr.  
Continuation of CA VA 871. May be repeated for maximum of 15 credits. **Prerequisites:** CA VA 871; MFA majors only.
- CA VA 891 MASTER'S RESEARCH  
3-15 cr.  
May be repeated for maximum of 15 credits. **Prerequisite:** CA VA 880.
- No degrees are offered in Architectural and Art History. Courses are offered to provide electives for students in other areas.*
- CA AH 603 HISTORY OF MODERN ARCHITECTURAL MOVEMENT  
3 cr. (3 and 0)
- CA AH 604 CURRENT DIRECTIONS IN ARCHITECTURE  
3 cr. (3 and 0)
- CA AH 605 THE HISTORY OF PLANNING AND CITIES  
3 cr. (3 and 0)

- CA AH 611 DIRECTED RESEARCH IN ART HISTORY  
3 cr. (3 and 0)
- CA AH 612 DIRECTED RESEARCH IN ART HISTORY  
3 cr. (3 and 0)
- CA AH 613 TWENTIETH CENTURY VISUAL ARTS  
3 cr. (3 and 0)
- CA AH 617 STUDIES IN THE ART AND ARCHITECTURE OF THE ANCIENT  
WORLD I  
3 cr. (3 and 0)
- CA AH 618 STUDIES IN THE ART AND ARCHITECTURE OF THE ANCIENT  
WORLD II  
3 cr. (3 and 0)
- CA AH 619 STUDIES IN THE ART AND ARCHITECTURE OF THE EARLY  
MIDDLE AGES  
3 cr. (3 and 0)
- CA AH 620 STUDIES IN THE ART AND ARCHITECTURE OF THE LATE  
MIDDLE AGES  
3 cr. (3 and 0)
- CA AH 623 STUDIES IN THE ART AND ARCHITECTURE OF THE  
RENAISSANCE I
- 3 cr. (3 and 0)
- CA AH 624 STUDIES IN THE ART AND ARCHITECTURE OF THE  
RENAISSANCE II  
3 cr. (3 and 0)
- CA AH 627 EIGHTEENTH CENTURY VISUAL ARTS  
3 cr. (3 and 0)
- CA AH 628 NINETEENTH CENTURY VISUAL ARTS  
3 cr. (3 and 0)
- CA AH 629 STUDIES IN THE ART AND ARCHITECTURE OF INDIA AND THE  
FAR EAST I  
3 cr. (3 and 0)
- CA AH 815 ART AND ARCHITECTURAL HISTORY SEMINAR I  
3 cr. (3 and 0)  
Particular aspect of period of art/architectural history. **Prerequisite:** Permission  
of instructor.
- CA AH 816 ART AND ARCHITECTURAL HISTORY SEMINAR II  
3 cr. (3 and 0)  
Continuation of CA AH 815.



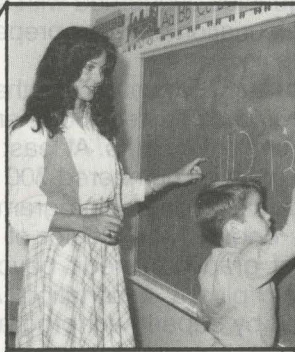
# COLLEGE OF EDUCATION

H. F. Landrith, Dean

The College of Education offers professional degree programs leading to the Master of Education, Master of Agricultural Education, Master of Education, the Specialist in Education, and the Doctor of Education.

- ADMINISTRATION AND SUPERVISION
- AGRICULTURAL EDUCATION
- ELEMENTARY EDUCATION
- INDUSTRIAL EDUCATION
- PERSONNEL SERVICES
- READING
- SECONDARY EDUCATION
- VOCATIONAL/TECHNICAL EDUCATION

# College Of Education



## AGRICULTURAL EDUCATION

L. H. Rodgers, Head, Department of Agricultural Education

Major: Agricultural Education  
Degree: M.A. Ed.

The Master of Agricultural Education degree is designed for people who wish to increase their competence in providing professional educational services in agriculture and vocational education. The flexible program permits specialization in interest areas. Degree recipients often return to positions as agriculture teachers in high schools, vocational schools, technical education centers and community colleges. They are also in demand for administrative, supervisory, and specialized positions in these institutions. Agricultural extension workers and many others who have educational responsibilities in the agricultural complex find this program to be a valuable step in their professional development.

- Candidates for the degree are required to complete:
1. A minimum of 12 semester hours in the student's major field.
  2. At least three semester hours in statistics and three semester hours in research methods.

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



## COLLEGE OF EDUCATION

H. F. Landrith, Dean

The College of Education offers professional degree programs leading to the Master of Education, Master of Agricultural Education\*, Master of Industrial Education, the Specialist in Education, and the Doctor of Education.

These programs provide a broad range of learning experiences and detailed study in the subject area. They are designed to prepare students for duties required in their areas of concentration, to encourage continuing professional development, and to enable them to meet standards recommended by agencies concerned with specific programs. The Specialist and Doctor of Education degrees prepare graduates for leadership positions in the profession.

The Master of Agricultural Education and the Master of Industrial Education programs require 30 semester hours, and the Master of Education program requires 36 semester hours. At least half of the courses required for master's degrees must be numbered 700 or above.

The Specialist in Education degree program requires 30 semester hours beyond the master's degree. The Doctor of Education degree requires 80 semester hours of graduate credit beyond the bachelor's degree, including an internship plus a dissertation. Additional requirements for each degree are listed by department/program.

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### AGRICULTURAL EDUCATION

J. H. Rodgers, Head, Department of Agricultural Education

Major	Degree
Agricultural Education	M.Ag.Ed.

The Master of Agricultural Education degree is designed for people who wish to increase their competence in providing professional educational services in agriculture and vocational education. The flexible program permits specialization in interest areas. Degree recipients often return to positions as agriculture teachers in high schools, vocational schools, technical education centers and community colleges. They are also in demand for administrative, supervisory and specialized positions in these institutions. Agricultural extension workers and many others who have educational responsibilities in the agribusiness complex find this program to be a valuable step in their professional development.

Candidates for the degree are required to complete:

1. A minimum of 12 semester hours in the student's major field.
2. At least three semester hours in statistics and three semester hours in research methods.

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

3. A minimum of six semester hours in an area of concentration outside the major field.

4. At least six semester hours of relevant courses approved by the candidate's advisory committee.

AG ED 601    **METHODS IN AGRICULTURAL EDUCATION**  
3 cr. (2 and 3) S

AG ED 623    **CURRICULUM**  
2 cr. (2 and 0) S

AG ED 625    **TEACHING AGRICULTURAL MECHANICS**  
2 cr. (1 and 3) S

AG ED 631    **METHODS IN ENVIRONMENTAL EDUCATION**  
3 cr. (3 and 0) SS

AG ED 650    **MODERN TOPICS AND ISSUES**  
3 cr. (3 and 0)

AG ED 665    **PROGRAM AND CURRICULUM DEVELOPMENT**  
3 cr. (3 and 0) F (even numbered years)

AG ED 667    **ADULT EDUCATION IN AGRICULTURE**  
3 cr. (2 and 3) S (odd numbered years)

AG ED 726    **AGRICULTURAL MECHANIZATION FOR INSERVICE TEACHERS**  
3 cr. (3 and 0)

Development of teaching materials, course construction and curriculum design in agricultural mechanics; procedures and processes for implementing a new course in agricultural mechanics at high school level.

AG ED 727    **AGRICULTURAL EDUCATION SHOP MANAGEMENT**  
3 cr. (1 and 6)

Basic processes and tools used in repair, maintenance and construction of farm equipment; shop management and methods of teaching technical skills; application of shop principles to design and construction of projects in agricultural mechanics.

AG ED 736    **INTERNSHIP: TEACHING**  
3 cr. (1 and 6) S

Professional competency and program development through classroom and practical experiences in planning, conducting and evaluating educational programs.

AG ED 737    **INTERNSHIP IN AGRIBUSINESS FIRMS**  
3 cr. (1 and 6)

Classroom and practical experiences in selected agricultural businesses and industries. Students identify and practice entry-level competencies required in selected agribusiness and natural resource management enterprises.

AG ED 803    **EVALUATION OF INSTRUCTIONAL PROGRAMS**  
3 cr. (2 and 3) F (odd numbered years)

Measurement and evaluation in general and as applied to agricultural and

vocational education; selection and/or development and use of instruments for appraising educational outcomes of student achievement and total programs.  
**Prerequisite:** Permission of instructor.

AG ED 804 SPECIAL PROBLEMS  
3 cr. (2 and 3) F, S, SS

Planning, conducting and reporting a special problem in agricultural education appropriate to students' needs.

AG ED 805 ADMINISTRATION AND SUPERVISION IN AGRICULTURAL EDUCATION  
3 cr. (3 and 0) S (even numbered years)

Developing a philosophy of education including application of administrative concepts in supervising agricultural education programs. **Prerequisite:** Experience in agricultural education.

AG ED 815 TEACHING AGRICULTURAL AND POWER MECHANICS  
3 cr. (2 and 3) SS (odd numbered years)

Methods of determining course content, organizing teaching modules in logical sequence, equipping shop, teaching agricultural and power mechanics to farm and agribusiness clientele, providing individualized instruction, developing off-farm experience programs.

AG ED 820 TEACHING YOUNG FARMERS  
3 cr. (3 and 0) F (even numbered years)

Principles and practices of problem solving in developing and conducting instructional programs for young farmers.

AG ED 825 SUPERVISION OF STUDENT TEACHING  
3 cr. (3 and 0)

Developing philosophy of teacher education; analyzing present teacher training program in South Carolina for problem situations on which to base teacher-education programs; determining relative emphasis for each teacher to place upon solving problems in teacher-education program; projecting plans for apprentice training program; supervising apprentice training. **Prerequisite:** Experience in agricultural education and permission of instructor.

AG ED 869 SEMINAR  
1-3 cr. (1-3 and 0)

Students and faculty review current topics in agricultural education.

AG ED 889 INTRODUCTION TO RESEARCH IN EDUCATION  
3 cr. (3 and 0) SS, F (odd numbered years)

Problem selection, types of educational research and techniques employed, use of ERIC system, interpretation of research findings.

**ELEMENTARY AND SECONDARY EDUCATION**

E. J. Kozma, Head, Department of Elementary and Secondary Education

<b>Major</b>	<b>Degrees</b>
Administration and Supervision	M.Ed., Ed.S.
Elementary Education	M.Ed.



Personnel Services	M.Ed.
Reading	M.Ed.
Secondary Education	M.Ed.

Students seeking admission to the Master of Education degree programs with majors in administration and supervision, elementary education, elementary education with an emphasis in special education, reading, personnel services (in the areas of elementary counseling, secondary counseling, secondary counseling with an emphasis in special education), and secondary education should have a valid professional teacher's certificate on the appropriate level. Emphasis in special education, available in elementary education and secondary counseling, also requires appropriate certification. Those seeking admission to the personnel services program in the areas of higher education counseling and vocational counseling must have at least 12 hours in psychology or educational psychology.

The Master of Education degree program requires at least 36 semester hours of graduate credit regardless of the major.

A major in educational administration and supervision is offered to experienced teachers who wish to prepare as elementary school administrators, elementary school supervisors, secondary school administrators, or secondary school supervisors. Courses may be selected from four areas as prescribed by the Department of Elementary and Secondary Education.

A major in elementary education is offered to teachers who hold professional elementary certificates. Courses may be selected from six areas as prescribed by the Department of Elementary and Secondary Education. Those students interested in the area of special education (emotionally handicapped, learning disabilities, or mental retardation) should enroll in the elementary education curriculum.

A major in personnel services is offered to those desiring to specialize in guidance counseling in the public schools, post-secondary schools, or the vocational counseling field. Degree candidates are required to complete:

1. A minimum of 21 hours in the area of specialization.
2. Three to six hours in field training at the level of specialization.
3. Three to six hours in statistics, research techniques or in a field related to the area of specialization.

A major in reading is offered for reading specialists, consultants and/or supervisors. The 36 semester hours are prescribed by the Department of Elementary and Secondary Education.

A major in secondary education is offered to high school or prospective junior college teachers in the subject areas of English, history and government, mathematics, and natural sciences. Candidates are required to complete at least 12 and not more than 18 hours in education and a minimum of 18 hours in the area of specialization.

The Educational Specialist degree program in school administration

consists of 30 semester hours beyond the master's degree which must be selected from five areas as prescribed by the Department of Elementary and Secondary Education. Admission requirements include a master's degree and an administrator's certificate.

- ED 601 THE COMMUNITY COLLEGE  
3 cr. (3 and 0)
- ED 606 HISTORY AND PHILOSOPHY OF EDUCATION  
3 cr. (3 and 0)
- ED 629 TEACHER AS MANAGER  
3 cr. (3 and 0)
- ED 631 SPECIAL INSTITUTE COURSE: EARLY CHILDHOOD EDUCATION  
3 cr. (3 and 0)
- ED 632 SPECIAL INSTITUTE COURSE: ELEMENTARY SCHOOL  
3 cr. (3 and 0)
- ED 633 SPECIAL INSTITUTE COURSE: SECONDARY SCHOOL  
3 cr. (3 and 0)
- ED 634 SPECIAL INSTITUTE COURSE: CURRENT PROBLEMS  
IN EDUCATION  
3 cr. (3 and 0)
- ED 635 SPECIAL INSTITUTE COURSE: CURRICULUM  
3 cr. (3 and 0)
- ED 636 SPECIAL INSTITUTE COURSE: SUPERVISION AND  
ADMINISTRATION  
3 cr. (3 and 0)
- ED 669 CHARACTERISTICS OF CHILDREN WITH EMOTIONAL  
HANDICAPS  
3 cr. (3 and 0)
- ED 670 CHARACTERISTICS OF CHILDREN WITH LEARNING  
DISABILITIES  
3 cr. (3 and 0)
- ED 671 THE EXCEPTIONAL CHILD  
3 cr. (3 and 0)
- ED 672 PSYCHOLOGY OF MENTAL RETARDATION  
3 cr. (3 and 0)
- ED 673 TEACHING THE MENTALLY RETARDED  
3 cr. (3 and 0)
- ED 674 EDUCATIONAL PROCEDURES FOR CHILDREN WITH  
EMOTIONAL HANDICAPS  
3 cr. (3 and 0)

- ED 675 EDUCATIONAL PROCEDURES FOR CHILDREN WITH LEARNING DISABILITIES  
3 cr. (3 and 0)
- ED 676 PRACTICUM IN LEARNING DISABILITIES  
3 cr. (2 and 3)
- ED 677 CHARACTERISTICS OF CHILDREN WHO ARE GIFTED  
3 cr. (3 and 0)
- ED 678 PRACTICUM IN EMOTIONALLY HANDICAPPED  
3 cr. (2 and 3)
- ED 679 PRACTICUM IN MENTALLY RETARDED  
3 cr. (2 and 3)
- ED 697 AUDIO VISUAL AIDS IN EDUCATION  
3 cr. (3 and 0)
- ED 705 PRINCIPLES OF GUIDANCE  
3 cr. (3 and 0)  
Principles, procedures, and policies of guidance programs in school and community settings.
- ED 707 READING AND INDEPENDENT STUDY IN EDUCATION  
3 cr. (3 and 0)  
Individualized, in-depth study of a particular topic not offered in other courses. Reading, research and independent study are supervised by a faculty member.  
**Prerequisite:** Permission of instructor.
- ED 720 SCHOOL PERSONNEL ADMINISTRATION  
3 cr. (3 and 0)  
School personnel selection, practices, and problems. **Prerequisites:** One administration course and three other graduate courses in education.
- ED 721 LEGAL PHASES OF SCHOOL ADMINISTRATION  
3 cr. (3 and 0)  
Legal principles involved in school administration and in court actions. **Prerequisites:** One administration course and three other graduate courses in education.
- ED 722 FIELD EXPERIENCES IN SCHOOL ADMINISTRATION AND SUPERVISION  
3 cr. (2 and 3)  
Practicum with an experienced administrator or supervisor. **Prerequisites:** One administration course and three graduate courses in education.
- ED 740 CURRICULUM PLANNING FOR EARLY CHILDHOOD EDUCATION  
3 cr. (3 and 0)  
Introduction to early childhood education (ages five through eight), the nature of learning and its bearing upon curriculum, and early childhood curriculum content.  
**Prerequisite:** Permission of instructor.

- ED 741 INTRODUCTION TO PUPIL PERSONNEL SERVICES IN HIGHER EDUCATION  
3 cr. (3 and 0)  
Pupil personnel services offered by institutions of higher education.
- ED 742 PSYCHOLOGY OF POST SECONDARY SCHOOL YOUTH  
3 cr. (3 and 0)  
Developmental aspects of young adult age group and its relationship to post secondary schools and training programs.
- ED 759 FUNDAMENTALS OF BASIC READING  
3 cr. (3 and 0)  
Historical progression of the teaching of reading; current theories and reading practices; teaching basic reading skills.
- ED 760 CURRICULUM DEVELOPMENT IN THE ELEMENTARY SCHOOL  
3 cr. (3 and 0)  
Curriculum planning practices in the elementary school.
- ED 761 READING INSTRUCTION IN THE ELEMENTARY SCHOOL  
3 cr. (3 and 0)  
Knowledge and skills necessary for teaching reading to varied types of elementary school learners.
- ED 762 READING DIAGNOSIS AND REMEDIATION  
3 cr. (2 and 3)  
Remedial methods and materials for teaching reading; use of diagnostic instruments and interpretation of test results. Student participates in laboratory/field experience and prepares case study with summary of diagnosis, emphasizing remediation procedures. **Prerequisite:** Three semester hours in reading or permission of instructor.
- ED 763 MIDDLE SCHOOL READING  
3 cr. (3 and 0)  
Techniques, materials and theories for teaching reading to middle school students emphasizing correlating reading skills into the content area. **Prerequisite:** Education major or permission of instructor.
- ED 764 THE ROLE OF THE LIBRARY IN THE READING PROGRAM  
3 cr. (3 and 0)  
Prepares librarians to work with teachers and pupils, and prepares teachers to work with librarians and pupils in the reading program. **Prerequisite:** Employment as a teacher or librarian and/or permission of instructor.
- ED 765 SECONDARY SCHOOL CURRICULUM  
3 cr. (3 and 0)  
Principles, techniques, and trends in secondary school curriculum development and evaluation.
- ED 794 SCHOOL AND COMMUNITY RELATIONSHIPS  
3 cr. (3 and 0)  
Interdependence of school and community; identifying and defining societal

expectations of schools and effect of these expectations on educational policy; impact of social, political, economic, and demographic change on educational policy.

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

Methods and materials for secondary reading programs in the following areas: developmental, corrective, remedial, adapted, content area, and recreational.

ED 801 SEMINAR IN HUMAN GROWTH AND DEVELOPMENT  
3 cr. (3 and 0)

Theory and research in human development. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

ED 802 HUMAN DEVELOPMENT: PSYCHOLOGY OF LEARNING  
3 cr. (3 and 0)

Major theories of learning processes applied to human education. Student conducts experiments in learning theory. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

ED 803 ADVANCED METHODS OF TEACHING IN THE  
SECONDARY SCHOOL  
3 cr. (3 and 0)

Principles and practices involved in promoting effective learning in secondary schools.

ED 804 ADVANCED METHODS OF TEACHING IN THE ELEMENTARY  
SCHOOL  
3 cr. (3 and 0)

Principles and practices involved in promoting effective learning in elementary schools; analysis and evaluation of educational media.

ED 808 EDUCATIONAL TESTS AND MEASUREMENT  
3 cr. (3 and 0) S

Construction, use and interpretation of subjective and standardized tests; measurement applications.

ED 809 ANALYSIS OF THE INDIVIDUAL  
3 cr. (3 and 0)

Experience in gathering, interpreting and utilizing data as it relates to the individual. Especially significant to counselors. **Prerequisite:** ED 808.

ED 810 THEORIES AND TECHNIQUES OF COUNSELING  
3 cr. (3 and 0)

Counseling theories and techniques. **Prerequisite:** ED 705 or permission of instructor.

ED 811 SCHOOL FINANCE  
3 cr. (3 and 0)

School finance relative to programs, revenues and experience.

ED 812 THE COUNSELOR AS CONSULTANT  
3 cr. (2 and 2)

Rationale, content and consultation process in school and non-school settings; study of and practice in various consulting activities. **Prerequisite:** ED 810 or 817 or permission of instructor.

**ED 813 EDUCATIONAL AND VOCATIONAL INFORMATIONAL SERVICE AND PLACEMENT**

3 cr. (3 and 0)

Gathering, interpreting and utilizing educational, social and occupational information; techniques used in placement, survey and follow-up.

**ED 814 FIELD EXPERIENCES IN ELEMENTARY SCHOOL GUIDANCE**

3 cr. (2 and 3)

Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those seeking certification on elementary school level. **Prerequisite:** ED 810 and permission of instructor.

**ED 815 FIELD EXPERIENCES IN SECONDARY SCHOOL GUIDANCE**

3 cr. (2 and 3)

Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those seeking certification on secondary school level. **Prerequisite:** ED 810 and permission of instructor.

**ED 816 FIELD EXPERIENCES IN PERSONNEL SERVICES IN HIGHER EDUCATION**

3 cr. (2 and 3)

Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those entering field of higher education. **Prerequisite:** ED 810 and permission of instructor.

**ED 817 DEVELOPMENT OF COUNSELING SKILLS**

3 cr. (3 and 0)

On-campus experience to help counselors develop communication skills through role-playing activities, audio and video taping, interviewing, lecture and discussion. **Prerequisite or Co-requisite:** ED 810.

**ED 818 FIELD PROBLEMS IN SCHOOL ADMINISTRATION AND SUPERVISION OF INSTRUCTION**

3 cr. (2 and 3)

Application of research techniques and practices in solution of field problems in school administration and supervision.

**ED 819 PSYCHOEDUCATIONAL EVALUATION INTERNSHIP**

3 cr. (0 and 6)

Internship in psychoeducational evaluation and counseling experiences with students in primary and elementary grades; consulting experiences with parents and teachers under supervision of school psychologists of Department of Elementary and Secondary Education. Open only to those seeking certification as elementary counselors or evaluators. **Prerequisite:** Permission of instructor.

**ED 820 TEACHING LANGUAGE ARTS TO THE EXCEPTIONAL CHILD**

3 cr. (3 and 0)

Various approaches to teaching listening, writing, reading and speaking skills to the exceptional child.

- ED 821      **ASSESSMENT OF THE EXCEPTIONAL CHILD**  
3 cr. (3 and 0)  
Interpreting psychological reports, writing educational prescriptions, administering selected tests, and designing informal tests. **Prerequisites:** ED 471/671 and sequence of ED 472/672 and 473/673; or ED 469/669 and 474/674; or ED 470/670 and 475/675; or permission of instructor.
- ED 822      **TEACHING MATHEMATICS TO THE EXCEPTIONAL CHILD**  
3 cr. (3 and 0)  
Various approaches to teaching mathematics to the exceptional child.
- ED 823      **MAINSTREAMING THE HANDICAPPED**  
3 cr. (3 and 0)  
Needs of the handicapped and instructional strategies for accommodating exceptional children in the mainstream. For regular classroom teachers and administrators. **Prerequisite:** Permission of instructor.
- ED 830      **TECHNIQUES OF SUPERVISION — THE PUBLIC SCHOOLS**  
3 cr. (3 and 0)  
Improving, coordinating and evaluating instruction; modern trends of supervisory practices.
- ED 831      **EVALUATION OF SECONDARY SCHOOL INSTRUCTION**  
3 cr. (3 and 0)  
Techniques of determining effectiveness of classroom instruction emphasizing curriculum.
- ED 832      **EVALUATION OF INSTRUCTION IN THE ELEMENTARY SCHOOL**  
3 cr. (3 and 0)  
Determination of effectiveness of instructional techniques and programs in terms of predetermined objectives.
- ED 840      **PROGRAM DEVELOPMENT AND IMPLEMENTATION  
IN EARLY CHILDHOOD EDUCATION**  
3 cr. (2 and 2)  
Early childhood education program goals, curriculum sources and beliefs supporting them. Students will develop a modified curriculum for a specific area and level. For advanced graduate students with teaching experience. **Prerequisites:** ED 740 and 801, relevant teaching experience or permission of instructor.
- ED 850      **PUBLIC SCHOOL ADMINISTRATION**  
3 cr. (3 and 0)  
Theoretical bases of school administration; organizational principles, patterns and practices in public schools; decision-making; administration of programs and services. **Prerequisite:** Three graduate education courses or permission of instructor.
- ED 853      **ADMINISTRATION AND SUPERVISION OF SPECIAL EDUCATION**  
3 cr. (3 and 0)  
Administrative and supervisory practices in initiating, maintaining and expanding special education programs. Especially for principals, supervisors, and directors of instruction. **Prerequisite:** ED 471/671 or permission of instructor.

- ED 856            INTRODUCTION TO SCHOOL BUILDING PLANNING  
3 cr. (2 and 2)  
Planning of educational facilities from conception of need through utilization of facility. **Prerequisite:** ED 850 or equivalent.
- ED 861            ORGANIZATION AND SUPERVISION OF READING PROGRAMS  
3 cr. (3 and 0)  
Supervisory problems with planning reading programs; analysis of methods and materials of teaching; evaluation of reading programs. **Prerequisite:** ED 762.
- ED 862            CLINICAL RESEARCH IN READING  
3 cr. (3 and 0)  
Reading research and literature. Original investigation in such problems as development of reading skills and attitudes, clinical procedures and techniques required. **Prerequisite:** ED 762.
- ED 863            PRACTICUM IN READING  
3 cr. (2 and 2)  
Supervised practicum emphasizing diagnostic and remedial work with readers in public schools. **Prerequisites:** ED 762 and permission of instructor.
- ED 864            SPECIAL PROBLEMS IN READING EDUCATION  
3 cr. (1 and 4)  
Individual study of a specific topic in reading. Student will be allowed to study a large diversity of topics. **Prerequisites:** ED 759 or 761, and ED 762, 808 and 862, or permission of instructor.
- ED 865            ADVANCED DIAGNOSIS AND REMEDIATION IN READING  
3 cr. (2 and 3)  
Advanced diagnosis and remediation in reading; review of diagnostic instruments and instructional materials. **Prerequisites:** ED 759 or 761, and ED 762, or permission of instructor.
- ED 866            THE PSYCHOLOGY OF TEACHING READING  
3 cr. (3 and 0)  
Psychological basis of reading process; principles applied in teaching reading. **Prerequisites:** ED 759 or 761 or permission of instructor.
- ED 867            ADVANCED PRACTICUM IN READING  
3 cr. (2 and 3)  
Diagnosis and remediation testing; remediation. Extensive case studies with recommendation for the classroom teacher required. **Prerequisites:** ED 865 and permission of instructor.
- ED 871            INTERPERSONAL AND GROUP RELATIONSHIPS  
3 cr. (3 and 0)  
Human relations, staff interaction, informal and small group processes, supervisor-teacher counseling, conducting group meetings, staff participation in decision-making, creating a climate conducive to change and success, human motivation.
- ED 881            INDIVIDUAL TESTING  
3 cr. (3 and 0)



Interpretation of Wechsler scales with supervised practice in their administration.  
**Prerequisites:** ED 801, 802, 808, 809 and permission of instructor.

*The following courses are applicable only to the Master of Education degree with emphasis in the specific subject areas. Complete descriptions are found in the sections for the College of Agricultural Sciences, the College of Liberal Arts, the College of Industrial Management and Textile Science, and the College of Sciences.*

#### History and Government

**J. W. Johnson, Advisor**

- ENGL 751 CHILDREN'S LITERATURE FOR TEACHERS  
3 cr. (3 and 0)
- ENGL 761 ENGLISH LITERATURE FOR TEACHERS I  
3 cr. (3 and 0)

#### History and Government

**R. P. Leemhuis, Advisor**

- HIST 715 HISTORY OF THE BLACK AMERICAN  
3 cr. (3 and 0)
- HIST 719 UNITED STATES HISTORY SINCE 1900  
3 cr. (3 and 0)
- HIST 732 MODERNIZATION OF EAST ASIA  
3 cr. (3 and 0)
- HIST 741 COMPARATIVE HISTORY OF THE AMERICAS  
3 cr. (3 and 0)
- ECON 750 ECONOMIC CONCEPTS AND CLASSROOM APPLICATIONS  
FOR TEACHERS  
3 cr. (3 and 0)
- ECON 751 CURRENT ISSUES IN ECONOMICS FOR TEACHERS  
3 cr. (3 and 0)

#### Mathematics

**J. L. Flatt, Advisor**

- MTH SC 701 NUMBER SYSTEMS FOR THE ELEMENTARY GRADES  
3 cr. (3 and 0)
- MTH SC 702 NUMBER SYSTEMS FOR THE MIDDLE GRADES  
3 cr. (3 and 0)
- MTH SC 703 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL  
TEACHERS — GEOMETRY  
3 cr. (3 and 0)
- MTH SC 705 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL  
TEACHERS — ALGEBRA, PROBABILITY, AND STATISTICS  
3 cr. (3 and 0)
- MTH SC 710 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT  
3 cr. (3 and 0)

- MTH SC 712 MODERN ALGEBRAIC CONCEPTS  
3 cr. (3 and 0)
- MTH SC 721 MATRIX ALGEBRA I  
3 cr. (3 and 0)
- MTH SC 722 MATRIX ALGEBRA II  
3 cr. (3 and 0)
- MTH SC 725 COMBINATORIAL MATHEMATICS FOR TEACHERS  
3 cr. (3 and 0)
- MTH SC 730 MODERN GEOMETRY FOR TEACHERS  
3 cr. (3 and 0)
- MTH SC 731 NON-EUCLIDEAN GEOMETRY  
3 cr. (3 and 0)
- MTH SC 732 PROJECTIVE GEOMETRY  
3 cr. (3 and 0)
- MTH SC 741 INTRODUCTION TO LINEAR PROGRAMMING WITH APPLICATIONS  
3 cr. (3 and 0)
- MTH SC 751 FUNDAMENTAL CONCEPTS OF CALCULUS I  
3 cr. (3 and 0)
- MTH SC 752 FUNDAMENTAL CONCEPTS OF CALCULUS II  
3 cr. (3 and 0)
- MTH SC 761 PROBABILITY AND STATISTICS  
3 cr. (3 and 0)
- MTH SC 771 NUMERICAL METHODS IN SECONDARY MATHEMATICS I  
3 cr. (3 and 0)
- MTH SC 772 NUMERICAL METHODS IN SECONDARY MATHEMATICS II  
3 cr. (3 and 0)
- MTH SC 781 HISTORY OF MATHEMATICS  
3 cr. (3 and 0)
- MTH SC 783 THEORY OF NUMBERS  
3 cr. (3 and 0)
- MTH SC 791 MATHEMATICAL PROBLEMS IN THE CURRICULUM  
3 cr. (3 and 0)

**Natural Sciences****T. M. McInnis, Advisor**

- ASTR 701 SOLAR SYSTEM ASTRONOMY FOR HIGH SCHOOL TEACHERS  
3 cr. (3 and 0)

- ASTR 711 STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS  
3 cr. (3 and 0)
- BOT 701 EVOLUTIONARY BOTANY FOR TEACHERS  
3 cr. (2 and 3)
- BOT 702 MODERN BOTANICAL CONCEPTS FOR TEACHERS  
3 cr. (3 and 0)
- CH 700 PHYSICAL SCIENCE IN THE ELEMENTARY  
SCHOOL — CHEMISTRY  
3 cr. (2 and 3)
- CH 701 REVIEW OF GENERAL CHEMISTRY I  
3 cr. (3 and 0)
- CH 702 CHEMISTRY FOR HIGH SCHOOL TEACHERS  
3 cr. (2 and 3)
- CH 703 SPECIAL PROBLEMS IN CHEMISTRY FOR ELEMENTARY  
AND SECONDARY SCHOOL TEACHERS  
3-6 cr. (2-6 and 6-0)
- GEN 701 MODERN DEVELOPMENTS IN GENETICS  
3 cr. (3 and 0)
- GEOL 700 EARTH SCIENCE I  
3 cr. (2 and 3)
- GEOL 750 EARTH SCIENCE II  
3 cr. (2 and 3)
- NUTR 706 NUTRITION FOR TEACHERS  
3 cr. (3 and 0)
- PHYS 700 PHYSICAL SCIENCE IN ELEMENTARY SCHOOL — PHYSICS  
3 cr. (3 and 0)
- PHYS 703 MODERN PHYSICS FOR HIGH SCHOOL TEACHERS  
3 cr. (3 and 0)
- PHYS 716 EXPERIMENTAL PHYSICS FOR HIGH SCHOOL  
TEACHERS  
4 cr. (2 and 4)
- PHYS 723 WEATHER SCIENCE FOR SCIENCE TEACHERS  
3 cr. (3 and 0)
- ZOOL 701 MAN'S IMPACT ON ECOLOGY  
3 cr. (3 and 0)

**INDUSTRIAL EDUCATION**

A. F. Newton, Head, Department of Industrial Education

**Major**  
Industrial Education

**Degree**  
M.In.Ed.

The Master of Industrial Education degree allows for specialization in four areas: industrial arts education, vocational-technical education, administration and supervision for the two-year college, and education for industry.

Sufficient flexibility is permitted to structure each student's plan of study to meet the objectives for any of the four areas of specialization listed above. The industrial arts area is designed to improve competencies in teaching industrial arts, pre-vocational, and career education. Persons desiring to improve their competencies in teaching and administering vocational or technical subjects in secondary or post-secondary institutions will specialize in the vocational-technical area. The education for industry area is designed to prepare training directors, educational specialists, training coordinators and personnel for other occupations in industry which are related to education. The program in administration and supervision for the two-year college is specifically designed for persons preparing for administrative or supervisory positions in the technical colleges.

In addition to the general requirements for admission to the Graduate School, departmental requirements for admission to each of the areas of specialization are as follows:

1. Industrial arts education applicants must hold or meet the minimum requirements for an industrial arts teacher's certificate.
2. Vocational-technical education applicants must hold or meet the minimum requirements for a trade and industrial teacher's certificate, or show vocational or technical competence through training, work experience, or proficiency test results.
3. The program in administration and supervision for the two-year college requires the applicant to show evidence of competency in a teaching area, or to have a minimum of 24 semester hours of courses appropriate to the vocational or technical program to be administered or supervised.
4. The education for industry program requires a minimum of 24 hours of undergraduate courses appropriate to the occupation or industry the applicant desires to enter.

Candidates for the Master of Industrial Education degree are required to complete:

1. Eighteen hours in subjects which contribute to the student's technical, administrative, and/or supervisory competence.
2. Six hours in research or six hours in special problems.
3. Six to twelve hours must be taken outside the major department.

- ED 608 TRAINING PROGRAMS IN INDUSTRY  
3 cr. (3 and 0)
- ED 610 SPECIAL INSTITUTE COURSE: TOPICS IN INDUSTRIAL EDUCATION  
1-3 cr. (1-3 and 0)
- ED 614 ELECTRONICS FOR TEACHERS  
3 cr. (1 and 6)
- ED 615 CONSTRUCTION PRACTICES  
3 cr. (2 and 3)
- ED 618 TECHNOLOGICAL CONCEPTS IN MANUFACTURING  
3 cr. (2 and 3)
- ED 622 HISTORY AND PHILOSOPHY OF INDUSTRIAL AND VOCATIONAL EDUCATION  
3 cr. (3 and 0)
- ED 624 SCHOOL SAFETY  
3 cr. (3 and 0)
- ED 625 TEACHING INDUSTRIAL SUBJECTS  
3 cr. (3 and 0)
- ED 632 ADVANCED WOODWORKING  
2 cr. (1 and 3)
- ED 635 ADVANCED INDUSTRIAL METALWORKING PRACTICES  
3 cr. (2 and 3)
- ED 638 ADVANCED MACHINING  
3 cr. (1 and 6)
- ED 640 ADVANCED TECHNIQUES OF THE GRAPHIC ARTS  
4 cr. (2 and 4)
- ED 644 GRAPHIC ARTS PRODUCTION CONTROL  
3 cr. (2 and 3)
- ED 652 ADVANCED PROJECTS  
1-6 cr. (0 and 3-18)
- ED 660 INTRODUCTION TO CAREER EDUCATION  
3 cr. (3 and 0)
- ED 664 STILL PICTURE PRODUCTION  
3 cr. (1 and 4)
- ED 665 MOTION PICTURE PRODUCTION  
3 cr. (1 and 4)
- ED 696 PUBLIC RELATIONS  
3 cr. (3 and 0)

## IN ED 815 SEMINAR IN INDUSTRIAL EDUCATION

1 cr. (1 and 0)

Students and faculty discuss and study new technological and professional advances. May be taken up to three times.

## IN ED 820 RECENT PROCESS DEVELOPMENTS

3 cr. (3 and 0)

New developments in production processes; ultrasonic and electrical discharge machining, high energy rate forming, precision casting methods, recent joining techniques.

## IN ED 840 SCHOOL SHOP DESIGN

3 cr. (3 and 0)

All aspects of unit shops, general shops and comprehensive shops for schools offering vocational industrial subjects and industrial arts courses.

## IN ED 845 CURRICULUM PLANNING AND DEVELOPMENT IN INDUSTRIAL EDUCATION

3 cr. (3 and 0)

Curriculum construction, departmental coordination of subject matter with other school subjects, curriculum modification, staff organization in curriculum development, selection and organization of course materials.

## IN ED 860 CURRICULUM MATERIALS DEVELOPMENT IN INDUSTRIAL EDUCATION

3 cr. (3 and 0)

Developing instructional materials and laboratory activities appropriate to learning and reinforcing concepts taught in industrial education. For industrial arts and vocational-technical education majors.

## IN ED 861 ADMINISTRATION AND SUPERVISION OF VOCATIONAL EDUCATION

3 cr. (3 and 0)

Principles and practices of administering and supervising various types of schools and classes under Federal vocational acts and state regulations.

## IN ED 865 AMERICAN INDUSTRIES

3 cr. (3 and 0)

Concepts and principles of American industry and technology; identification of content of industrial arts courses taught in public schools. Fifteen plant visits supplement study of industrial organization, economics, management, production, and products.

## IN ED 894 PROJECT RESEARCH

1-6 cr. (1-6 and 0)

Research related to departmental projects. (Open only to students planning to pursue advanced graduate study. Joint use with IN ED 895, 896 not permitted for degree.)

## IN ED 895 SPECIAL PROBLEMS I

3 cr. (3 and 0)

Special problems in industrial education varying with interests, experiences, and needs of students.

## IN ED 896 SPECIAL PROBLEMS II

3 cr. (3 and 0)

Continuation of IN ED 895.

**VOCATIONAL/TECHNICAL EDUCATION**

H. F. Landrith, Program Coordinator, College of Education

**Major**Vocational/Technical  
Education**Degree**

Ed.D.

The Doctor of Education degree in vocational and technical education prepares graduates for leadership positions in the profession. Curricula are designed for vocationally and technically oriented personnel in colleges, universities and public schools.

Areas of specialization are available in the following fields:

- Administration — Technical colleges and public schools.
- Curriculum and Instruction — Technical colleges and public schools. Emphasis is on curriculum development, materials and instructional technologies.
- Guidance — Technical colleges, public schools, vocational.
- Teaching — Technical colleges and public schools. Teaching areas in most fields taught at Clemson University.

An applicant for the Ed.D. degree must hold bachelor's and master's degrees from approved colleges and must have completed a minimum of three years of successful experience appropriate to his/her proposed field of professional service. (This requirement may be waived for admission, but the applicant cannot become a candidate for the degree until the requirement is met.)

The Ed.D. program consists of graduate course work in vocational and technical foundations, statistics and research; advanced study and an internship in an appropriate field of professional services; and a dissertation.

## VT ED 710 FOUNDATIONS OF VOCATIONAL AND TECHNICAL EDUCATION

3 cr. (3 and 0)

Evolution of vocational and technical education during the twentieth century and current trends; sociological, psychological and philosophical theories underlying current objectives; definition of broad parameters of the field.

## VT ED 733 CURRICULUM CONSTRUCTION IN VOCATIONAL AND TECHNICAL EDUCATION

3 cr. (3 and 0)

Students develop a specific course in a selected vocational and technical education area by specifying performance goals and building around these objectives. **Prerequisite:** AG ED 665 or IN ED 605 or equivalent.

## VT ED 735 APPLICATION OF INSTRUCTIONAL TECHNOLOGY

3 cr. (3 and 0)

Developing and managing programs of instructional technologies for higher education, public schools and industrial training. **Prerequisite:** Basic course or experience in audio visual media.

VT ED 760 PROGRAMS, CONCEPTS AND ISSUES IN VOCATIONAL AND TECHNICAL EDUCATION  
3 cr. (3 and 0)

Current activities and debates in vocational and technical education; traditional and innovative programs, career education, school finance, disadvantaged students, handicapped youth, sex equality and other specialized programs.

VT ED 761 ADMINISTRATION AND SUPERVISION IN VOCATIONAL AND TECHNICAL EDUCATION  
3 cr. (3 and 0)

Principles and practices for administering and supervising vocational and technical schools and classes under federal vocational acts, state regulations and local policies. **Prerequisite:** VT ED 710 or permission of instructor.

VT ED 763 IN-SERVICE AND CONTINUING EDUCATION  
3 cr. (3 and 0)

Information and skills for developing and administering in-service and continuing education programs. **Prerequisite:** Permission of instructor.

VT ED 812 VOCATIONAL AND TECHNICAL PROGRAM FINANCE  
3 cr. (3 and 0)

National, state and local legislation governing financial support of vocational/technical programs. Students develop budget, audit and financial administrative plans and systems. **Prerequisites:** VT ED 710 and ED 811 or equivalent.

VT ED 876 COLLEGE TEACHING  
3 cr. (3 and 0)

Instructional practices, curriculum, techniques of organizing and planning learning experiences, analysis of teaching strategies and systems.

VT ED 882 SEMINAR  
1 cr. (1 and 0)

Current issues and problems and proposed research projects.





ENGINEERING

# College Of Engineering

- AGRICULTURAL ENGINEERING
- BIOENGINEERING
- CERAMIC ENGINEERING
- CHEMICAL ENGINEERING
- CIVIL ENGINEERING
- COMPUTER ENGINEERING
- ELECTRICAL ENGINEERING
- ENGINEERING MECHANICS
- ENVIRONMENTAL SYSTEMS ENGINEERING
- MATERIALS ENGINEERING
- MECHANICAL ENGINEERING
- SYSTEMS ENGINEERING



## AGRICULTURAL ENGINEERING

B. K. Webb, Head, Department of Agricultural Engineering

Major

Agricultural Engineering

M.Engr., M.S., Ph.D.

Graduate programs in agricultural engineering are designed to prepare the individual for leadership, creative accomplishment and continued

\*Jointly administered by the College of Engineering and the College of Agricultural Sciences. The M.Engr., M.S., and Ph.D. degrees are awarded by the College of Engineering.



## COLLEGE OF ENGINEERING

J. C. Jennett, Dean

The College of Engineering awards advanced degrees in the following areas of study:

Agricultural Engineering*	Electrical Engineering
Bioengineering	Engineering Mechanics
Ceramic Engineering	Environmental Systems Engineering
Chemical Engineering	Materials Engineering
Civil Engineering	Mechanical Engineering
Computer Engineering	Systems Engineering

Degrees offered are the Master of Engineering, Master of Science and Doctor of Philosophy. Precise offerings in each area are found in the individual departmental or program descriptions.

The M.S. and Ph.D. programs serve for the most part on-campus graduate students. Industrial Residency Programs leading to the Master of Science degree are also available in certain departments. Financial aid for students studying for these degrees is often available from the many sponsored research grants and contracts, notably in the areas of energy, environmental studies, micro-electronics and microprocessors, computer systems, polymers, and many more. These are all administered by the College of Engineering. Other on-campus graduate students work as teaching assistants.

The Master of Engineering program is open to individuals both on and off campus who have baccalaureate degrees from ABET accredited engineering programs or their equivalent, have academic and professional records which indicate motivation for and the ability to complete additional professional study, and are accepted by the head of the department in which they plan to major and by the dean of the College of Engineering. Details including complete admissions, program and graduation requirements may be obtained from the dean of Engineering.

The College offers cooperative graduate programs with industry in which semesters of on-campus study are alternated with work assignments in industry.

### AGRICULTURAL ENGINEERING

B. K. Webb, Head, Department of Agricultural Engineering

Major	Degrees
Agricultural Engineering	M.Engr., M.S., Ph.D.

Graduate programs in agricultural engineering are designed to prepare the individual for leadership, creative accomplishment and continued

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professional learning, and to qualify the student to conduct independent scientific research.

Each degree program is planned individually to augment the student's previous engineering and science background with adequate breadth in engineering and specialization in an area of agricultural engineering. Course work, in addition to agricultural engineering, consists of mathematics, physics, chemistry, statistics, biological science, and selected engineering sciences.

- AG E 616      AGRICULTURAL MACHINERY DESIGN  
3 cr. (2 and 3) S
- AG E 622      SOIL AND WATER RESOURCES ENGINEERING II  
3 cr. (2 and 3) S
- AG E 631      AGRICULTURAL STRUCTURES DESIGN  
3 cr. (2 and 3) F
- AG E 633      DESIGN CRITERIA FOR PLANT AND ANIMAL ENVIRONMENT  
2 cr. (2 and 0) S
- AG E 642      AGRICULTURAL PROCESS ENGINEERING  
3 cr. (2 and 3) S
- AG E 665      ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS  
2 cr. (1 and 3) S
- AG E 781      SPECIAL PROBLEMS  
1-3 cr.

Student selects subject and conducts library, laboratory and/or field research; technical report documenting study required; may be repeated for maximum of six credits. For Master of Engineering degree candidates only.

- AG E 811      TILLAGE AND SOIL DYNAMICS  
3 cr. (3 and 0)

Physical and dynamic properties of soil related to actions of tillage tools, tractive vehicles and plant growth and development; soil strength parameters, seedling environment and emergence, mechanics of tillage implements, soil compaction causes and effects, tractive efforts of wheel and track-type vehicles and off-the-road locomotion. **Prerequisite:** AG E 416/616 or equivalent.

- AG E 822      WATER MOVEMENT IN SOILS  
3 cr. (3 and 0) F

Theory and principles of water movement in soils; theory and application of flow of water through soil in unsaturated and saturated states, flow nets and seepage forces, and fundamentals of engineering design with respect to ground water problems and soil moisture relationships. **Prerequisite:** MTH SC 208 or equivalent.

- AG E 865      HEAT AND MOISTURE TRANSFER IN BIOLOGICAL MATERIALS  
3 cr. (3 and 0) S

Heat and moisture diffusion in biological materials; criteria for selecting proper

operational mathematics to solve certain boundary value problems; integral transforms of Laplace, Fourier, and Hankel applied to various geometric configurations; influence of respiration heat and transpiration moisture production. **Prerequisites:** MTH SC 453/653 or 457/657, or permission of instructor.

**AG E 871      SELECTED TOPICS IN AGRICULTURAL ENGINEERING**  
1-3 cr. (1-3 and 0)

Supervised, in-depth study of an area not covered in other courses. Performance measured by oral and written reports and/or by examination; may be repeated for a maximum of six credits.

**AG E 882      SYSTEMS ENGINEERING**  
3 cr. (2 and 3) F

Systems analysis methods applied to engineering of agricultural operations; activity network analysis, critical path method, PERT, linear programming, modeling, simulation, linear systems analysis, application of digital computation in analysis of complex systems.

**AG E 891      MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**AG E 901      SPECIAL PROBLEMS IN AGRICULTURAL ENGINEERING**  
3 cr. (3 and 0)

Library and/or laboratory research on one of the following subjects, depending on student's field of study or interests: power and machinery, soil and water resources, farm structures, electric power and processing, food engineering, forest engineering, or waste management. Technical report required.

**AG E 991      DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

**BIOENGINEERING**

F. W. Cooke, Head, Department of Interdisciplinary Studies

<b>Major</b>	<b>Degrees</b>
Bioengineering	M.S., Ph.D.

The bioengineering program is devoted to the application of engineering science, methods and techniques to problems ranging from basic bio-medical research to applied health care delivery. The principal areas of concentration are biomaterials and biomechanics, systems physiology, medical computing and clinical (hospital) engineering. The traditionally strong emphasis in the areas of materials and mechanics is directed toward the development of materials and devices (including artificial organs) for surgical implantation. Systems physiology is concerned with analyzing the complex of physical, chemical and biological processes that constitute living systems. Heavy reliance is placed on computer assisted modeling, direct laboratory experience and bioinstrumentation. The clinical engineering effort is designed to prepare master's candidates to deal directly with the many facets of modern medical technology, especially computers, which are encountered in hospitals.

The faculty is augmented by six adjunct medical faculty, and many research programs are conducted in collaboration with leading institutions for clinical or research medicine. All students have some direct experience with an appropriate aspect of this medical involvement.

Students enrolling in this program usually have a strong background in one of the more traditional engineering disciplines such as materials, engineering mechanics, mechanical engineering, electrical engineering or chemical engineering. Some background in general biology and physiology is recommended but is not a prerequisite. Students with degrees in science may also be considered for admission if they can demonstrate proficiency in certain prescribed engineering courses.

Candidates are allowed wide flexibility in planning their program but are encouraged to seek advice and direction from the faculty because of the rapid evolution of this emerging discipline.

**BIO E 601 COMPUTERS FOR BIOSCIENTISTS**

1 cr. (1 and 0)

**BIO E 602 MEDICAL APPLICATIONS OF ENGINEERING SCIENCE**

3 cr. (3 and 0)

**BIO E 615 DENTAL MATERIALS**

2 cr. (2 and 0)

**BIO E 650 SPECIAL TOPICS IN BIOMEDICAL ENGINEERING**

1-4 cr.

**BIO E 800 SEMINAR IN BIOMEDICAL ENGINEERING RESEARCH**

1 cr. (1 and 0)

Special topics and original research in biomedical engineering. Credit may be earned for more than one semester.

**BIO E 801 BIOMATERIALS**

3 cr. (3 and 0)

Primary and secondary factors determining performance of artificial organs in terms of materials used and design properties for each specific site of implantation. Topics include: metallurgy of stainless steel, cobalt-chromium alloys, dental amalgams, chemistry of medical polymers, physical properties of reinforced structures, ceramic-metallic bonding and corrosion in biological media.

**BIO E 802 RESEARCH TECHNIQUES IN BIOMATERIALS EVALUATION**

3 cr. (1 and 6)

Autoradiography, microradiography, electron beam microprobe, electron microscopy, optical microscopy, ultraviolet fluorescence, immunoelectrophoresis, blood chemistry analysis, urine chemistry analysis; techniques employed in determining compatibility of biomaterials with the physiological environment; research techniques associated with determining thrombogenic characteristics of biomaterials; corrosion and wear of biomaterials. **Prerequisite:** BIO E 801.

**BIO E 803 POLYMERS AS BIOMATERIALS**

3 cr. (3 and 0)

Problems and accomplishments in bioengineering pertaining to utilization of polymeric materials; interactions caused by contact of such compositions with living systems; review of state of the art of this branch of biomaterials; presentation of outlook to an active research area.

**BIO E 820 STRUCTURAL BIOMECHANICS**

3 cr. (3 and 0)

Mechanical functions of the human body treated as an engineering structure and of the devices used to assist and supplement these functions; movement of the musculoskeletal system; locomotion, gait, prehension, lifting, function of artificial limbs, orthopedic prostheses and braces, effect of vibration and impact on the body, mathematical and other models of the body. **Prerequisite:** Permission of instructor.

**BIO E 823 ARTIFICIAL CARDIAC ASSISTANCE AND REPLACEMENT**

2 cr. (2 and 0)

Medical and bioengineering aspects of artificial hearts and cardiac assist devices; physiological and pathological aspects of patients with need for such devices; history of artificial heart development; design aspects of current devices; state of the art in animal experiments and human preliminary trials. **Prerequisites:** BIO E 882 and ZOO 459/659.

**BIO E 846 ELEMENTS OF BIOENGINEERING I**

3 cr. (3 and 0)

Instrumentation for biological systems; signal conditioning, telemetry, impedance measurements, noise; biological materials and mechanics; physiology of cells and tissue, physical properties of tissue, mathematical models of muscular action; nervous system; physiology of central nervous system, information coding, analogs of nerves, EEG, EKG, nerve conduction velocity.

**BIO E 847 ELEMENTS OF BIOENGINEERING II**

4 cr. (4 and 0)

Cardiovascular systems and regulation; physiology of blood, heart, and organ blood flow; properties of blood as a fluid; fluid flow equations; turbulence; pulse propagation; respiration and control of breathing; gas exchange; heart-lung bypass devices; renal function and control; artificial kidney-devices; heat flow and temperature regulation; and mathematical models. **Prerequisite:** ZOO 459/659.

**BIO E 850 SPECIAL TOPICS IN BIOMEDICAL ENGINEERING**

1-4 cr. (0-4 and 12-0)

Directed study of advanced topics in bioengineering intended to develop in-depth areas of particular student interest. Credit may be earned for more than one semester. **Prerequisite:** Permission of instructor.

**BIO E 870 BIOINSTRUMENTATION**

3 cr. (2 and 2)

Concepts and techniques of instrumentation in bioengineering emphasizing effects of instrumentation on the biological system under investigation; transducers and couplers, data conversion, conditioning and transmission; experimental problems in acute and chronic procedures with static and dynamic subjects.

**BIO E 880 APPLIED HEALTH ENGINEERING LABORATORY**  
1 cr. (0 and 3)

Exposure of advanced bioengineering graduate students to the "real world" of the medical community. Trips will be taken to medical facilities so students can see firsthand current types of engineering problems; class projects designed to provide possible solutions to some of these problems. **Prerequisite:** BIO E 847 and permission of instructor.

**BIO E 882 EXPERIMENTAL SURGERY**  
3 cr. (1 and 4)

All phases of experimental surgery including selection of animal models, preparation of animals for surgery, general and special surgical techniques and basic and applied instrumentation. **Prerequisite:** ZOOL 459/659 or equivalent.

**BIO E 890 INTERNSHIP**  
1-5 cr. (0 and 8-40)

Observation and assignment in a medical college, dental college, hospital, veterinary clinic, dental clinic, health service or industrial department. Credits to be arranged. **Prerequisite:** Permission of department head.

**BIO E 891 MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**BIO E 991 DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

*The following courses offered by various departments represent possible electives for the student in bioengineering. Descriptions for all 800-level courses are listed under the respective department headings.*

**AN PH 801 ELECTRON MICROSCOPY OF BIOLOGICAL SPECIMENS**  
3 cr. (1 and 6)

**AN PH 803 CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY**  
4 cr. (3 and 3)

**AN PH 805 PHARMACOLOGY**  
3 cr. (2 and 3)

**BIOCH 606 PHYSIOLOGICAL CHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 608 PHYSIOLOGICAL CHEMISTRY LABORATORY**  
1 cr. (0 and 3)

**BIOCH 623 PRINCIPLES OF BIOCHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 624 PRINCIPLES OF BIOCHEMISTRY**  
3 cr. (3 and 0)

**E&CE 870 BIOSYSTEMS ANALYSIS**  
3 cr. (3 and 0)

MAT E 605	PHYSICAL METALLURGY 3 cr. (3 and 0)
ME 601	DESIGN OF MECHANICAL SYSTEM COMPONENTS 3 cr. (3 and 0)
SE 860	DYNAMIC PROGRAMMING 3 cr. (3 and 0)
ZOOL 658	CELL PHYSIOLOGY 3 cr. (2 and 3)
ZOOL 659	SYSTEMS PHYSIOLOGY 4 cr. (3 and 3)

### CERAMIC ENGINEERING

G. C. Robinson, Head, Department of Ceramic Engineering

<b>Major</b>	<b>Degrees</b>
Ceramic Engineering	M.Engr., M.S.

Enrollment is open to students with baccalaureate degrees in any branch of engineering and to those with degrees in chemistry or physics who have credit for certain prescribed courses in engineering.

Students may direct their program toward traditional fields of ceramic engineering or toward multi-disciplinary fields such as biomedical engineering and systems engineering.

CR E 602	SOLID STATE CERAMICS 3 cr. (3 and 0)
CR E 603	GLASSES 3 cr. (3 and 0)
CR E 604	CERAMIC COATINGS 3 cr. (3 and 0)
CR E 610	ANALYTICAL PROCESSES 3 cr. (2 and 3)
CR E 612	RAW MATERIAL PREPARATION 3 cr. (3 and 0)
CR E 616	ELECTRONIC CERAMICS 3 cr. (3 and 0)
CR E 618	PROCESS CONTROL 3 cr. (3 and 0)
CR E 619	SCIENCE OF ENGINEERING MATERIALS 3 cr. (3 and 0)
CR E 620	SCIENCE OF ENGINEERING MATERIALS 3 cr. (3 and 0)



**CR E 701 SPECIAL PROBLEMS**

3 cr. (1-3 and 0)

Practical problems in ceramic engineering analysis or design. Students are assigned individual problems with topics varying from year to year in keeping with developments and interests and experience of students and instructor; may be repeated for additional credit.

**CR E 807 SPECIALIZED CERAMICS**

3 cr. (3 and 0)

Student makes advanced study of one of the following: structural products, refractories, whitewares, abrasives, enamels, glass, cements, or raw materials processing.

**CR E 809 HIGH-TEMPERATURE MATERIALS**

3 cr. (3 and 0)

Properties of oxides, carbides, nitrides, borides and silicides; obtainment and measurement of high temperatures; measurement of properties at high temperatures.

**CR E 814 CERAMIC PHYSICAL PROCESSING**

3 cr. (3 and 0)

Role of physical processing in determining structure and composition of products.

**CR E 815 COLLOIDAL AND SURFACE SCIENCE**

3 cr. (3 and 0)

Theory and application of colloidal and surface chemistry to ceramic materials and processes.

**CR E 816 CONSTITUTION AND STRUCTURE OF GLASSES**

3 cr. (3 and 0)

Modern concepts of glass structure and properties.

**CR E 821 ANALYTICAL PROCEDURES AND EQUIPMENT I**

3 cr. (2 and 3)

Theory and application of powder X-ray diffractometry, emission spectroscopy, electron microscopy, and optical microscopy to ceramic problems.

**CR E 822 ANALYTICAL PROCEDURES AND EQUIPMENT II**

3 cr. (2 and 3)

Continuation of CR E 821.

**CR E 824 MECHANICAL PROPERTIES OF CERAMIC MATERIALS**

3 cr. (3 and 0)

Stress-strain-time relations in elasticity, plasticity, and rupture showing effects of high and low temperature and structures.

**CR E 825 MAGNETIC AND ELECTRICAL CERAMIC MATERIAL**

3 cr. (3 and 0)

Application of magnetic and electrical theory to ceramic insulators, semi-conductors, and ferroelectric and ferromagnetic products.

**CR E 826 CERAMIC COATINGS**

3 cr. (3 and 0)

Glassy and crystalline coatings emphasizing fundamentals of application, adhesion theories, and development of required properties.

CR E 828 SOLID STATE CERAMIC SCIENCE

3 cr. (3 and 0)

Bonding and structure of crystalline materials as related to mechanical, thermal, and chemical properties of solids.

CR E 891 MASTER'S THESIS RESEARCH

Credit to be arranged.

**CHEMICAL ENGINEERING**

W. B. Barlage, Jr., Head, Department of Chemical Engineering

**Major**

Chemical Engineering

**Degrees**

M.Engr., M.S., Ph.D.

Students may be accepted with backgrounds in chemistry, physics or branches of engineering other than chemical engineering. Special programs will be planned for non-chemical engineering graduates.

Minors for doctoral students may be taken in chemistry, physics, mathematics, life science, or other branches of engineering.

CH E 601 TRANSPORT PHENOMENA

3 cr. (3 and 0)

CH E 607 UNIT OPERATIONS LABORATORY II

2 cr. (0 and 6)

CH E 615 INTRODUCTION TO NUCLEAR ENGINEERING I

3 cr. (3 and 0)

CH E 621 PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS I

3 cr. (2 and 3)

CH E 622 PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS II

3 cr. (0 and 9)

CH E 624 INTRODUCTION TO INDUSTRIAL POLLUTION

3 cr. (3 and 0)

CH E 630 CHEMICAL ENGINEERING THERMODYNAMICS

3 cr. (3 and 0)

CH E 650 CHEMICAL ENGINEERING KINETICS

3 cr. (3 and 0)

CH E 802 PROCESS DYNAMICS AND CONTROL

3 cr. (3 and 0)

Utilization of engineering principles in dynamic analysis and design of chemical

processes, processing equipment and plants; systems dynamics; closed loop control and optimization. **Prerequisites:** CH E 353 and MTH SC 208 or permission of instructor.

#### CH E 803 HEAT, MASS, AND MOMENTUM TRANSFER

3 cr. (3 and 0)

Fundamental mechanisms of molecular and turbulent transport of heat, mass and momentum.

#### CH E 804 CHEMICAL ENGINEERING THERMODYNAMICS

3 cr. (3 and 0)

Equilibria of physical and chemical systems, generalized properties of hydrocarbons, and application of thermodynamic methods in equipment design.

#### CH E 805 CHEMICAL ENGINEERING KINETICS

3 cr. (3 and 0)

Kinetics of chemical reactions, particularly in design and operation of chemical reactors.

#### CH E 806 PROCESS SYSTEMS ANALYSIS AND SIMULATION

3 cr. (3 and 0)

Formulation and solution of mathematical models describing dynamic and steady state behavior of chemical and physical process systems; methodology of systems analysis, and techniques of analog and digital solutions.

#### CH E 812 POLYMER ENGINEERING

3 cr. (3 and 0)

Synthetic polymer design; reactor designs used in polymer production, effect on reactor design of kinetics of step and addition polymerization, epoxy curing reactions, polymer solubility behavior, and influence of polymerizer design and polymerization conditions on polymer crystallinity; morphological changes occurring in fiber and film processing. **Prerequisite:** Permission of instructor.

#### CH E 814 APPLIED NUMERICAL METHODS IN PROCESS SIMULATION

3 cr. (3 and 0)

Numerical solution techniques as applied to chemical process systems; finite difference techniques for partial differential equations stressing applied numerical methods rather than theoretical numerical analysis; standard methods for ordinary differential equations reviewed. **Prerequisite:** Permission of instructor.

#### CH E 815 POLYMER ENGINEERING LABORATORY

3 cr. (2 and 3)

Techniques and fundamental principles of polymerization reactor design and processing unit operations. Laboratory experiments emphasize relation between synthesis/processing and product and properties pilot-scale equipment. **Prerequisite:** Permission of instructor.

#### CH E 818 POLYMER PROCESSING

3 cr. (3 and 0)

Processing of polymeric materials; injection molding, calendaring, extrusion and surface activation of plastic film; physical science principles such as crystallization, surface chemistry, heat transfer and rheology applied to process operations.

- CH E 821      HEAT TRANSPORT  
3 cr. (3 and 0)  
Heat transport by conduction, convection and radiation.
- CH E 822      MASS TRANSFER AND DIFFERENTIAL CONTACT OPERATIONS  
3 cr. (3 and 0)  
Diffusion theory in binary and multicomponent gas and liquid systems, HTU concept, design considerations in absorption and extraction.
- CH E 823      MASS TRANSFER AND STAGewise CONTACT OPERATIONS  
3 cr. (3 and 0)  
Stagewise contact operations emphasizing distillation; vapor-liquid equilibria, integral and differential distillation, binary and multicomponent rectification, analytical methods, batch rectification, azeotropic and extractive distillation.
- CH E 845      SELECTED TOPICS IN CHEMICAL ENGINEERING  
3 cr. (3 and 0)  
Topics not covered in other courses emphasizing current literature and results of current research. Topics vary from year to year to keep pace with developments; may be repeated for credit.
- CH E 846      SELECTED TOPICS IN CHEMICAL ENGINEERING  
3 cr. (3 and 0)  
Topics not covered in other courses emphasizing current literature and results of current research. Topics vary from year to year to keep pace with developments; may be repeated for credit.
- CH E 891      MASTER'S THESIS RESEARCH  
Credit to be arranged.
- CH E 904      CHEMICAL ENGINEERING THERMODYNAMICS  
3 cr. (3 and 0)  
Continuation of CH E 804 including non-ideal behavior of mixtures, statistical thermodynamics and irreversible process. **Prerequisite:** CH E 804.
- CH E 945      SELECTED TOPICS IN CHEMICAL ENGINEERING  
3 cr. (3 and 0)  
Primarily a more comprehensive study of topics first covered in CH E 845 and 846.
- CH E 946      SELECTED TOPICS IN CHEMICAL ENGINEERING  
3 cr. (3 and 0)  
Primarily a more comprehensive study of topics first covered in CH E 845 and 846.
- CH E 991      DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## CIVIL ENGINEERING

H. W. Busching, Head, Department of Civil Engineering

### Major

Civil Engineering

### Degrees

M.Engr., M.S., Ph.D.

The Department of Civil Engineering offers programs of study in the specialty areas of traffic and transportation, structures, construction and water resources. A program may also encompass course work in several related interdisciplinary fields including environmental systems, bio-engineering and systems engineering.

Excellent facilities for graduate work are available, and each student's educational and research program can be arranged to suit his/her personal and professional goals.

- CE 603 USE OF COMPUTERS IN STRUCTURAL ANALYSIS AND DESIGN  
3 cr. (2 and 2)
- CE 604 MASONRY STRUCTURAL DESIGN  
3 cr. (3 and 0)
- CE 605 STRUCTURAL SYSTEMS DESIGN  
3 cr. (2 and 3)
- CE 610 TRAFFIC ENGINEERING OPERATIONS  
3 cr. (3 and 0) S
- CE 612 URBAN TRANSPORTATION PLANNING  
3 cr. (3 and 0) F
- CE 617 AIRPHOTO INTERPRETATION I  
3 cr. (2 and 3) F
- CE 619 GENERAL PHOTOGRAMMETRY  
3 cr. (2 and 3) S
- CE 621 HYDROLOGY  
3 cr. (3 and 0)
- CE 631 APPLIED SOIL MECHANICS  
3 cr. (2 and 2)
- CE 632 CONSTRUCTION PROJECT ADMINISTRATION  
3 cr. (2 and 3)
- CE 633 CONSTRUCTION PLANNING AND SCHEDULING  
3 cr. (2 and 3)
- CE 634 CONSTRUCTION ESTIMATING AND PROJECT CONTROL  
3 cr. (2 and 3)
- CE 635 ENGINEERING PROJECT ANALYSIS  
3 cr. (2 and 2)
- CE 636 SUBSURFACE CONSTRUCTION  
3 cr. (3 and 0)

- CE 638 CONSTRUCTION SUPPORT OPERATIONS  
3 cr. (2 and 3)
- CE 639 CONSTRUCTION EQUIPMENT SELECTION AND MAINTENANCE  
3 cr. (2 and 3)
- CE 641 APPLIED HYDRAULICS  
3 cr. (3 and 0)
- CE 653 ADVANCED STRUCTURAL ANALYSIS  
3 cr. (3 and 0)
- CE 662 COASTAL ENGINEERING I  
3 cr. (3 and 0)
- CE 663 COASTAL ENGINEERING II  
3 cr. (3 and 0)
- CE 664 PHYSICAL MODELS IN FLUID MECHANICS  
3 cr. (2 and 2)
- CE 670 PROBABILISTIC DESIGN IN CIVIL ENGINEERING  
3 cr. (3 and 0)
- CE 801 MATRIX METHODS OF STRUCTURAL ANALYSIS  
3 cr. (3 and 0)

**126** Matrix methods of structural analysis; development of member stiffness and flexibility matrices, procedures used to employ matrix methods.. Student writes and/or uses computer programs to analyze and design complex structures such as continuous span bridges, tall and low rise buildings, towers, arches and truss domes. **Prerequisite:** CE 453/653 or permission of instructor.

- CE 802 PRESTRESSED CONCRETE ANALYSIS AND DESIGN  
3 cr. (3 and 0)

Analysis and design of prestressed concrete beams, columns and slabs; loss of prestress, balanced design concept, cable layout, continuous spans, and anchorage details. **Prerequisite:** CE 402.

- CE 803 REINFORCED CONCRETE STRUCTURAL SYSTEMS  
3 cr. (3 and 0)

Second course in design of reinforced concrete structures. Advanced concepts in analysis and design of beams, columns and slabs; effect of past and present research in formulation of reinforced concrete design codes. **Prerequisite:** CE 402.

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

Development of plate equations for elastic analysis and design of thin rectangular, circular and continuous plates by classical methods; solutions for concentrated point and ring loads; use of influence functions; development of linear buckling theory for plates; use of numerical methods such as finite difference schemes and finite element techniques in the solution of plate problems. **Prerequisite:** Permission of instructor.

CE 805 PLASTIC ANALYSIS AND DESIGN OF STEEL STRUCTURES  
3 cr. (3 and 0)

Plastic analysis of unbraced and braced frameworks; moment-curvature relationships in the inelastic range; concept of yield hinge and theorems of limit analysis; statical and kinematical methods for calculating plastic collapse loads and displacements at incipient plastic collapse; design examples of multi-story frames; plastic potential flow law, yield conditions and elastic-plastic stress-strain relations. **Prerequisites:** CE 302 and CE 453/653, or permission of instructor.

CE 806 METAL COMPRESSION MEMBERS  
3 cr. (3 and 0)

Theoretical behavior of compression members: struts, beams, beam-columns, plate girders, and arches; theoretical predictions related to experimental results and to recognized design specifications for metals. **Prerequisite:** CE 453/653 or permission of instructor.

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

Application of numerical methods to solution of structural problems such as non-uniform beams, column and frame stability, beams on elastic foundation, and vibration of beams and frames; principal emphasis on use of Newmark's method of numerical analysis. **Prerequisite:** CE 453/653 or permission of instructor.

CE 808 FINITE ELEMENT METHODS IN ENGINEERING  
3 cr. (3 and 0)

Basic concepts of finite element analysis; development of simple triangular, rectangular and quadrilateral elements in plane stress, plane strain and axisymmetric cases; plate bending; shell and three dimensional elements; higher order elements and relative advantages and disadvantages of their use; applications of the method to problems of heat flow, seepage, dynamics and inelastic behavior. **Prerequisite:** CE 801 or permission of instructor.

CE 811 HIGHWAY GEOMETRIC DESIGN  
3 cr. (2 and 3)

Geometric design of roadways, at-grade intersections, and interchanges in accordance with conditions imposed by driver ability, vehicle performance, safety and economics. **Prerequisite:** CE 310/610.

CE 812 AIRPHOTO INTERPRETATION II  
3 cr. (2 and 3)

Principles of airphoto interpretation as applied to transportation planning; identification and analysis of cultural, industrial and recreational land use features to predict future needs of transportation system. Transportation projects utilizing airphoto interpretation required.

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

Structural design of rigid and flexible pavements; design of bases and sub-bases; theory of stresses and application of plate bearing, triaxial, and California Bearing Ratio design methods to flexible pavements; Westergaard analysis for rigid pavements; pavement evaluation methods. **Prerequisite:** CE 330.

## CE 814 TRAFFIC FLOW THEORY

3 cr. (3 and 0)

Qualitative and quantitative description of traffic flow, parameters used to characterize flow, procedures for adjusting parameters to optimize flow, solution of traffic flow problems by analogy and queuing theory. **Prerequisite:** CE 410/610.

## CE 815 TRANSPORTATION SAFETY ENGINEERING

3 cr. (3 and 0)

Present methodology for conducting transportation accident studies, accident characteristics as related to operator facility and mode, statistical applications to accident data, current trends and problems in transportation safety. **Prerequisite:** CE 310.

## CE 816 HIGHWAY PLANNING

3 cr. (3 and 0)

Various aspects of highway planning; planning surveys, needs studies, impact studies, sufficiency ratings, highway finance, highway administration, and extensive treatment of economic evaluation of alternative highway projects by benefit cost ratio, annual cost, rate of return and investment return procedures.

## CE 817 MASS TRANSIT PLANNING

3 cr. (3 and 0)

Mass transit planning; characteristics of modern mass transit systems, case studies of mass transit in selected cities, transit studies, marketing and financing mass transit, recent innovation in mass transit, current issues in mass transit planning, and future developments in mass transit.

## CE 818 AIRPORT PLANNING AND DESIGN

3 cr. (3 and 0)

Planning and design of airports and other air transportation facilities; characteristics of air transport; future role of air transport in overall transportation program.

## CE 819 TRANSPORTATION RESEARCH

2-4 cr.

Independent investigation of problems in transportation engineering.

## CE 822 AGGREGATES AS CONSTRUCTION MATERIALS

3 cr. (2 and 3)

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

## CE 830 ADVANCED SOIL MECHANICS

3 cr. (3 and 0)

Stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, analysis of flexible retaining wall and bulkheads, solution of problem by elastic theory. **Prerequisite:** CE 330.

## CE 831 FOUNDATION ENGINEERING

3 cr. (2 and 3)

Requirements for satisfactory foundations, theory and design of shallow foundations, pressure distribution beneath rigid and flexible shallow foundations, bearing capacity and settlement of deep foundations, foundation failures. Laboratory includes site investigation field tests and determination of design parameters. **Prerequisite:** CE 830.



- CE 835            CONSTRUCTION PROJECT MODELING AND CONTROL  
3 cr. (2 and 3)  
Planning the project from standpoint of constructibility and available resources; optimization of crew size, equipment size and operations; Kelvin modeling concept, linear programming, queuing theory, learning curve and uncertainty; simple modeling examples; organizational project control networks. **Prerequisites:** CE 433 and MTH SC 208 or equivalent.
- CE 837            CONSTRUCTION SPECIFICATIONS AND CONTRACTS  
3 cr. (2 and 3)  
Elements of specifications delineating responsibilities of all involved parties and identifying courses of action during abnormal circumstances; necessary parts of a contract dealing with governmental regulations and institutional preferences; licenses, bonds, insurance, and taxes. **Prerequisite:** CE 424 or equivalent.
- CE 840            CONSTRUCTION OF NUCLEAR POWER PLANTS  
3 cr. (2 and 3)  
Activities involved in identifying need for new plant, designing plant, obtaining construction permit, constructing plant, and testing plant; roles of EPA, NRC and other regulatory agencies; comparison of nuclear power plants with fossil fuel plants. **Prerequisite:** CE 424 or equivalent.
- CE 846            FLOW IN OPEN CHANNELS  
3 cr. (3 and 0)  
Free surface flow problems; applications of digital computer, concepts of boundary layer theory, uniform and varied flow, hydraulic jump, design criteria for prismatic channels and transitions, some applications of unsteady flow. **Prerequisites:** Graduate standing and permission of instructor.
- CE 861            MECHANICS OF SEDIMENT TRANSPORT  
3 cr. (2 and 2)  
Characterization of sediments; physical principles governing processes of aeolian, fluvial, and estuarine sediment transport. **Prerequisite:** CE 421/621 or equivalent.
- CE 862            HEAT TRANSFER AT WATER SURFACES  
3 cr. (3 and 0)  
Daily and annual heat transfer at air-water interface of rivers and lakes, including calculation of heat rejection rates on artificially heated lakes, wind speed functions, bulk aerodynamic methods, and Bowen ratio concepts; various techniques currently used to measure evaporation; effects of atmospheric stability on evaporation. **Prerequisite:** EM 320.
- CE 865            HYDROLOGIC SYSTEMS ANALYSIS  
3 cr. (3 and 0)  
Hydrologic cycle as a hydrologic system; deterministic hydrology; all aspects of physical hydrology emphasizing balanced approach to ground water hydrology and surface water hydrology; meteorology, infiltration, soil moisture and evapotranspiration; probability analysis and partial system synthesis by unit hydrograph techniques. **Prerequisite:** Permission of instructor.

- CE 866      ADVANCED HYDROLOGIC SYSTEMS ANALYSIS  
3 cr. (3 and 0)  
Continuation of CE 865. Deterministic hydrology emphasizing parametric hydrology, system synthesis and correlation analysis; statistical hydrology, time series analysis, and stochastic hydrology. **Prerequisite:** CE 865 or permission of instructor.
- CE 871      COASTAL HYDRODYNAMICS  
3 cr. (3 and 0)  
Hydrodynamics applied to coastal waters; gravity wave theory, tidal wave phenomenon, oceanic turbulence, mathematical modeling of estuaries and bays. **Prerequisite:** EM 320.
- CE 872      MARINE POLLUTION CONTROL  
2 cr. (2 and 0)  
Current technology and problems related to water quality management in marine environment; coastal and estuarine problems; submarine outfall systems; disposal of dredged material and wastewater sludges; thermal and oil pollution; water quality instrumentation, monitoring and surveillance in the marine environment; design of oceanographic surveys required for water quality control. **Prerequisites:** EM 320 and ESE 601 or equivalent.
- CE 889      SPECIAL PROBLEMS I  
1-3 cr.  
Research design problems from field of structures, construction, soil mechanics, transportation, ocean and coastal engineering, or materials engineering. Subject matter varies with interest and experience of student and instructor.
- CE 890      SPECIAL PROBLEMS II  
1-3 cr.  
Research design problems from field of structures, construction, soil mechanics, transportation, ocean and coastal engineering, or materials engineering. Subject matter varies with interest and experience of student and instructor.
- CE 891      MASTER'S THESIS RESEARCH  
Credit to be arranged.
- CE 893      SELECTED TOPICS IN CIVIL ENGINEERING  
1-6 cr. (1-6 and 1-6)  
Topics not covered in other courses. May be repeated for credit.
- CE 901      THEORY AND DESIGN OF SHELL STRUCTURES  
3 cr. (3 and 0)  
Theory and design of thin shell structures; membrane theory of shells of revolution and translation; analysis and design of domes, hyperbolic paraboloid, elliptic paraboloid, cylindrical and prismatic shells; design of folded plates, cylindrical shell roofs and cylindrical tanks; design recommendations for concrete shells. **Prerequisite:** CE 801 or permission of instructor.
- CE 902      DYNAMIC ANALYSIS OF STRUCTURES  
3 cr. (3 and 0)

Analysis and design of structures subjected to dynamic loading, response of lumped and distributed parameter systems of one or many degrees of freedom, approximate design methods, introduction to earthquake analysis and design.

**Prerequisite:** CE 801 or permission of instructor.

CE 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## COMPUTER ENGINEERING

A. W. Bennett, Head, Department of Electrical and Computer Engineering

Major	Degree
Computer Engineering	M.S.

The computer engineering program is a combination of computer software, hardware, systems, and applications. Enrollment is open to graduates in any branch of engineering, computer science, or applied mathematics who have an appropriate computer background.

E&CE 617 SOFTWARE DESIGN  
3 cr. (3 and 0)

E&CE 622 ELECTRONICS III  
3 cr. (3 and 0) F, S

E&CE 623 DESIGN FOR LARGE-SCALE INTEGRATION FUNCTIONS  
3 cr. (3 and 0) S

E&CE 625 MICROCOMPUTERS I  
3 cr. (2 and 2) F

E&CE 626 DIGITAL COMPUTER DESIGN  
3 cr. (3 and 0) S

E&CE 629 COMPUTER ORGANIZATION  
3 cr. (3 and 0) F

E&CE 631 DIGITAL ELECTRONICS  
3 cr. (2 and 2) S

E&CE 638 COMPUTER COMMUNICATIONS  
3 cr. (3 and 0)

E&CE 641 THEORY OF SEQUENTIAL MACHINES  
3 cr. (3 and 0)

E&CE 650 COMPUTER SYSTEM DESIGN PROJECT  
2 cr. (0 and 4)

E&CE 652 PROGRAMMING SYSTEMS  
3 cr. (3 and 0) S

E&CE 654 PHYSIOLOGICAL CONTROL SYSTEMS  
3 cr. (2 and 2)

- E&CE 660      COMPUTER-AIDED ANALYSIS AND DESIGN  
3 cr. (3 and 0) F
- E&CE 661      ANALOG/HYBRID COMPUTATION AND SIMULATION  
3 cr. (2 and 2) S
- E&CE 663      MICROCOMPUTERS II  
3 cr. (2 and 2)
- E&CE 667      INTRODUCTION TO DIGITAL SIGNAL PROCESSING  
3 cr. (3 and 0) F
- E&CE 671      MICROCOMPUTER APPLICATION IN MEDICAL  
INSTRUMENTATION  
3 cr. (3 and 0)
- E&CE 672      MICROCOMPUTER SYSTEMS APPLICATIONS  
3 cr. (2 and 2)
- E&CE 691      SELECTED TOPICS  
1-3 cr. (1-3 and 0)
- E&CE 812      DIGITAL CONTROL SYSTEMS\*  
3 cr. (3 and 0) F
- E&CE 841      DISTRIBUTED COMPUTING AND NETWORKS  
3 cr. (3 and 0)
- Design oriented toward distributed computing and computing concepts; design issues, implementation techniques, communication networks, analytical tools for system evaluation, data transmission principles, and data concentration.  
**Prerequisite:** E&CE 438/638.
- E&CE 842      ADVANCED COMPUTER ARCHITECTURE  
3 cr. (3 and 0)
- Case study approach to advanced computer architecture provides framework for studying the numerous computer systems now extant as a guide to designing systems for the future. **Prerequisites:** E&CE 426/626 and 429/629.
- E&CE 843      COMPUTER GRAPHICS  
3 cr. (3 and 0)
- Concepts and structure of integrated graphics computer system design, operation of various graphical input and display devices, three-dimensional display concepts, structure of graphical display files, and graphics programming languages. **Prerequisite:** Programming experience in FORTRAN, COBOL and other high level languages.
- E&CE 844      DIGITAL SIGNAL PROCESSING\*  
3 cr. (3 and 0)
- E&CE 845      COMPUTER SYSTEM DESIGN AND OPERATION  
3 cr. (3 and 0)
- Factors involved in design, acquisition and operation of a computer system; analysis methods, alternative computer systems, computer economics, perfor-

\*Descriptions of these 800-level courses are listed under Electrical Engineering.

mance evaluation, and operational requirements. **Prerequisite:** Permission of instructor.

E&CE 846 DIGITAL PROCESSING OF SPEECH SIGNALS\*  
3 cr. (3 and 0)

E&CE 847 DIGITAL IMAGE PROCESSING\*  
3 cr. (3 and 0)

E&CE 850 COMPUTATION AND SIMULATION  
3 cr. (3 and 0) S

Computer modeling as related to engineering problems; matching problems and computers to obtain most effective solution.

E&CE 851 THEORY AND DESIGN OF DIGITAL-ANALOG MACHINES  
3 cr. (3 and 0) S

Theory and design of general purpose, special purpose, hybrid and sequential machines emphasizing practical applications.

E&CE 852 DIGITAL AND INFORMATION PROCESSES  
3 cr. (3 and 0) F

Techniques and problems of computer and information processing technology; algorithmic approach to problem solving, software concepts, and machine organization. **Prerequisite:** Prior knowledge of computer programming.

E&CE 853 COMPUTER DATA DISPLAYS  
3 cr. (3 and 0) S

Methods and hardware required for visually displaying computer output; cathode ray, discrete readout, and large screen displays. **Prerequisite:** E&CE 429/629 or approval of instructor.

E&CE 855 ARTIFICIAL INTELLIGENCE  
3 cr. (3 and 0) F

Problem of creating intelligent behavior in machines, emphasizing computer-oriented approaches; models of cognitive processes, goal-seeking behavior, self-organizing systems, learning algorithms, game-playing machines, pattern recognition, and heuristic programming; practical applications such as machine aids to human problem-solving and computer control of external manipulators; current developments.

E&CE 856 PATTERN RECOGNITION\*  
3 cr. (3 and 0) S

E&CE 858 AUTOMATA THEORY  
3 cr. (3 and 0) S

Structure and capabilities of sequential machines; machine identification, regular expressions, linear machines, and stochastic machines.

E&CE 890 SPECIAL PROBLEMS IN ELECTRICAL AND  
COMPUTER ENGINEERING  
1-3 cr. (1-3 and 0)

\*Descriptions of these 800-level courses are listed under Electrical Engineering.

Problems selected to meet interests and experience of student and instructor. May be repeated for additional credit. **Prerequisite:** Permission of instructor.

E&CE 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

E&CE 893 SELECTED TOPICS IN ELECTRICAL AND COMPUTER ENGINEERING  
1-3 cr. (1-3 and 0)

Topics not covered in other courses; current literature and results of current research. Topics vary from year to year in keeping with developments in the field; may be repeated for additional credit. **Prerequisite:** Permission of instructor.

### ELECTRICAL ENGINEERING

A. W. Bennett, Head, Department of Electrical and Computer Engineering

#### Major

Electrical-Engineering

#### Degrees

M.Engr., M.S., Ph.D.

Students in electrical engineering may direct their program toward the fields of networks, controls, communications, electronics, power systems, computers or one of the multi-disciplinary fields such as biomedical engineering or systems engineering.

E&CE 603 ENERGY CONVERSION  
3 cr. (3 and 0) F

E&CE 604 SEMICONDUCTOR DEVICES  
3 cr. (3 and 0)

E&CE 606 INTRODUCTION TO INTEGRATED CIRCUITS  
3 cr. (3 and 0) F

E&CE 610 INTRODUCTION TO DIGITAL CONTROL SYSTEMS  
3 cr. (3 and 0) F, S

E&CE 611 ELECTRICAL SYSTEMS  
1 cr. (0 and 2) F, S

E&CE 612 DIGITAL COMPUTER SYSTEMS  
3 cr. (3 and 0) S

E&CE 615 INFORMATION THEORY  
3 cr. (3 and 0)

E&CE 616 INTRODUCTION TO MODERN CONTROL SYSTEMS  
3 cr. (3 and 0) F

E&CE 617 SOFTWARE DESIGN  
3 cr. (3 and 0)

E&CE 620 POWER SYSTEM ANALYSIS I  
3 cr. (3 and 0) S

E&CE 621	ELECTRICAL MACHINERY 3 cr. (2 and 2) F
E&CE 622	ELECTRONICS III 3 cr. (3 and 0) F, S
E&CE 623	DESIGN FOR LARGE-SCALE INTEGRATION FUNCTIONS 3 cr. (3 and 0) S
E&CE 624	POWER SYSTEMS ANALYSIS II 3 cr. (3 and 0) S
E&CE 625	MICROCOMPUTERS I 3 cr. (2 and 2) F
E&CE 626	DIGITAL COMPUTER DESIGN 3 cr. (3 and 0) S
E&CE 627	OPERATIONAL AMPLIFIERS 2 cr. (2 and 0) S
E&CE 628	COMMUNICATIONS THEORY I 3 cr. (3 and 0) F, S
E&CE 629	COMPUTER ORGANIZATION 3 cr. (3 and 0) F
E&CE 630	COMMUNICATIONS THEORY II 3 cr. (3 and 0) S
E&CE 631	DIGITAL ELECTRONICS 3 cr. (2 and 2) S
E&CE 632	INSTRUMENTATION 3 cr. (3 and 0) S
E&CE 634	POWER ELECTRONICS 3 cr. (3 and 0) F
E&CE 635	COMMUNICATION CIRCUITS 3 cr. (3 and 0) S
E&CE 636	RADIATION AND WAVE PROPAGATION 3 cr. (3 and 0) F
E&CE 637	LASER TECHNOLOGY AND APPLICATIONS 3 cr. (3 and 0) S
E&CE 638	COMPUTER COMMUNICATIONS 3 cr. (3 and 0)
E&CE 641	THEORY OF SEQUENTIAL MACHINES 3 cr. (3 and 0)

- E&CE 650 COMPUTER SYSTEM DESIGN PROJECT  
2 cr. (0 and 4)
- E&CE 651 SYSTEM DESIGN PROJECT  
2 cr. (0 and 4) F, S
- E&CE 652 PROGRAMMING SYSTEMS  
3 cr. (3 and 0) S
- E&CE 654 PHYSIOLOGICAL CONTROL SYSTEMS  
3 cr. (2 and 2)
- E&CE 659 COMPUTER-AIDED DESIGN OF ELECTRONIC CIRCUITS  
3 cr. (3 and 0)
- E&CE 660 COMPUTER-AIDED ANALYSIS AND DESIGN  
3 cr. (3 and 0) F
- E&CE 661 ANALOG/HYBRID COMPUTATION AND SIMULATION  
3 cr. (2 and 2) S
- E&CE 663 MICROCOMPUTERS II  
3 cr. (2 and 2)
- E&CE 667 INTRODUCTION TO DIGITAL SIGNAL PROCESSING  
3 cr. (3 and 0) F
- E&CE 670 COMPUTER APPLICATIONS FOR NONENGINEERS  
3 cr. (3 and 0)
- E&CE 671 MICROCOMPUTER APPLICATIONS IN MEDICAL INSTRUMENTATION  
3 cr. (3 and 0)
- E&CE 672 MICROCOMPUTER SYSTEMS APPLICATIONS  
3 cr. (2 and 2)
- E&CE 691 SELECTED TOPICS  
1-3 cr. (1-3 and 0)
- E&CE 701 SPECIAL PROBLEMS  
1-3 cr. F, S  
Practical problems in engineering analysis or design in students' fields of interest. May be repeated for additional credit.
- E&CE 702 ELECTRIC MOTOR CONTROL  
3 cr. (3 and 0)  
Starting and speed control of ac and dc motors including typical starting and speed control apparatus. Machines are modeled, and starting and speed control are simulated using computers. **Prerequisite:** E&CE 421/621.
- E&CE 801 ANALYSIS OF LINEAR SYSTEMS  
3 cr. (3 and 0) F



Foundations of linear system analysis; matrix algebra, linear graph theory, and operational mathematics applied to formulation and solution of system equations in time and frequency domains.

**E&CE 803 LINEAR CONTROL THEORY AND DESIGN**

3 cr. (3 and 0)

Analysis and design of continuous and discrete linear control systems; vector spaces, transformation, notation of a basis, transfer functions, state variable formulation, Cayley-Hamilton theorem, Jordan canonical forms, controllability, observability, adjoint systems, stability, multiple input-output systems, and design techniques. **Prerequisite:** E&CE 410/610 or equivalent.

**E&CE 804 OPTIMAL CONTROL THEORY**

3 cr. (3 and 0)

Design of optimum control systems; ordinary minima with constraints, Lagrange multipliers, variational approach to control problems, necessary and sufficient conditions, free and fixed endpoint problems, Hamilton-Jacobi equations, minimum principle of Pontryagin, design of time and fuel optimal control systems, design of linear systems with quadratic criteria and systems with the control constrained to a hypersphere. **Prerequisite:** E&CE 803. **Co-requisite:** MTH SC 654 or 664 or permission of instructor.

**E&CE 807 POWER SYSTEM TECHNIQUES**

3 cr. (3 and 0) S

Electric power system operation; development of models of transmission line components and networks; computer methods for solving linear and nonlinear systems of network equations; operating problems in load flow, scheduling and economic dispatch. **Prerequisite:** Permission of instructor.

**E&CE 809 SEMICONDUCTOR MATERIALS**

3 cr. (3 and 0)

Solids, crystalline state, energy band structure of semiconductors; effective mass approximation, impurity states, surface states, transport phenomenon, galvanomagnetic effects, electro-optical effects and magneto-optical effects. **Prerequisite:** E&CE 404.

**E&CE 812 DIGITAL CONTROL SYSTEMS**

3 cr. (3 and 0)

Analysis and design of digital control systems; sampling theory and data reconstructions; z-transforms and state variable analysis techniques; stability; compensation; and performance. **Prerequisite:** E&CE 302 or permission of instructor.

**E&CE 817 POWER SYSTEM TRANSIENTS**

3 cr. (3 and 0)

Power system transients; stability studies, fault analysis using bus impedance matrix, switching transients. **Prerequisite:** Permission of instructor.

**E&CE 819 DETECTION AND ESTIMATION THEORY**

3 cr. (3 and 0) F

Theory of statistical testing of hypotheses applied to detection and estimation of communication signal parameters; detection of signals with random amplitude, phase and arrival time in noise; detection of single and multiple observation; estimates and their properties; signal resolution. **Prerequisite:** E&CE 820.

**E&CE 820 THEORY OF COMMUNICATIONS I**

3 cr. (3 and 0) F

Modern communications systems emphasizing modulation and methods of taking into account effects of noise on various systems. **Prerequisite:** E&CE 428/628 or equivalent.

**E&CE 821 THEORY OF COMMUNICATIONS II**

3 cr. (3 and 0) S

Continuation of E&amp;CE 820.

**E&CE 822 INFORMATION THEORY**

3 cr. (3 and 0) F

Statistical problems encountered in information handling; relations of probability, information, and coding theory; unified treatment of set theory, sample space, random variables, information measure and capacity applied to communication.

**E&CE 823 INTEGRATED CIRCUIT TECHNOLOGY**

3 cr. (3 and 0) F

Characteristics of semiconductor devices as used in integrated circuits; monolithic and hybrid construction related to electrical performance; categorization of circuits by technology and design guidelines.

**E&CE 825 SOLID-STATE ELECTRONICS**

3 cr. (3 and 0) S

Modern physics approach to electron in solids; elementary quantum mechanics, statistics, plasmas, and band theory; application of these principles to modern amplifiers, e.g., the traveling-wave tube, tunnel diode, masers, and parametric amplifiers.

**E&CE 830 ELECTROMAGNETICS**

3 cr. (3 and 0) F

Vector analysis, electrostatics, electrostatic fields in material bodies, solution of boundary-value problems, stationary currents, static magnetic fields, magnetic field in material bodies, quasi-stationary magnetic fields. **Prerequisite:** Permission of instructor.

**E&CE 840 PHYSICS OF SEMICONDUCTOR DEVICES**

3 cr. (3 and 0)

Semiconductor device physics emphasized rather than circuits; detailed analysis of the p-n junction, traps, surface states and conduction processes in devices; analysis and models of Schottky diode, MIS diode, MOSFET, charge couples devices and solar cells; charge control concepts, transit time effects, surface type devices and practical aspects of device process. **Prerequisites:** E&CE 404 and 406/606.

**E&CE 841 DISTRIBUTED COMPUTING AND NETWORKS\***

3 cr. (3 and 0)

**E&CE 842 ADVANCED COMPUTER ARCHITECTURE\***

3 cr. (3 and 0)

\*Descriptions of these 800-level courses are listed under Computer Engineering.

E&CE 843 COMPUTER GRAPHICS\*  
3 cr. (3 and 0)

E&CE 844 DIGITAL SIGNAL PROCESSING  
3 cr. (3 and 0)

Digital filter design; discrete Hilbert transforms; discrete random signals; effects of finite register length in digital signal processing; homomorphic signal processing; power spectrum estimation; speech processing, radar, and other applications.  
**Prerequisite:** E&CE 467/667.

E&CE 845 COMPUTER SYSTEM DESIGN AND OPERATION\*  
3 cr. (3 and 0)

E&CE 846 DIGITAL PROCESSING OF SPEECH SIGNALS  
3 cr. (3 and 0)

Application of digital signal processing techniques to problems related to speech synthesis, recognition, and communication; digital models and representations of speech waveforms; Fourier analysis; homomorphic processing; linear predictive coding; algorithms for recognizing isolated words and continuous speech; man-machine communications by voice. **Prerequisite:** E&CE 467/667.

E&CE 847 DIGITAL IMAGE PROCESSING  
3 cr. (3 and 0)

Digital image fundamentals; comparison of image transforms, including KL, Fourier, Walsh, Hadamard, cosine, and slant; image data compression techniques; image enhancement algorithms; image restoration; image encoding process; image segmentation and description. **Prerequisite:** E&CE 467/667.

E&CE 850 COMPUTATION AND SIMULATION\*  
3 cr. (3 and 0) F

E&CE 851 THEORY AND DESIGN OF DIGITAL-ANALOG MACHINES\*  
3 cr. (3 and 0) S

E&CE 852 DIGITAL AND INFORMATION PROCESSES\*  
3 cr. (3 and 0) F

E&CE 853 COMPUTER DATA DISPLAYS\*  
3 cr. (3 and 0) S

E&CE 855 ARTIFICIAL INTELLIGENCE\*  
3 cr. (3 and 0) F

E&CE 856 PATTERN RECOGNITION  
3 cr. (3 and 0) S

Several approaches to general pattern recognition problem with practical computer-oriented applications; feature extraction, classification algorithms, discriminant functions, learning schemes, statistical methods, information theoretic approaches, applications, current developments.

E&CE 857 CODING THEORY  
3 cr. (3 and 0) S

\*Descriptions of these 800-level courses are listed under Computer Engineering.

Principles of algebraic coding and its application to transmission of information over noisy communications channels; introduction to abstract algebra, code performance bounds, code representations, linear codes of the Hamming and Bose-Chandhuri types and burst-error correcting codes, problems of implementation and decoding. **Prerequisite:** E&CE 822.

E&CE 858 AUTOMATA THEORY\*  
3 cr. (3 and 0) S

E&CE 870 BIOSYSTEMS ANALYSIS  
3 cr. (3 and 0) F

Classical and recent mathematical models of biological systems, particularly as they relate to modern systems theory and as they apply to humans; biomedical instrumentation; data collection and processing.

E&CE 890 SPECIAL PROBLEMS IN ELECTRICAL AND  
COMPUTER ENGINEERING  
1-3 cr. (1-3 and 0)

Problems selected to meet interests and experience of student and instructor. May be repeated for additional credit. **Prerequisite:** Permission of instructor.

E&CE 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

E&CE 893 SELECTED TOPICS IN ELECTRICAL AND COMPUTER  
ENGINEERING  
1-3 cr. (1-3 and 0)

Topics not covered in other courses; current literature and results of current research. Topics vary from year to year in keeping with developments in the field; may be repeated for additional credit. **Prerequisite:** Permission of instructor.

E&CE 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## ENGINEERING MECHANICS

E. G. Prziembel, Head, Department of Mechanical Engineering

**Major**  
Engineering Mechanics

**Degrees**  
M.S., Ph.D.

Enrollment is open to students with 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 solid mechanics, dynamics and fluid mechanics. Some limitations are imposed on the selection of courses to reflect the particular concentration. The usual minor is mathematics. Suitable minor programs may also be arranged in physics, materials engineering, civil engineering or mechanical engineering.

\*Descriptions of these 800-level courses are listed under Computer Engineering.

- EM 625      **ADVANCED STRENGTH OF MATERIALS**  
3 cr. (3 and 0)
- EM 650      **MECHANICAL VIBRATIONS**  
3 cr. (3 and 0)
- EM 670      **EXPERIMENTAL STRESS ANALYSIS**  
3 cr. (2 and 3)
- EM 829      **ENERGY METHODS AND VARIATIONAL PRINCIPLES**  
3 cr. (3 and 0)  
Application of variational principles in solid mechanics problems; virtual work, Castigliano's theorems on deflection and rotation, stationary potential energy, energy stability criterion, and Hamilton's principle. **Prerequisite:** EM 831 or permission of instructor.
- EM 831      **THEORY OF ELASTICITY I**  
3 cr. (3 and 0)  
Theory of stress and deformation for continuous media; linear stress-strain relations for elastic material; two-dimensional problems including Airy stress function, polynomial solutions, plane stress and plane strain in rectangular and polar coordinates, torsion and bending of prismatic bars and thermal stresses. **Prerequisites:** EM 304 and MTH SC 208.
- EM 832      **THEORY OF ELASTICITY II**  
3 cr. (3 and 0)  
Continuation of EM 831 including topics from either three-dimensional problems associated with an infinite elastic medium, elastic half-space, contact stresses, symmetrically loaded sphere and circular cylinder, or complex variable methods in plane elasticity, stress concentrations problems, singular stresses and fracture, and composite materials. **Prerequisites:** EM 831 and MTH SC 658.
- EM 834      **PRINCIPLES OF STRUCTURAL STABILITY**  
3 cr. (3 and 0)  
Practical criteria for analysis of conservative and nonconservative systems stability; methods of adjacent equilibrium, initial imperfections, total potential energy, and vibration as applied to practical problems. **Prerequisite:** EM 831.
- EM 845      **INTERMEDIATE DYNAMICS**  
3 cr. (3 and 0)  
Kinematics and dynamics of particles and rigid bodies, Lagrange and Hamilton's formulation of mechanics; two-body central force problem; rendezvous of two bodies in a central force field; rotation of rigid bodies about a fixed point in space; vector analysis and matrix methods as aids in mathematical analysis. **Prerequisite:** EM 202 or permission of instructor.
- EM 891      **MASTER'S THESIS RESEARCH**  
Credit to be arranged.
- EM 893      **SELECTED TOPICS IN ENGINEERING MECHANICS**  
1-6 cr. (1-6 and 0)  
Topics not covered in other courses. May be repeated for credit.

EM 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

### ENVIRONMENTAL SYSTEMS ENGINEERING

T. M. Keinath, Head, Department of Environmental Systems Engineering

#### Major

Environmental Systems  
Engineering

#### Degrees

M.Engr., M.S., Ph.D.

Environmental systems engineering is an interdisciplinary field concerned with the engineering aspects of the control of man's environment. Emphasis is placed on applying basic principles of the sciences through research and design to environmental engineering problems.

The M.Engr., M.S., and Ph.D. programs are planned to augment the student's previous engineering or science background with specialization either in the design, operations and management areas of water or air quality control or in the nuclear environmental area. Students with a baccalaureate degree in any branch of engineering, as well as chemistry, physics, and biology majors with a strong mathematical background, may be admitted to the program. No foreign language is required.

The Ph.D. program is designed to accommodate the background and objectives of the candidate. The major field of study generally is interdisciplinary in nature, consisting of course work in several areas of engineering and the basic sciences. Dissertation research is guided by environmental systems engineering faculty.

ESE 601	ENVIRONMENTAL ENGINEERING 3 cr. (3 and 0)
ESE 602	WATER AND WASTE TREATMENT SYSTEMS 3 cr. (3 and 0)
ESE 610	ENVIRONMENTAL RADIATION PROTECTION 3 cr. (3 and 0)
ESE 611	ENVIRONMENTAL RADIATION PROTECTION LABORATORY I 1 cr. (0 and 3)
ESE 630	AIR POLLUTION ENGINEERING 3 cr. (3 and 0)
ESE 643	ENVIRONMENTAL ENGINEERING CHEMISTRY I 3 cr. (3 and 0) F
ESE 644	ENVIRONMENTAL ENGINEERING CHEMISTRY LABORATORY I 1 cr. (0 and 3) F
ESE 670	WATER RESOURCES ENGINEERING 3 cr. (3 and 0)

**ESE 701 SPECIAL PROBLEMS**

1-6 cr. (1-6 and 0)

Problems are selected in the field of environmental engineering to meet the interests and experience of student and instructor. Formal report is required. Restricted to Master of Engineering students.

**ESE 802 PRINCIPLES OF WATER TREATMENT SYSTEMS**

4 cr. (4 and 0)

Fundamental principles important to water and wastewater treatment systems. Topics considered are the principles of biological and chemical reactions, mass and heat transfer, reactor kinetics, adsorption and ion exchange, classification and thickening, transient response analysis and control theory, statistics, and methods of operations research.

**ESE 803 LABORATORY IN PRINCIPLES OF WATER TREATMENT**

1 cr. (0 and 3)

Demonstrations and selected laboratory exercises which illustrate the fundamental principles of water and wastewater treatment systems including respirometer studies, reactor systems, dispersion, gas transfer, adsorption, thickening, and control systems. Emphasis is placed on the relation between theory and experimental results. **Prerequisite:** ESE 802 or concurrent registration in ESE 802.

**ESE 804 DESIGN AND OPERATION OF WATER TREATMENT SYSTEMS**

4 cr. (4 and 0)

An investigation of the design and operational criteria that are significant to the processes employed for the treatment of water and wastewater. Topics include coagulation and flocculation, filtration, adsorption and ion exchange, membrane separation, chemical precipitation and water stabilization, chemical oxidation and disinfection, activated sludge, fixed-film biological reactors, anaerobic digestion, solids handling and disposal, and municipal and industrial economics. **Prerequisites:** ESE 802 and 803.

**ESE 805 LABORATORY IN DESIGN AND OPERATION OF WATER TREATMENT SYSTEMS**

1 cr. (0 and 3)

Laboratory exercises in selected water and wastewater treatment processes. Coagulation, flocculation, filtration, reverse osmosis, softening, activated sludge, anaerobic digestion, and sludge handling and disposal are typical topics studied. Emphasis is directed toward the operation of these processes and on securing suitable design parameters. **Prerequisites:** ESE 802, 803, and 804 or concurrent registration in ESE 804.

**ESE 806 INTEGRATED PROBLEMS IN WATER TREATMENT SYSTEMS**

2 cr. (2 and 0)

Integration of water and wastewater treatment processes into complex systems emphasizing functional design and operation through consideration of process economics and plant control systems. The team approach is employed in the design and analysis of several integrated water treatment systems. **Prerequisites:** ESE 802, 803, 804, and 805.

**ESE 812 ENVIRONMENTAL NUCLEAR ENGINEERING**

3 cr. (3 and 0)

Environmental aspects of nuclear technology emphasizing nuclear reactors and the nuclear fuel cycle: environmental transport of radioactive materials, radioactive effluents from nuclear power plants, nuclear power plant safety, environmental aspects of fuel cycle activities, waste management. **Prerequisites:** ESE 610 and permission of instructor.

**ESE 813 ENVIRONMENTAL RADIATION PROTECTION LABORATORY II**  
1 cr. (0 and 3)

Continuation of ESE 611; advanced experiments in radiation detection, radiation protection, health physics and environmental monitoring. **Prerequisites:** ESE 611 and permission of instructor.

**ESE 831 AIR QUALITY MONITORING**  
3 cr. (2 and 3)

Principles of ambient and source measurements of air pollutants and siting of air pollution monitors. Laboratory exercises include source testing and ambient air analysis. **Prerequisite:** Permission of instructor.

**ESE 832 AIR POLLUTION METEOROLOGY**  
3 cr. (3 and 0)

Applications of meteorology to air pollution, micrometeorology, plume rise modeling, atmospheric diffusion, deposition and washout of pollutants, air chemistry, and applications of diffusion modeling to air quality planning. **Prerequisite:** Permission of instructor.

**ESE 833 AIR POLLUTION CONTROL SYSTEMS**  
3 cr. (3 and 0)

Principles and design of air pollution control equipment including mechanical collectors, electrostatic precipitators, baghouse filters, wet scrubbers, adsorbers, and incinerators. **Prerequisite:** ESE 430/630 or permission of instructor.

**ESE 847 ADVANCED TOPICS IN ENVIRONMENTAL  
ENGINEERING CHEMISTRY**  
2 cr. (2 and 0)

Advanced principles and methods in environmental engineering chemistry with applications to both natural and treatment systems; current investigative and study techniques. Topics include the nature, fluxes, and controlling processes of chemical species and radionuclides in environmental systems. **Prerequisite:** ESE 443/643 or equivalent.

**ESE 848 ENVIRONMENTAL ENGINEERING CHEMISTRY II**  
2 cr. (2 and 0)

Applications of principles of organic chemistry and biochemistry to problems of environmental control and waste treatment; treatability and potential health hazards of complex organic compounds emphasized.

**ESE 849 ENVIRONMENTAL SYSTEMS ENGINEERING CHEMISTRY  
LABORATORY II**  
2 cr. (0 and 6)

Theory and applications of instrumental methods of analysis as applied to measurements for environmental control; spectroscopy and spectrophotometric



techniques, electrochemical analyses, chromatographic methods of analysis, and light scattering and electrophoretic measurements.

**ESE 850 STREAM AND ESTUARINE ANALYSIS**

3 cr. (3 and 0)

Physical, chemical and biological processes and relationships which exist in streams and estuaries; estuarine environment, free-flowing streams, mechanisms which describe transport of conservative and non-conservative materials through estuarine systems; the estuary as a resource and techniques for its management.

**ESE 852 ECOLOGICAL MODELS**

3 cr. (2 and 3)

Systems analysis applied to ecology; construction of models which predict ecological consequences of stresses to the environment; frequency response analysis, energy models, information flow, and transfer functions for population interactions. **Prerequisites:** A course in ecology and in computer programming, or permission of instructor.

**ESE 856 POLLUTION OF THE AQUATIC ENVIRONMENT**

3 cr. (3 and 0)

Effects of domestic and industrial water pollution on the physical, chemical and biological characteristics of natural waters; associated environmental determinants of human disease, toxicology and epidemiology of chronic disease.

**ESE 857 POLLUTION OF THE AQUATIC ENVIRONMENT LABORATORY**

1 cr. (0 and 3)

Field and laboratory investigations into physical, chemical and biological effects resulting from pollution of the aquatic environment.

**ESE 861 ENVIRONMENTAL SYSTEMS ENGINEERING SEMINAR**

1 cr. (1 and 0) F, S

Current advances and research developments in various areas of environmental engineering. Off-campus speakers, students, and faculty participate.

**ESE 862 ENVIRONMENTAL QUALITY CASE STUDY**

1 cr. (0 and 3) F

An in-depth analysis and investigation of a significant current or recent situation affecting or involving some facet of environmental quality. Study will be conducted by a team of students and will result in a comprehensive position paper which integrates the pertinent social, political, and economic considerations in the case with the technical aspects.

**ESE 875 WATER RESOURCES PLANNING**

3 cr. (3 and 0)

Water and environmental planning, emphasizing factors underlying planning process; historical treatment of water resources development; changing objectives and goals from national and local standpoints; current legislation and guidelines for planning and economic analyses; evolving policy issues; political and institutional dimensions; roles of Congress, executive agencies, and interest groups in environmental planning and implementation.

**ESE 876 WATER RESOURCES SYSTEMS**  
3 cr. (3 and 0)

Current mathematical modeling, optimization, and simulation techniques applied to design of various water resources systems, including environmental control systems, hydrologic systems, and integrated multipurpose systems. Specific techniques utilized are linear programming, dynamic programming, Monte Carlo simulation, queuing theory, and Markov processes.

**ESE 881 SPECIAL PROBLEMS**  
1-4 cr. F, S, SS

Problems selected to meet interests and experience of student and instructor.

**ESE 883 SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING**  
1-4 cr.

A comprehensive study of a topic in environmental engineering not covered in another course. Topics will vary to keep pace with current developments. May be taken concurrently with ESE 884 which (if offered) would be a different topic.

**ESE 884 SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING**  
1-4 cr.

A comprehensive study of a topic in environmental engineering not covered in another course. Topics will vary to keep pace with current developments. May be taken concurrently with ESE 883 which (if offered) would be a different topic.

**ESE 891 MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**ESE 991 DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

**MATERIALS ENGINEERING**

G. C. Robinson, Head, Department of Ceramic Engineering

<b>Major</b>	<b>Degree</b>
Materials Engineering	M.S.

Students with a baccalaureate degree in engineering or science may be accepted. This is a multidisciplinary program in which the relationship between the structures and the properties of materials is emphasized to provide an understanding of material behavior in a variety of applications.

To accomplish this understanding, the student is exposed to learning experiences in the fields of chemistry, engineering, mathematics and physics in order to comprehend and be able to predict the properties and behaviors of ceramics, metals and polymers. The student may select areas of concentration in either materials science or the industrial application of materials. Further study in specific areas of interest is accomplished by completion of courses associated with the student's research which, in turn, will culminate in a master's thesis.

- MAT E 605      PHYSICAL METALLURGY  
3 cr. (3 and 0)
- MAT E 620      INTRODUCTION TO MECHANICAL METALLURGY  
3 cr. (3 and 0)
- MAT E 622      INTRODUCTION TO CHEMICAL METALLURGY  
3 cr. (3 and 0)
- MAT E 624      INTRODUCTION TO EXTRACTIVE METALLURGY  
3 cr. (3 and 0)
- MAT E 650      SPECIAL TOPICS IN MATERIALS ENGINEERING  
1-4 cr.
- MAT E 661      ELEMENTS OF METALLURGY  
3 cr. (2 and 3)
- MAT E 662      HEAT TREATMENT OF STEELS  
3 cr. (2 and 3)
- MAT E 663      METALLURGY OF WELDING AND NON-DESTRUCTIVE TESTING  
3 cr. (2 and 3)
- MAT E 664      INDUSTRIAL CORROSION OF METALS  
3 cr. (2 and 3)
- MAT E 665      INTRODUCTION TO PLASTICS  
3 cr. (3 and 0)
- MAT E 800      SEMINAR IN MATERIALS RESEARCH  
1 cr. (1 and 0)

Presentation and discussion of special topics and original research in materials engineering. Required of all materials engineering graduate students each semester in residence; credit may be earned for more than one semester.

- MAT E 820      DEFORMATION MECHANISMS IN SOLIDS  
3 cr. (3 and 0)
- Dislocation theory of solids; mechanisms of plastic deformation in single crystals and polycrystalline aggregates of metals and non-metals; ductile and brittle fractures; fatigue, creep and stress corrosion cracking metals. **Prerequisite:** MAT E 461/661 or equivalent.

- MAT E 822      CHEMICAL METALLURGY  
3 cr. (3 and 0)
- Applications of chemical thermodynamics to metallic systems including gas-metal reactions, metallic solutions, phase equilibria, and diffusion. **Prerequisite:** A course in thermodynamics.

## MAT E 824     EXTRACTIVE METALLURGY

3 cr. (3 and 0)

Materials and processes used in extraction of metals from ores, emphasizing theory and practice; pyrometallurgy, oxidation-reduction reactions, smelting and refining processes, hydrometallurgy, and electrometallurgy. **Prerequisite:** A course in thermodynamics or physical chemistry.

## MAT E 891     MASTER'S THESIS RESEARCH

Credit to be arranged.

*The following courses offered by various departments represent possible electives for the student in materials engineering. Descriptions of all 800-level courses are listed under the respective department headings.*

## CR E 809     HIGH TEMPERATURE MATERIALS

3 cr. (3 and 0)

## CR E 816     CONSTRUCTION AND STRUCTURE OF GLASSES

3 cr. (3 and 0)

## CR E 821     ANALYTICAL PROCEDURES — X-RAY

3 cr. (3 and 0)

## CR E 825     MAGNETIC AND ELECTRICAL CERAMIC MAT

3 cr. (3 and 0)

## CR E 828     SOLID-STATE CERAMIC SCIENCE

3 cr. (3 and 0)

## BIO E 801     BIOMATERIALS

3 cr. (3 and 0)

## BIO E 802     RESEARCH TECHNIQUES IN BIOMATERIALS EVALUATION

3 cr. (1 and 6)

## BIO E 803     POLYMERS AS BIOMATERIALS

3 cr. (3 and 0)

## E&amp;CE 825     SOLID-STATE ELECTRONICS

3 cr. (3 and 0)

## EM 802     EXPERIMENTAL STRESS ANALYSIS II

3 cr. (2 and 3)

## ME 842     ADVANCED MECHANICAL ENGINEERING DESIGN

3 cr. (3 and 0)

## CH E 818     POLYMER PROCESSING

3 cr. (3 and 0)

TC 811	POLYMER SCIENCE I 3 cr. (3 and 0)
TC 812	POLYMER SCIENCE II 3 cr. (3 and 0)
TC 821	CHEMISTRY OF NATURAL POLYMERS I 3 cr. (3 and 0)
TC 822	CHEMISTRY OF NATURAL POLYMERS II 3 cr. (3 and 0)

**MECHANICAL ENGINEERING**

E. G. Przirembel, Head, Department of Mechanical Engineering

**Major**

Mechanical Engineering

**Degrees**

M.Engr., M.S., Ph.D.

Students will be accepted for the Master of Engineering degree program with undergraduate degrees in mechanical engineering (or equivalent) from ABET accredited programs. Enrollment in the M.S. and Ph.D. programs is open to those students with degrees in physics, applied mathematics, or any branch of engineering.

Programs may be selected with concentrations in applied mechanics, mechanical and manufacturing systems design, and thermal sciences (fluid mechanics, heat transfer, and thermodynamics).

ME 601	DESIGN OF MECHANICAL SYSTEMS COMPONENTS 3 cr. (3 and 0)
ME 602	INNOVATIVE DESIGN III 3 cr. (2 and 3)
ME 604	CONTROL SYSTEMS DESIGN 3 cr. (2 and 2)
ME 606	COMPUTER CONTROL OF MACHINES AND PROCESSES 3 cr. (2 and 2)
ME 607	APPLIED HEAT TRANSFER 3 cr. (3 and 0)
ME 608	NUMERICAL METHODS IN ENGINEERING ANALYSIS 3 cr. (3 and 0)
ME 609	DESIGN OF MACHINE ELEMENTS 3 cr. (3 and 0)
ME 610	MECHANICAL PROCESSING OF MATERIALS 3 cr. (3 and 0)

- ME 611      GAS POWER SYSTEMS  
3 cr. (3 and 0)
- ME 619      CENTRAL-STATION ELECTRIC POWER GENERATION  
3 cr. (3 and 0)
- ME 620      ALTERNATIVE ENERGY SOURCES AND THEIR UTILIZATION  
3 cr. (3 and 0)
- ME 622      PRINCIPLES OF TURBOMACHINERY  
3 cr. (3 and 0)
- ME 625      KINEMATICS: KINEMATIC DESIGN OF MACHINES  
3 cr. (3 and 0)
- ME 629      THERMAL ENVIRONMENTAL CONTROL  
3 cr. (3 and 0)
- ME 630      FLUID POWER — HYDRAULICS  
3 cr. (3 and 0)
- ME 652      SAFETY ENGINEERING  
3 cr. (2 and 3)
- ME 701      APPLICATIONS OF ENGINEERING ANALYSIS  
3 cr. (3 and 0)  
Derivation of conservation and describing equations; initial and boundary conditions for engineering problems; lumped and distributed parameter models; review and application of analytical and numerical solutions to engineering problems.
- ME 801      FOUNDATIONS OF FLUID MECHANICS  
3 cr. (3 and 0)  
Derivations of basic equations for multi-dimensional flow fields; analytical techniques for solving problems in laminar viscous flow and laminar inviscid flow; theories of similitude. **Prerequisites:** Graduate standing and permission of instructor.
- ME 805      HEAT AND MASS TRANSFER I  
3 cr. (3 and 0)  
Conduction and radiation heat transfer; fundamentals, material properties, applications to engineering problems, classical and numerical solutions, diffusion mass transfer. **Prerequisite:** Permission of instructor.
- ME 806      HEAT AND MASS TRANSFER II  
3 cr. (3 and 0)  
Convective heat transfer; convective mass transfer; conservation equations; laminar and turbulent internal and external flow; analytical and numerical solutions; empirical correlations; application to engineering design. **Prerequisite:** Permission of instructor.
- ME 807      MECHANICAL SYSTEMS I  
3 cr. (3 and 0)

Integration and application of selected topics from strength of materials, elasticity, kinematics and dynamics; nature of stress and strain in engineering materials, computer synthesis and analysis of planar linkages, rigid body dynamics applied to engineering systems, and energy techniques. **Prerequisites:** EM 304 and ME 405.

**ME 810      MACROSCOPIC THERMODYNAMICS**  
3 cr. (3 and 0)

First, second and third laws of thermodynamics with engineering applications; thermodynamic property relations; chemical equilibrium. Required for thermal science majors. **Prerequisite:** ME 312 or equivalent.

**ME 811      GAS DYNAMICS**  
3 cr. (3 and 0)

Concepts from thermodynamics, one-dimensional gas dynamics, one-dimensional wave motion, normal and oblique shocks; flow in ducts and wind tunnels; two-dimensional equation of motion; small perturbation theory. **Prerequisite:** EM 320 or equivalent.

**ME 812      EXPERIMENTAL FLUID MECHANICS**  
3 cr. (3 and 0)

Techniques and fundamental principles in measuring fluid properties, velocity, pressure, temperature and methods of flow visualization. Details of instrumentations introduced in the laboratory. **Prerequisite:** ME 801.

**ME 814      TURBULENT BOUNDARY LAYER**  
3 cr. (3 and 0)

Semi-empirical theories of Reynolds stress terms, analytical methods of solving turbulent boundary layer momentum and energy equations for flows with pressure gradient and/or heat transfer, theories pertinent to experimental techniques used for turbulent boundary layer study. **Prerequisite:** ME 801.

**ME 816      ENERGY CONVERSION**  
3 cr. (3 and 0)

Nonconventional methods of energy conversion emphasizing power aspects; solar thermal, solar photovoltaic, fusion, magneto-hydrodynamics, thermoelectrics, thermionics, and fuel cells. **Prerequisite:** Graduate standing.

**ME 820      MODERN CONTROL ENGINEERING**  
3 cr. (3 and 0)

Mathematical modeling of engineering systems using differential and difference state equations; state variable time solutions using analytic and computer aided analysis techniques; state control principles of controllability, observability, stability and performance specification; trade-offs between state variable and transfer function techniques. **Prerequisite:** An undergraduate controls course or permission of instructor.

**ME 821      ADVANCED CONTROL ENGINEERING**  
3 cr. (3 and 0)

Concepts in multivariable, nonlinear, stochastic and optimal control engineering; design and analysis considerations related to physical machines and processes;

mathematical methods as needed. **Prerequisite:** An undergraduate controls course or permission of instructor.

**ME 830 CONDUCTIVE HEAT TRANSFER**  
3 cr. (3 and 0)

Physical properties; steady conduction in one- and two-dimensional systems; conduction under periodic and transient conditions; conduction in systems with moving heat sources; numerical methods of computation. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

**ME 831 CONVECTIVE HEAT TRANSFER**  
3 cr. (3 and 0)

Derivation of continuity, momentum and energy equations for boundary layer flow; solutions for confined and external flow regimes in laminar and turbulent flow. **Prerequisites:** ME 304 or equivalent, and MTH SC 208.

**ME 832 RADIATIVE HEAT TRANSFER**  
3 cr. (3 and 0)

Radiation properties; enclosure theory; radiation exchange between solid bodies; radiation exchange in the presence of absorbing, transmitting and emitting media; combined radiation, conduction and convection exchange. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

**ME 833 HEAT TRANSFER WITH CHANGE OF PHASE**  
3 cr. (3 and 0)

Nucleate boiling in a pool, film boiling in a pool, forced nucleate boiling, forced film boiling, effect of impurities on boiling phenomena, dropwise condensation, filmwise condensation, effect of noncondensable gases on condensation, boiling and condensing processes in systems. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

**ME 841 ADVANCED MECHANICAL ENGINEERING DESIGN I**  
3 cr. (3 and 0)

Design projects selected from industry or government are addressed by a graduate student/faculty design team. Students are required to create and structure a problem solution, the solution being a preliminary design study encompassing analysis, synthesis, evaluation, economic cost/benefit considerations and engineering project organization. **Prerequisite:** Graduate standing or permission of instructor.

**ME 842 ADVANCED MECHANICAL ENGINEERING DESIGN II**  
3 cr. (3 and 0)

Case study method of individual design problems and projects. Cases used as basis for problem formulation, problem analysis, design theory exemplification, and for class discussion and evaluation. Principles of mechanical and engineering sciences introduced and utilized as required for case considerations. **Prerequisite:** ME 401/601 or equivalent, or permission of instructor.

**ME 845 VIBRATION OF CONTINUOUS MEDIA**  
3 cr. (3 and 0)

Fundamental principles of generation, propagation, absorption, reflection and scattering of vibrational waves in solids and fluids; free and forced oscillation of



flexible strings, bars, membranes, and plates; theory of wave motion in liquids and gases. **Prerequisite:** Permission of instructor.

**ME 890 ENGINEERING PROJECT**  
1-3 cr. (0 and 3-9)

Comprehensive analytical and/or experimental treatment of phenomena of current interest in mechanical engineering emphasizing modern technological problems. May be repeated for a maximum of nine credits.

**ME 891 MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**ME 893 SELECTED TOPICS IN MECHANICAL ENGINEERING**  
1-6 cr. (1-6 and 0)

Topics not covered in other courses. May be repeated for credit.

**ME 930 ADVANCED TOPICS IN HEAT TRANSFER**  
1-6 cr. (1-6 and 0)

Topics not covered in other courses. May be repeated for a maximum of six credits.

**ME 991 DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

## SYSTEMS ENGINEERING

R. M. Harnett, Program Coordinator, Department of Electrical and Computer Engineering

Major	Degrees
Systems Engineering	M.S., Ph.D.

Systems engineering is an interdisciplinary field of study. It combines elements of modern industrial engineering/operations research with elements of systems theory. The result is a program that prepares engineers for the design and scientific management of complex systems in their totality. These engineers may pursue careers in manufacturing; in another sphere of engineering activity such as defense, energy, transportation, communications, and health care systems design; or in a combination of these through consulting. This career flexibility and the intellectual stimulation associated with systems problems are important aspects of systems engineering as a profession.

Students with a bachelor's degree in engineering or sciences may be accepted, while those with other backgrounds may be accepted but will be required to make up certain prerequisite courses before formal entrance into the program.

**SE 650 INTRODUCTION TO SYSTEMS ENGINEERING**  
3 cr. (3 and 0)

**SE 652 RELIABILITY ENGINEERING**  
3 cr. (3 and 0)

SE 680 INTRODUCTION TO METHODS OF OPERATIONS RESEARCH  
3 cr. (3 and 0)

SE 681 LINEAR METHODS OF OPERATIONS RESEARCH AND APPLICATIONS  
3 cr. (3 and 0)

SE 684 ENGINEERING ECONOMIC ANALYSIS  
3 cr. (3 and 0)

SE 686 WORK FLOW SYSTEMS AND CONTROL  
3 cr. (3 and 0)

SE 703 ENGINEERING PROJECT OPERATIONS  
3 cr. (3 and 0)

Project organization and planning; project engineering, decision-making process, and patterns of leadership; project financial analysis, time-cost-performance trade-offs, and sensitivity analysis; project scheduling and control techniques; project documentation, communication, and communication skills. **Prerequisite:** B.S. degree in engineering.

SE 803 ENGINEERING OPTIMIZATION AND APPLICATIONS  
3 cr. (3 and 0)

Nonlinear programming, search methods, dynamic programming and discrete optimization; quadratic programming, linearization, direct search, gradient methods, penalty functions, recursive optimization and implicit enumeration. **Prerequisite:** Permission of instructor.

SE 807 DISCRETE SYSTEMS SIMULATION  
3 cr. (3 and 0)

Discrete and Monte Carlo simulation used to model and study stochastic operational systems; simulation languages GPSS V and GASP IV. **Prerequisite:** Permission of instructor.

SE 808 CONTINUOUS SYSTEMS SIMULATION  
3 cr. (3 and 0)

Continuous systems simulation and feedback type simulation models and their use in analyzing engineering, business, governmental and military systems; concept of industrial dynamics; simulation languages GASP IV and DYNAMO. **Prerequisite:** Permission of instructor.

SE 860 DYNAMIC PROGRAMMING  
3 cr. (3 and 0)

Theory and methodology of dynamic programming, Bellman's principle of optimality, Mitten's sufficiency conditions, recursive optimization of serial and nonserial multistage systems, optimization of discrete and continuous systems through decomposition. Emphasis is placed on special aspects of problem formulation. **Prerequisites:** SE 680, 803, 861 or permission of instructor.

SE 861 NONLINEAR PROGRAMMING AND METHODS OF SEARCH  
3 cr. (3 and 0)

Methods for nonlinear, continuous problems; classical optimization, separable

programming, quadratic programming, geometric programming, gradient methods, feasible directions, and accelerating adaptive direct search methods. **Prerequisite:** SE 480/680 or equivalent, or permission of instructor.

SE 880            ADVANCED METHODS OF OPERATIONS RESEARCH  
3 cr. (3 and 0)

Methods and applications in discrete optimization; integer and mixed integer programming, Boolean minimization, network optimization, permutation methods, implicit enumeration, surrogate and aggregate constraints. **Prerequisite:** Permission of instructor.

SE 885            DESIGN AND ANALYSIS OF SIMULATION MODELS  
3 cr. (3 and 0)

Design and validation of operations research-type simulation models; analysis of statistical properties of input data of these models. **Prerequisites:** SE 807 and MGT SC 614 or equivalent.

SE 886            OPERATIONS RESEARCH IN PRODUCTION CONTROL I  
3 cr. (3 and 0)

Latest techniques in scientific inventory management, scheduling, and forecasting; operations research, statistics, computer methods, and case studies.

SE 888            APPLIED QUEUING THEORY AND MARKOV PROCESSES  
3 cr. (3 and 0)

Analysis of single and multiple channel queues using mathematical queuing theory; Markov processes including rewards and value and policy iteration techniques.

SE 890            SPECIAL PROBLEMS IN SYSTEMS ENGINEERING  
1-3 cr. (1-3 and 0)

Principles and methods of systems engineering applied to analysis of a current interest problem. May be repeated for additional credit. **Prerequisite:** Permission of instructor.

SE 891            MASTER'S THESIS RESEARCH  
Credit to be arranged.

SE 893            SELECTED TOPICS IN SYSTEMS ENGINEERING  
1-3 cr. (1-3 and 0)

Selected topics in systems engineering emphasizing new developments in systems science, systems analysis and operations research. May be repeated for additional credit. **Prerequisite:** Permission of instructor.

SE 895            SYSTEMS ENGINEERING SEMINAR  
1 cr. (1 and 0)

Specific industrial and governmental applications of systems engineering throughout life cycle of system. Students present and lead discussions on current research and advanced techniques in systems engineering. **Prerequisite:** Permission of instructor.

SE 991            DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

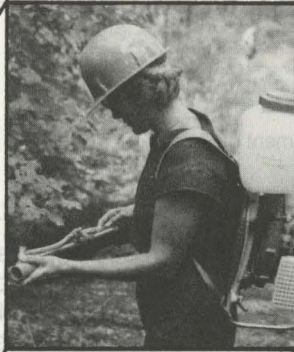


# COLLEGE OF FOREST AND RECREATION RESOURCES

B. H. Box Dean

## College Of Forest And Recreation Resources

FORESTRY  
RECREATION AND PARK  
ADMINISTRATION



### FORESTRY

R. M. Allen, Head, Department

Major  
Forestry

Enrollment in the Forestry program is open to students who have completed the required or disciplinary courses. The candidate may be required to satisfy the minimum requirements before being admitted to the program.

A formal thesis is required for the M.S. degree. For the M.F. a non-thesis degree, a minimum of 36 semester hours of graduate course work must be completed with at least 18 of the required hours coming from courses numbered 700 or above.

FOR 601 HARVESTING FOREST PRODUCTS I

3 cr. (2 and 3)

FOR 602 FOREST MEASUREMENT

3 cr. (2 and 3)

FOR 603 FOREST SOILS SEMINAR

1 cr. (1 and 2)

FOR 604 FOREST ECONOMICS

3 cr. (3 and 4)

FOR 605 FOREST INFLUENCES

2 cr. (2 and 4)

FOR 606 WOOD AND WOOD FIBER IDENTIFICATION

2 cr. (1 and 3)

FOR 607 FOREST PATHOLOGY

3 cr. (2 and 3)



## COLLEGE OF FOREST AND RECREATION RESOURCES

B. H. Box, Dean

The College of Forest and Recreation Resources awards the Master of Science degree in forestry. In addition, the college awards two professional degrees, the Master of Forestry and the Master of Recreation and Park Administration.

The College of Forest and Recreation Resources is concerned with the management, use, and stewardship of our forest resources and with improving the quality of life through rewarding use of leisure. These two general areas of study offer broad opportunities in the management of our forest and our recreation resources for their maximum service to present and future generations.

### FORESTRY

R. M. Allen, Head, Department of Forestry

Major  
Forestry

Degrees  
M.For., M.S.

Enrollment in the Master of Forestry and Master of Science programs is open to students having baccalaureate degrees in forestry, wood utilization, or disciplines related to these fields. The candidate may be required to satisfy undergraduate deficiencies before being admitted to full status.

A formal thesis is required for the M.S. degree. For the M.For., a non-thesis degree, a minimum of 36 semester hours of graduate course work must be completed with at least 18 of the required hours coming from courses numbered 700 or above.

FOR 601	HARVESTING FOREST PRODUCTS I 3 cr. (2 and 3) S
FOR 602	FOREST MENSURATION 3 cr. (2 and 3) S
FOR 603	FOREST SOILS SEMINAR 1 cr. (1 and 0) S
FOR 604	FOREST ECONOMICS 3 cr. (3 and 0) S
FOR 605	FOREST INFLUENCES 2 cr. (2 and 0)
FOR 606	WOOD AND WOOD FIBER IDENTIFICATION 2 cr. (1 and 3) S
FOR 607	FOREST PATHOLOGY 3 cr. (2 and 3)

- FOR 608 AERIAL PHOTOGRAPHS IN FORESTRY  
3 cr. (2 and 3) F
- FOR 609 MULTIPLE-USE FORESTRY  
3 cr. (3 and 0) F
- FOR 610 SILVICULTURE  
4 cr. (3 and 3) S
- FOR 611 HARVESTING FOREST PRODUCTS II  
3 cr. (2 and 3) S
- FOR 612 FOREST PROTECTION  
2 cr. (2 and 0) S
- FOR 614 MANAGEMENT PLANS  
1 cr. (0 and 3) S
- FOR 615 FOREST WILDLIFE HABITAT MANAGEMENT  
3 cr. (2 and 3)
- FOR 616 FOREST POLICY AND ADMINISTRATION  
2 cr. (2 and 0) S
- FOR 617 FOREST MANAGEMENT AND REGULATION  
4 cr. (3 and 3) F
- FOR 618 FOREST VALUATION  
3 cr. (3 and 0) S
- FOR 620 FOREST PRODUCTS  
3 cr. (2 and 3) F
- FOR 621 BIOLOGY AND SILVICULTURE OF HARDWOOD FORESTS  
2 cr. (1 and 2)
- FOR 623 LECTURES IN FORESTRY  
2-4 cr. (2-4 and 0-3)
- FOR 624 FOREST GENETICS AND TREE BREEDING  
3 cr. (3 and 0) S
- FOR 629 WOOD DESIGN  
3 cr. (2 and 3) F
- FOR 630 COMPOSITE WOOD MATERIALS  
3 cr. (2 and 3)
- FOR 631 RECREATION RESOURCE PLANNING IN FOREST  
MANAGEMENT  
3 cr. (3 and 0) F
- FOR 632 FOREST SITE CAPABILITY  
2 cr. (2 and 0)

- FOR 633      **MERCHANDISING OF FOREST PRODUCTS**  
3 cr. (3 and 0)
- FOR 634      **FOREIGN WOODS AND THEIR PROPERTIES**  
2 cr. (1 and 3)
- FOR 635      **PARK AND FOREST STRUCTURES**  
2 cr. (2 and 0)
- FOR 636      **WOOD AS AN ENERGY SOURCE**  
2 cr. (2 and 0)
- FOR 640      **FOREST WETLAND ECOLOGY**  
5 cr. (3 and 6)
- FOR 707      **SPECIAL PROBLEMS IN FORESTRY**  
1-3 cr. (1-3 and 0) F, S, SS  
Directed individual study of a special problem in an applied field of forestry. Written report of study results required.
- FOR 801      **DATA PROCESSING IN FORESTRY PROBLEMS**  
3 cr. (2 and 3) F, S  
Illustration, analysis and discussion of specific approaches used in forestry problems for handling, arranging and analyzing large volumes of field data and for presenting in concise, meaningful form. **Prerequisite:** CP SC 205 or permission of instructor.
- FOR 802      **ADVANCED MENSURATION**  
3 cr. (2 and 3) S (even numbered years)  
Continuation of FOR 602 emphasizing specialized sampling techniques and statistical methods often required only in forestry, compilation of timber volume tables, and forest survey problems. **Prerequisites:** EX ST 301, FOR 302/602 or permission of instructor.
- FOR 803      **PHOTO INTERPRETATION**  
3 cr. (2 and 3) S (odd numbered years)  
Current methodology in aerial photo interpretation techniques, flight plans, taking and processing aerial photographs, and using aerial photographs in timber inventories and cruising. **Prerequisites:** EX ST 301, FOR 308/608 or permission of instructor.
- FOR 804      **ADVANCED FOREST ECONOMICS**  
3 cr. (2 and 3) S (odd numbered years)  
Examination, discussion and application of economic principles to forestry problems in use of land, labor and capital; use of theory to problems of resource allocation and efficiency in forest management. **Prerequisites:** FOR 304/604 and 418/618, or permission of instructor.
- FOR 805      **ADVANCED SILVICULTURE I — FOREST SOILS**  
3 cr. (3 and 0) F (even numbered years)  
Effects of soil on tree growth; kinds, extent and quality of sites; individual soil characteristics such as nutrients, moisture, structure and physiography will be

related to tree growth and site productivity; site manipulation by physical, chemical and biological methods. **Prerequisite:** Permission of instructor.

**FOR 806 ADVANCED SILVICULTURE II — FOREST TREE GROWTH AND DEVELOPMENT**

3 cr. (3 and 0) S (odd numbered years)

Growth and development of economically important forest tree species; structure, function, phenology and wood formation related under forest stand conditions; manipulation of forest tree growth by cultural practice; examination of current research in growth and culture of forest trees and stands. **Prerequisite:** BOT 421/621 or permission of instructor.

**FOR 807 SPECIAL PROBLEMS IN FORESTRY**

Credit to be arranged. F, S, SS

Special problems in forestry research methods that do not directly pertain to the candidate's thesis.

**FOR 808 SEMINAR**

1 cr. (1 and 0) F, S

Discussions of research and current developments in forestry. Students and staff participate; may be taken up to two semesters for credit; graded on a pass-fail basis.

**FOR 891 MASTER'S THESIS RESEARCH**

Credit to be arranged. F, S, SS

**RECREATION AND PARK ADMINISTRATION**

H. Brantley, Head, Department of Recreation and Park Administration

Major	Degree
Recreation and Park Administration	M.R.P.A.

This program is designed for persons who wish to increase their competence in providing leisure services. Flexibility permits individual development in professional interest areas of research and park planning, therapeutic recreation, outdoor/environmental interpretation, or administration of recreation and park systems.

A minimum of 36 semester hours is required. Each candidate completes an original, independent project to meet degree requirements.

Applicants whose academic records do not meet full admission requirements may be considered if successful work experience in a recreation position can be demonstrated. Students from non-recreation disciplines are required to develop background knowledge of recreation through undergraduate course work. All applicants must submit scores on the aptitude section of the Graduate Record Examination.

**RPA 600 SUPERVISION OF RECREATION PERSONNEL, PATTERNS AND PROCESSES**

3 cr. (3 and 0)



- RPA 601 WORLD GEOGRAPHY OF RECREATION AND PARKS  
3 cr. (3 and 0)
- RPA 611 THERAPEUTIC RECREATION FOR SELECTED POPULATIONS  
3 cr. (2 and 3)
- RPA 612 THERAPEUTIC RECREATION AND MENTAL HEALTH  
3 cr. (3 and 0)
- RPA 613 THERAPEUTIC RECREATION FOR PHYSICALLY DISABLED  
3 cr. (2 and 3)
- RPA 621 RECREATION FINANCIAL RESOURCE MANAGEMENT  
3 cr. (3 and 0)
- RPA 631 METHODS OF ENVIRONMENTAL INTERPRETATION  
3 cr. (2 and 3)
- RPA 632 HISTORIC SITE INTERPRETATION  
3 cr. (3 and 0)
- RPA 633 INTRODUCTION TO MUSEOLOGY  
3 cr. (2 and 3)
- RPA 641 COMMERCIAL RECREATION  
3 cr. (3 and 0)
- RPA 642 TOURISM  
3 cr. (3 and 0)
- RPA 701 PHILOSOPHICAL FOUNDATIONS OF RECREATION AND PARK ADMINISTRATION  
3 cr. (3 and 0)

Current theories and philosophies in recreation as it is influenced by and has influence on leisure and man's rapidly changing environment in America. Student develops own professional philosophy of recreation and leisure for world of tomorrow.

- RPA 702 GROUP PROCESSES IN LEISURE SERVICE  
3 cr. (3 and 0)

Improvement in human relations' skills and knowledge of interpersonal needs and problems of individuals and groups; students gain understanding of how others affect them and how they affects others and become more effective professional recreators and park administrators, supervisors, interpreters and educators.

- RPA 703 SEMINAR IN RECREATION AND PARK ADMINISTRATION  
3 cr. (3 and 0)

Case problems relating to administration of a park and recreation agency.

- RPA 704 COMPREHENSIVE RECREATION PLANNING  
3 cr. (3 and 0)

Comprehensive recreation planning theories and practices at federal, state and local levels. Selected case study projects are undertaken in cooperation with other university departments and governmental agencies.

## RPA 705 RECREATIONAL ASPECTS OF WATER RESOURCES

3 cr. (3 and 0)

Relationship of recreation to water; history and legislative background; governmental involvement; current research related to planning, pollution, and demand; future policy decisions.

## RPA 706 URBAN RECREATION ANALYSIS

3 cr. (3 and 0)

Principles of providing recreation services in urban areas.

## RPA 707 PRINCIPLES OF ENVIRONMENTAL INTERPRETATION

3 cr. (3 and 0)

Methods of providing learning experiences in out-of-doors focusing on meaning, scope and values of interpretation.

## RPA 708 SELECTED TOPICS

3 cr. (3 and 0)

Problems of recreation and leisure through a directed reading program and seminar. Student also studies problem areas of own specialization.

## RPA 709 SPECIAL PROBLEMS

1-3 cr. (1-3 and 0)

Directed, individual comprehensive investigation of special problem to utilize knowledge gained in formal courses, to provide experience and training in research, and to prepare for professional goals. Topics vary in areas of interest or experience of student and instructor. Report of findings required.

## RPA 710 CURRENT ISSUES IN RECREATION

1 cr. (1 and 0)

Current topics seminar emphasizing student preparation, organization and communication of material and ideas not covered in formal courses. May be repeated for a maximum of three semester hours of credit.

## RPA 811 RESEARCH AND EVALUATION IN RECREATION

3 cr. (3 and 0)

Principles, methods and strategies for planning, designing, evaluating, and applying studies of recreation. **Prerequisite:** MTH SC 601, or MGT SC 611 or 414/614, or EX ST 801.

## RPA 815 THERAPEUTIC RECREATION AND ACTIVITY THERAPY ADMINISTRATION

3 cr. (3 and 0)

Service delivery structures, interdisciplinary relationships, consultation methods, inservice training, funding sources, and service evaluation in therapeutic recreation and activity therapy programs.

## RPA 820 RECREATION RESOURCE POLICY ISSUES AND PROCESSES

3 cr. (3 and 0)

Outdoor recreation policy-formation structures and processes are surveyed through case studies involving past and current public policy issues.



COLLEGE OF INDUSTRIAL MANAGEMENT AND TEXTILE SCIENCE

# College Of Industrial Management And Textile Science

- ACCOUNTING
- BUSINESS ADMINISTRATION
- ECONOMICS
- ENGINEERING MANAGEMENT
- MANAGEMENT
- MANAGEMENT SCIENCE
- TEXTILE AND POLYMER SCIENCE
- TEXTILE CHEMISTRY
- TEXTILE SCIENCE



the electives for students in  
 management jointly offers the  
 B.A. with Furman University.  
 faculty from both institutions.  
 of Industrial Management  
 students for professional  
 and educational.

Courses are also of  
 other areas.  
 In addition, the D  
 Master of Business  
 Courses are taught  
 Graduate program  
 and Textile Science  
 careers in business

## ACCOUNTING

J. R. Davis, Head, Department of Accounting  
 Advanced degrees are offered in accounting and finance. Courses  
 are offered to provide electives for students in other areas

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ACCT 805 ADVANCED FEDERAL TAXES 3 cr. (3 and 0)

ACCT 810 BUDGETING AND EXECUTIVE CONTROL 3 cr. (3 and 0) F, S

ACCT 811 ADVANCED ACCOUNTING 3 cr. (3 and 0)

ACCT 815 AUDITING 3 cr. (3 and 0)

\*Jointly administered by the Department of Agricultural Economics and Rural Sociology and the Department of Economics. The Ph.D. degree is awarded by the College of Agricultural Sciences.

\*\*Offered by the Department of Industrial Management in cooperation with the College of Engineering.

\*\*\*Jointly administered by the Department of Industrial Management and the Department of Mathematical Sciences. The Ph.D. degree is awarded by the College of Industrial Management and Textile Science.

The Ph.D. degree program is jointly administered by the Department of Textiles and the Department of Chemistry. The Ph.D. in chemistry with a major in textile chemistry is awarded by the College of Sciences.



## COLLEGE OF INDUSTRIAL MANAGEMENT AND TEXTILE SCIENCE

R. C. Amacher, Dean

The College of Industrial Management and Textile Science awards advanced degrees in the following areas of study:

Economics	Management Science***
Applied Economics*	Textile and Polymer Science
Engineering Management**	Textile Chemistry†
Management	Textile Science

Courses are also offered in accounting to provide electives for students in other areas.

In addition, the Department of Industrial Management jointly offers the Master of Business Administration degree (M.B.A.) with Furman University. Courses are taught on the Furman campus by faculty from both institutions.

Graduate programs offered by the College of Industrial Management and Textile Science are designed to equip students for professional careers in business, industry, government, and education.

### ACCOUNTING

J. R. Davis, Head, Department of Accounting and Finance

Advanced degrees are not awarded in accounting and finance. Courses are offered to provide electives for students in other areas.

ACCT 605      ADVANCED FEDERAL TAXES

3 cr. (3 and 0)

ACCT 610      BUDGETING AND EXECUTIVE CONTROL

3 cr. (3 and 0) F, S

ACCT 611      ADVANCED ACCOUNTING

3 cr. (3 and 0)

ACCT 615      AUDITING

3 cr. (3 and 0)

\*Jointly administered by the Department of Agricultural Economics and Rural Sociology and the Department of Economics. The Ph.D. degree is awarded by the College of Agricultural Sciences.

\*\*Offered by the Department of Industrial Management in cooperation with the College of Engineering.

\*\*\*Jointly administered by the Department of Industrial Management and the Department of Mathematical Sciences. The Ph.D. degree is awarded by the College of Industrial Management and Textile Science.

†The Ph.D. degree program is jointly administered by the Department of Textiles and the Department of Chemistry. The Ph.D. in chemistry with a major in textile chemistry is awarded by the College of Sciences.

ACCT 616	AUDITING PRACTICE AND PROCEDURE 3 cr. (3 and 0)
ACCT 630	GOVERNMENTAL AND INSTITUTIONAL ACCOUNTING 3 cr. (3 and 0)
FIN 602	CAPITAL BUDGETING 3 cr. (3 and 0)
FIN 606	PORTFOLIO MANAGEMENT AND THEORY 3 cr. (3 and 0)

## ECONOMICS

R. L. Cottle, Head, Department of Economics

<b>Major</b>	<b>Degree</b>
Economics	M.A.
Applied Economics	Ph.D.

Applicants to the M.A. degree program must have completed at least 12 semester hours of undergraduate economics, including a course in intermediate price theory. A background in mathematics, including at least one course each in calculus and statistics, and a course in computer science equivalent to CP SC 205 are also required. In some instances, the computer science course may be waived for applicants who have completed satisfactorily a year of an appropriate foreign language. When necessary, the economic theory, mathematics, statistics and computer science courses may be taken at Clemson before enrolling in or during the early part of the program.

The graduate program will include one course in econometrics or statistics and one course in mathematical economics as part of the major.

The Department of Economics and the Department of Agricultural Economics and Rural Sociology in the College of Agricultural Sciences jointly offer and administer a Ph.D. program in applied economics. It is described under Applied Economics in the College of Agricultural Sciences.

ECON 603	DEVELOPMENT OF ECONOMIC THOUGHT 3 cr. (3 and 0)
ECON 604	COMPARATIVE ECONOMIC SYSTEMS 3 cr. (3 and 0)
ECON 607	NATIONAL INCOME AND EMPLOYMENT ANALYSIS 3 cr. (3 and 0) F, S
ECON 608	ARBITRATION 3 cr. (3 and 0)
ECON 610	ECONOMIC DEVELOPMENT 3 cr. (3 and 0)

ECONOMICS

- ECON 612 INTERNATIONAL TRADE AND FINANCE  
3 cr. (3 and 0) S
- ECON 619 ECONOMICS OF DEFENSE  
3 cr. (3 and 0)
- ECON 620 PUBLIC SECTOR ECONOMICS  
3 cr. (3 and 0)
- ECON 621 URBAN ECONOMICS  
3 cr. (3 and 0)
- ECON 622 MONETARY THEORY AND POLICY  
3 cr. (3 and 0)
- ECON 624 THE ORGANIZATION OF INDUSTRIES  
3 cr. (3 and 0) F
- ECON 750 ECONOMIC CONCEPTS AND CLASSROOM APPLICATIONS FOR TEACHERS  
3 cr. (3 and 0)

Introduction to economic concepts, analysis and methods emphasizing microeconomics and the market system; development of approaches to teaching economic concepts in public schools. Not open to graduate students in the College of Industrial Management and Textile Science.

- ECON 751 CURRENT ISSUES IN ECONOMICS FOR TEACHERS  
3 cr. (3 and 0)

Analysis of current economic policy issues such as inflation, regulation, protectionism, and energy policy, emphasizing the presentation of these topics to secondary school students. Not open to graduate students in the College of Industrial Management and Textile Science. **Prerequisite:** ECON 200, 201 or 750.

- ECON 801 MICROECONOMIC THEORY  
3 cr. (3 and 0) F

Microeconomic theory and its use to analyze and predict the behavior of industries, firms, and consumers under various market conditions.

- ECON 802 ADVANCED ECONOMIC CONCEPTS AND APPLICATIONS I  
3 cr. (3 and 0)

Rigorous development of price theory under alternative product and resource market structures. **Prerequisite:** Permission of instructor.

- ECON 805 MACROECONOMIC THEORY  
3 cr. (3 and 0) S

Macroeconomic theory involving static and dynamic models and their use in analysis of economic problems and policies.

- ECON 809 MATHEMATICAL ECONOMICS  
3 cr. (3 and 0)

Continuation of ECON 802; examination of current literature developing such topics as demand for capital, industrial structures, labor markets, and monetary phenomena. **Prerequisite:** ECON 802.

**ECON 812 HISTORY OF ECONOMIC THOUGHT**

3 cr. (3 and 0)

Development of economic thought from early Greek thought to Keynesian economics; writings of major economists such as Smith, Ricardo, Marx, Marshall, and Keynes; development of major economic theories.

**ECON 816 LABOR ECONOMICS**

3 cr. (3 and 0)

Wage and employment theory, labor markets, labor history and current problems in labor and manpower economics.

**ECON 817 PUBLIC EMPLOYEE LABOR RELATIONS**

3 cr. (3 and 0)

Labor relations in public sector; analysis of employer-employee relationships in government institutions and factors affecting these relationships including potential role of public employee unions in decision-making process.

**ECON 820 PUBLIC SECTOR ECONOMICS**

3 cr. (3 and 0)

Impact of government on resource allocation, income distribution, and stability; role of regulation; principles of taxation.

**ECON 825 ECONOMICS OF ENVIRONMENTAL QUALITY**

3 cr. (3 and 0) F (even numbered years)

Pricing and distribution emphasizing effects upon economic welfare; goods allocated by government purchase for joint consumption and those distributed by rationing; alternate plans for allocating public goods. **Prerequisite:** ECON 314 or equivalent.

**ECON 831 SEMINAR IN URBAN DEVELOPMENT ECONOMICS**

3 cr. (3 and 0)

Economic analysis of development of urban areas within system of cities; central place theory and general equilibrium models of interregional economic activity emphasizing central place systems, spatial interaction, and stochastic processes; internal development of city focusing on housing and land use patterns, transportation, and urban form.

**ECON 840 INTERNATIONAL TRADE THEORY**

3 cr. (3 and 0)

Theory of free trade from Ricardo to present; theory and application of optimal and second-best tariffs; recent empirical testing of trade and tariff theory. **Prerequisites:** ECON 314, ECON 802 or permission of instructor.

**ECON 850 MONETARY THEORY**

3 cr. (3 and 0)

Economic analysis of money in our economy and effects of monetary policy on prices, interest rates, output, and employment.

**ECON 888 DIRECTED READING IN ECONOMICS**

1-3 cr. (1-3 and 0)

Directed reading and research in the student's field of interest. May be repeated for up to three credit hours.

ECON 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.

ECON 900 SEMINAR IN ADVANCED ECONOMIC THEORY  
3 cr. (3 and 0) F (odd numbered years)

Selected topics that have been and are being discussed in scholarly journals.

### ENGINEERING MANAGEMENT

B. J. Todd, Head, Department of Industrial Management

Major	Degree
Engineering Management	Ph.D.

This program is offered in cooperation with the Department of Industrial Management and the College of Engineering. It is designed to develop a high-level manager/scholar who can apply the most advanced concepts and methods of management science, administrative theory and research techniques to engineering and scientific projects and enterprises.

Entering students must have completed, or must schedule during their first semester, basic courses in accounting, calculus, economics and statistics.

In addition to a management core, the program includes supporting courses in economics and statistical theory. The elective policy allows a student to select an engineering option (12 credits) from the following areas: environmental planning and management, water resources planning and management, food and agricultural management systems, transportation industrial systems, engineering analysis systems, computer application and simulation, computer organization and system structure, programming systems, computing systems, and energy transmission and distribution.

All candidates for the Ph.D. degree in engineering management are required to take responsibility for and instruct an undergraduate course in either management, economics, engineering or mathematics.

E MGT 910 SEMINAR IN OPERATIONS MANAGEMENT  
1-3 cr. (1-3 and 0)

New methodological developments, both analytical and philosophical, in operations management; development of theory of management science; converting management theory to practice while considering behavioral and economic aspects of the problem. **Prerequisite:** Permission of instructor.

E MGT 911 SEMINAR IN DECISION THEORY  
1-3 cr. (1-3 and 0)

Framework and methodology for management decision making in a statistical setting. **Prerequisite:** Permission of instructor.

E MGT 912 SEMINAR IN FINANCIAL ANALYSIS  
3 cr. (3 and 0)

Management of firm's financial affairs in attempt to develop an optimal capital structure. **Prerequisite:** Permission of instructor.



**MGT 913 MANAGEMENT SYSTEMS ANALYSIS**

3 cr. (3 and 0)

Design, construction, and analysis of stochastic simulation models for typical management decisions; design, input-output, variance reduction, applications, validation, implementation, optimum seeking techniques, designed experiments. Emphasis on effect of model results on managerial policy decisions. **Prerequisite:** OP SC 205 or equivalent.

**MGT 914 SEMINAR IN MARKETING MANAGEMENT**

3 cr. (3 and 0)

Concepts and problems in marketing management. Theory readings, discussions and individual reports in selected areas required. **Prerequisite:** Permission of instructor.

**MGT 991 DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged.

**MANAGEMENT**

J. Todd, Head, Department of Industrial Management

**Major**

Management

**Degree**

M.S.

Requirements for this degree include a minimum of 31 semester hours of work beyond the bachelor's degree. All students take a core curriculum of 21 hours in the areas of quantitative economic analysis, financial analysis, managerial policy, operations management, human resource management, statistical analysis and management science. Electives may be selected from the disciplines of management, economics, engineering, mathematics and statistics. Proficiency in computer programming and statistics is a departmental requirement.

A thesis or non-thesis option is allowed. For the non-thesis program, at least one formal paper or report of substantial content proving the student's ability to do original, effective writing is required. This research and writing requirement carries one semester hour credit. The formal paper must be approved by the student's major advisor.

The department also jointly administers the Master of Business Administration degree (M.B.A.) with the Department of Economics and Business of Furman University. Classes are held on the Furman campus in Greenville, South Carolina. The program is primarily for the industrial manager/engineer who is employed full time. Further information may be obtained by writing the Director, Clemson-Furman M.B.A. Program, Furman University, Greenville, SC 29613.

**MGT 800 MANAGEMENT GAMING**

1 cr. (0 and 3)

Introduction to management game literature and practical application of management games as educational adjuncts. Student participation required in a comprehensive, computerized management simulation game. **Prerequisite:** Permission of instructor.

- MGT 801**      **QUANTITATIVE ECONOMIC ANALYSIS**  
3 cr. (3 and 0)  
Mathematical formulation of economic theory as it applies to management decision making; analytical ideas, rigorous techniques of economic analysis. **Prerequisite:** IM 404/604 or permission of instructor.
- MGT 802**      **FINANCE**  
3 cr. (3 and 0) F  
Analysis of financial condition of business firms as means of recognizing current and long-term financial needs; selection of most feasible actions necessary to secure best possible financing under varied circumstances.
- MGT 803**      **OPERATIONS MANAGEMENT**  
3 cr. (3 and 0)  
Selected topics of advanced management science techniques including quality control, inventory analysis and control, economics of equipment replacement macro and micro production planning and control, scheduling heuristics, network analysis and queuing, Koenig's theorem. **Prerequisite:** IM 402/602 or equivalent.
- MGT 804**      **MANAGERIAL POLICY**  
3 cr. (3 and 0) F  
Management policy making emphasizing determining objectives and developing sound policies for achieving them. Managerial Policy builds upon and integrates the other graduate courses; case method is used extensively; written and oral presentation required.
- MGT 805**      **ADVANCED QUALITY CONTROL**  
3 cr. (3 and 0)  
Statistical techniques employed in complex quality control schemes including recent developments in statistical quality control. **Prerequisite:** MTH SC 301 and IM 304, or equivalent.
- MGT 807**      **COMPARATIVE MANAGEMENT THEORY**  
3 cr. (3 and 0)  
Evolution of management theory up to and including contemporary theories integrating early management thought with more recent contributions in scientific management, behavioral management, and quantitative management. **Prerequisite:** Graduate standing.
- MGT 810**      **MANAGEMENT AND THE LAW**  
3 cr. (3 and 0)  
Legal environment in which managers operate; legal processes, institutions and machinery and those areas in the substantive law, including both private law and governmental regulations, that affect various managerial functions. **Prerequisite:** IM 322 or equivalent or permission of instructor.
- MGT 811**      **ADVANCED MARKETING ANALYSIS**  
3 cr. (3 and 0)  
Seminar in marketing approaching topic from viewpoint of highest level management and emphasizing decision making process in marketing. **Prerequisite:** IM 412/612 or permission of instructor.

- MGT 812**      **TRANSPORTATION PLANNING AND POLICY**  
3 cr. (3 and 0)  
Transportation policy and planning in U.S. from 1789 to present; various transport modes with respect to economic efficiency and environmental effect; feasibility and likely results of substituting one mode for another in context of integrated transportation system; future transportation systems and attendant problems and policies. **Prerequisite:** IM 405/605 or permission of instructor.
- MGT 816**      **MANAGEMENT OF HUMAN RESOURCES**  
3 cr. (3 and 0) S  
Advanced consideration of topics covered in IM 416/616. **Prerequisite:** IM 416/616 or permission of instructor.
- MGT 891**      **MASTER'S THESIS RESEARCH**  
Credit to be arranged.
- H ADM 610**    **HOSPITAL INTERNSHIP**  
3 cr. (0 and 9)
- H ADM 800**    **THE FUNCTION AND ORGANIZATION OF HOSPITALS AND HEALTH SERVICES ADMINISTRATION**  
3 cr. (3 and 0)  
Overview of organization, function, place in community and society of hospitals, individual health services and public health services. This course in conjunction with an administrative internship prepares student for major responsibilities in health service administration.
- IM 601**        **QUANTITATIVE MARKETING ANALYSIS**  
3 cr. (3 and 0) F, S
- IM 602**        **OPERATIONS PLANNING AND CONTROL**  
3 cr. (3 and 0)
- IM 604**        **MANAGERIAL ECONOMICS**  
3 cr. (3 and 0) F, S
- IM 605**        **ECONOMICS OF TRANSPORTATION**  
3 cr. (3 and 0) F
- IM 606**        **THEORY OF INDUSTRIAL LOCATION**  
3 cr. (3 and 0) S
- IM 608**        **WORK SIMPLIFICATION AND STANDARDIZATION**  
3 cr. (3 and 0) F, S
- IM 612**        **MARKETING MANAGEMENT**  
3 cr. (3 and 0) S
- IM 613**        **MARKETING COMMUNICATIONS**  
3 cr. (3 and 0)
- IM 615**        **BUSINESS POLICY**  
3 cr. (3 and 0)

- IM 616            MANAGEMENT OF HUMAN RESOURCES  
3 cr. (3 and 0)
- IM 617            LOGISTICS MANAGEMENT  
3 cr. (3 and 0)
- IM 618            MANAGEMENT INFORMATION SYSTEMS  
3 cr. (3 and 0)
- IM 619            MARKETING INFORMATION  
3 cr. (3 and 0)
- IM 620            MANAGEMENT OF DEFENSE EXPENDITURES  
3 cr. (3 and 0) F
- IM 621            CONSUMER BEHAVIOR  
3 cr. (3 and 0)

**MANAGEMENT SCIENCE**

N. K. Womer, Program Coordinator, Department of Industrial Management

Major	Degree
Management Science	Ph.D.

The Departments of Industrial Management and Mathematical Sciences jointly offer and administer this program. Applicants should have a demonstrated aptitude for quantitative analysis and a primary interest in scientific management research and practice. The program is for persons interested in using and developing the growing array of statistical and quantitative techniques being used in decision-making by the larger and more sophisticated American, foreign, and multinational firms. Such techniques include probability models; statistical analysis; linear, nonlinear, and dynamic programming; and decision theory.

The program structure blends courses in statistical theory, operations research, functional areas of management, econometrics, and economics to provide a balanced offering of advanced work in each field contributing to the degree.

- MGT SC 611    INTRODUCTION TO ECONOMETRICS  
3 cr. (3 and 0)
- MGT SC 613    MANAGEMENT SCIENCE I  
3 cr. (3 and 0) F
- MGT SC 614    STATISTICAL ANALYSIS  
3 cr. (3 and 0) F
- MGT SC 806    REGIONAL SCIENCE METHODS  
3 cr. (3 and 0)

Regional growth theory, regional development and planning; role of resources and migration in regional development, definition of regions, concept of planning

regions, objectives and measures of regional development. **Prerequisite:** Permission of instructor.

**MGT SC 807 ECONOMETRIC METHODS I**  
3 cr. (3 and 0)

Economic models expressed as systems of equations are presented. Problems of identification, parameter estimation, measurement errors, and statistical inference are treated. Techniques of simulation, forecasting, model validation, and interpretation are discussed and illustrated.

**MGT SC 808 ECONOMETRIC METHODS II**  
3 cr. (3 and 0) S

Continuation of MGT SC 807; current economic models and estimation procedures. **Prerequisite:** MGT SC 807.

**MGT SC 812 MANAGEMENT SCIENCE II**  
3 cr. (3 and 0)

Continuation of MGT SC 613; dynamic, integer, and nonlinear programming emphasizing applications of different types of mathematical programming to business and industrial problems. **Prerequisite:** MGT SC 413/613 or permission of instructor.

*The following courses offered by various departments represent possible electives for the student in management science. Descriptions for all 800-level courses are listed under the respective department headings.*

**E MGT 913 MANAGEMENT SYSTEMS ANALYSIS**  
3 cr. (3 and 0)

**MTH SC 602 THEORY OF PROBABILITY**  
3 cr. (3 and 0)

**MTH SC 603 STATISTICAL INFERENCE**  
3 cr. (3 and 0)

**MTH SC 652 LINEAR PROGRAMMING**  
3 cr. (3 and 0)

**MTH SC 671 APPLIED STATISTICAL DECISION THEORY**  
3 cr. (3 and 0)

**MTH SC 673 INTRODUCTION TO NONLINEAR OPTIMIZATION**  
3 cr. (3 and 0)

**MTH SC 801 GENERAL LINEAR HYPOTHESIS I**  
3 cr. (3 and 0)

**MTH SC 802 GENERAL LINEAR HYPOTHESIS II**  
3 cr. (3 and 0)

**MTH SC 803 STOCHASTIC PROCESSES I**  
3 cr. (3 and 0)

- MTH SC 805 DATA ANALYSIS  
3 cr. (3 and 0)
- MTH SC 809 TIME SERIES ANALYSIS, FORECASTING AND CONTROL  
3 cr. (3 and 0)
- MTH SC 811 NONLINEAR PROGRAMMING  
3 cr. (3 and 0)
- MTH SC 812 DYNAMIC PROGRAMMING  
3 cr. (3 and 0)
- MTH SC 813 ADVANCED LINEAR PROGRAMMING  
3 cr. (3 and 0)
- MTH SC 814 NETWORK FLOWS AND INTEGER PROGRAMMING  
3 cr. (3 and 0)
- MTH SC 817 STOCHASTIC MODELS IN OPERATIONS RESEARCH I  
3 cr. (3 and 0)
- MTH SC 818 STOCHASTIC MODELS IN OPERATIONS RESEARCH II  
3 cr. (3 and 0)
- MTH SC 867 SYSTEMS AND SOFTWARE  
3 cr. (3 and 0)
- MTH SC 868 AN INTRODUCTION TO NUMERICAL PROCESSES  
3 cr. (3 and 0)
- MTH SC 907 MULTIVARIATE ANALYSIS  
3 cr. (3 and 0)
- MGT 801 QUANTITATIVE ECONOMIC ANALYSIS  
3 cr. (3 and 0)
- MGT 802 FINANCE  
3 cr. (3 and 0) F
- MGT 803 OPERATIONS MANAGEMENT  
3 cr. (3 and 0)
- MGT 807 COMPARATIVE MANAGEMENT THEORY  
3 cr. (3 and 0)
- MGT 816 MANAGEMENT OF HUMAN RESOURCES  
3 cr. (3 and 0) S

**TEXTILE AND POLYMER SCIENCE**

E. A. Vaughn, Head, Textile Department

<b>Major</b>	<b>Degree</b>
Textile and Polymer Science	Ph.D.

Qualification to pursue the degree is accomplished by obtaining a grade of A or B in at least three courses that are representative of the major areas of textile and polymer science or by standing special examinations in three courses. Courses currently considered representative are TEXT 821, Fiber Physics; TEXT 835, Textile Structures; TC 811, Polymer Science; TC 831, Physical Chemistry of Dyeing; or TC 821, Chemistry of Natural Polymers.

Other courses, tailored to the individual's objectives, will be selected by the student and his/her advisory committee. The student will normally take a minor in a selected field of science or engineering and will satisfy the requirements established by the minor department. This usually involves 12-24 credit hours in the minor field. A reading knowledge of one foreign language selected by the advisory committee is also required.

## TEXTILE CHEMISTRY

E. A. Vaughn, Head, Textile Department

Major	Degree
Textile Chemistry	M.S.

Applicants must have a bachelor's degree in textile chemistry, textile science, the physical or life sciences, engineering, or a related discipline and must have training in chemistry, physics and mathematics.

The student's major area of study normally will be in fiber chemistry, polymer chemistry, the chemistry of dyeing and/or finishing of fibers and textiles, or the chemistry of composite systems. The minor area of study usually will be in chemistry, physics, engineering, life sciences, or mathematics. Each candidate will conduct an original, independent, scientific investigation in his/her major area and will report the results and conclusions in a thesis.

TC 615	INTRODUCTION TO POLYMER SCIENCE AND ENGINEERING 3 cr. (3 and 0)
TC 616	CHEMICAL PREPARATION OF TEXTILES 3 cr. (2 and 3)
TC 657	DYEING AND FINISHING I 3 cr. (3 and 0)
TC 658	DYEING AND FINISHING II 3 cr. (3 and 0)
TC 659	DYEING AND FINISHING LABORATORY 1 cr. (0 and 3)
TC 675	CELLULOSE CHEMISTRY 2 cr. (2 and 0)
TC 811	POLYMER SCIENCE I 3 cr. (3 and 0)

Chemistry, kinetics, and mechanisms of polymerization reactions; fabrication, preparation, properties, and structure of polymers, copolymers, terpolymers, etc., emphasizing fiber forming polymers, polymer solution chemistry and methods for molecular characterization.

**TC 812 POLYMER SCIENCE II**  
3 cr. (3 and 0)

Classical and statistical thermodynamics applicable to the theory of molecular modeling of polymer melt structure emphasizing transport properties, viscoelastic behavior, and non-Newtonian properties with particular attention to fiber forming polymers.

**TC 821 CHEMISTRY OF NATURAL POLYMERS I**  
3 cr. (3 and 0)

Chemistry of natural polymers emphasizing cellulose and fibrous proteins; monosaccharides; cellulose and related polysaccharides including degradation and substitution reactions; globular and fibrous proteins in terms of structure, conformation, and chemistry of constituent amino acids.

**TC 831 PHYSICAL CHEMISTRY OF DYEING**  
3 cr. (3 and 0)

Fundamental properties of dye systems; kinetic and thermodynamic data used to correlate dye and fiber structure with proposed dyeing mechanisms; kinetics of diffusions in dyeing processes; theory of color and its use in dyeing operations. **Prerequisite:** TC 457/657.

**TC 891 MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**TEXTILE SCIENCE**

E. A. Vaughn, Head, Textile Department

Major	Degree
Textile Science	M.S.

Applicants must have a bachelor's degree in textile chemistry, textile science, the physical or life sciences, engineering, or related disciplines.

A student's major area of study usually is in fiber science, polymer science, or textile technology. The minor normally is in the life or physical sciences, engineering, mathematics, or management. Each student must complete an original, independent, scientific or technical investigation and report the results and conclusions in a thesis.

**TEXT 603 FIBER PROCESSING**  
3 cr. (2 and 2)

**TEXT 611 FABRIC DEVELOPMENT**  
3 cr. (2 and 2)

**TEXT 621 FIBER SCIENCE**  
3 cr. (2 and 2)



TEXT 622      PROPERTIES OF TEXTILE STRUCTURES  
3 cr. (2 and 2)

TEXT 626      INSTRUMENTATION  
3 cr. (3 and 0)

TEXT 640      COLOR SCIENCE  
3 cr. (3 and 0)

TEXT 660      TEXTILE PROCESSES  
3 cr. (3 and 0)

TEXT 701      APPLIED SCIENCE TECHNOLOGIES  
3 cr. (2 and 4)

Theoretical concepts in chemistry and physics related to applied technologies via a study of selected processes and techniques used in polymer, fiber, and textile industries today. Concepts developed in classroom will be translated into industrial applications by use of field trips, demonstrations, and experimentation in the laboratory. Not open to students in College of Industrial Management and Textile Science. **Prerequisite:** Permission of instructor.

TEXT 821      FIBER PHYSICS  
3 cr. (3 and 0)

Concepts and theories of fiber structure; methods of investigating natural and man-made fiber structure; examination of various interpretations of fiber structure based upon methods used to investigate structure; analytical and empirical models of fiber structure.

TEXT 830      TEXTILE PHYSICS  
3 cr. (3 and 0)

Physical principles underlying manufacturing environments in which fibers, yarns and fabrics are produced. Physical and mathematical techniques are developed for the study and analysis of the textile plant environment, controls and energy requirements.

TEXT 835      TEXTILE STRUCTURES I  
3 cr. (3 and 0)

Pioneering works relating fiber properties to yarn properties; yarn geometry, fiber arrangements in twisted yarns, extension and breakage of continuous filament yarns, deformation of staple fiber yarns.

TEXT 840      ADVANCED COLOR SCIENCE  
3 cr. (2 and 3)

Application of modern instruments and computers to color matching and control of color in industrial environment.

TEXT 866      FIBER FORMATION  
3 cr. (3 and 0)

Formation of fibers by wet, dry, and melt spinning emphasizing rheology of solutions and melts, fiber structure, stretching and drawing processes, and inter-relationships of polymer properties and processes that determine fiber properties.

**TEXT 870      ADVANCES IN TEXTILE MANUFACTURING**  
 3 cr. (3 and 0)

Comparisons among cotton, woolen, and worsted processing systems with respect to suitability to fiber characteristics, processing of fiber blends, modern yarn production, non-woven fabrics, and latest developments in textile machinery.

**TEXT 880      SELECTED TOPICS**  
 3 cr. (3 and 0)

Topics not covered in other textile chemistry or textile science courses.

**TEXT 891      MASTER'S THESIS RESEARCH**  
 Credit to be arranged.

**TEXT 991      DOCTORAL DISSERTATION RESEARCH**  
 Credit to be arranged.



# COLLEGE OF LIBERAL ARTS

R. A. Waller, Dean

The College of Liberal Arts offers the Master of Arts degree in English and history. Graduate courses are also offered in political science, psychology and sociology to provide electives for students in other areas.

- ENGLISH
- HISTORY
- POLITICAL SCIENCE
- PSYCHOLOGY
- SOCIOLOGY

## College Of Liberal Arts



An applicant for a semester credits of more level. An applicant in English emphasis should include one of these requirements: A.M. students courses and write a thesis of approved credits of secondary education with a minimum of 18 credits taken in the

Candidates for graduate degrees must also satisfy the following departmental requirements: demonstrated proficiency in completion of ENGL 890, Introduction to Research; completion of ENGL 603 (required to graduate assistants and M.Ed. students but recommended for all); a reading knowledge of an approved foreign language (M.A. program only); and a comprehensive oral examination.

An applicant for a semester credits of more level. An applicant in English emphasis should include one of these requirements: A.M. students courses and write a thesis of approved credits of secondary education with a minimum of 18 credits taken in the

Candidates for graduate degrees must also satisfy the following departmental requirements: demonstrated proficiency in completion of ENGL 890, Introduction to Research; completion of ENGL 603 (required to graduate assistants and M.Ed. students but recommended for all); a reading knowledge of an approved foreign language (M.A. program only); and a comprehensive oral examination.

Candidates for graduate degrees must also satisfy the following departmental requirements: demonstrated proficiency in completion of ENGL 890, Introduction to Research; completion of ENGL 603 (required to graduate assistants and M.Ed. students but recommended for all); a reading knowledge of an approved foreign language (M.A. program only); and a comprehensive oral examination.

ENGL 802	THE ENGLISH LANGUAGE	3 cr. (3 and 0)
ENGL 603	COMPOSITION FOR TEACHERS	3 cr. (3 and 0)
ENGL 804	STRUCTURE OF MODERN ENGLISH	3 cr. (3 and 0)
ENGL 805	SHAKESPEARE	3 cr. (3 and 0)
ENGL 806	STUDIES IN SHAKESPEARE	3 cr. (3 and 0)
ENGL 808	CHAUCER	3 cr. (3 and 0)



## COLLEGE OF LIBERAL ARTS

R. A. Waller, Dean

The College of Liberal Arts offers the Master of Arts degree in English and history. Graduate courses are also offered in political science, psychology and sociology to provide electives for students in other areas.

### ENGLISH

M. T. Inge, Head, Department of English

Major  
English

Degree  
M.A.

An applicant for the M.A. degree in English must present at least 12 semester credits of undergraduate courses in English beyond the sophomore level. An applicant for the M.Ed. degree in secondary education with emphasis in English must present at least nine such credits. The credits should include one course each in the English language, Shakespeare, and American literature above the sophomore level; students deficient in these requirements may seek provisional admission.

M.A. students complete 24 semester credits of approved graduate courses and write a thesis; or, under the non-thesis option, complete 36 credits of approved graduate courses. The M.Ed. degree program in secondary education with emphasis in English requires a total of 36 credits, with a minimum of 12 and a maximum of 18 credits taken in the College of Education.

Candidates for graduate degrees must also satisfy the following departmental requirements: demonstrated proficiency in composition; completion of ENGL 890, Introduction to Research; completion of ENGL 603 (required of graduate assistants and M.Ed. students but recommended for all); a reading knowledge of an approved foreign language (M.A. program only); and a comprehensive oral examination.

ENGL 602	THE ENGLISH LANGUAGE 3 cr. (3 and 0)
ENGL 603	COMPOSITION FOR TEACHERS 3 cr. (3 and 0)
ENGL 604	STRUCTURE OF MODERN ENGLISH 3 cr. (3 and 0)
ENGL 605	SHAKESPEARE 3 cr. (3 and 0)
ENGL 606	STUDIES IN SHAKESPEARE 3 cr. (3 and 0)
ENGL 609	CHAUCER 3 cr. (3 and 0)

- ENGL 610    MEDIEVAL ENGLISH LITERATURE  
3 cr. (3 and 0)
- ENGL 611    THE CLASSICS IN TRANSLATION  
3 cr. (3 and 0)
- ENGL 613    CLASSICAL DRAMA  
3 cr. (3 and 0)
- ENGL 616    MODERN DRAMA  
3 cr. (3 and 0)
- ENGL 622    AMERICAN LITERATURE I  
3 cr. (3 and 0)
- ENGL 623    AMERICAN LITERATURE II  
3 cr. (3 and 0)
- ENGL 624    AMERICAN LITERATURE III  
3 cr. (3 and 0)
- ENGL 625    THE ROMANTIC PERIOD  
3 cr. (3 and 0)
- ENGL 627    THE VICTORIAN PERIOD  
3 cr. (3 and 0)
- ENGL 631    THE RESTORATION AND EIGHTEENTH CENTURY  
3 cr. (3 and 0)
- ENGL 635    SOUTHERN LITERATURE  
3 cr. (3 and 0)
- ENGL 636    MILTON AND HIS AGE  
3 cr. (3 and 0)
- ENGL 637    THE ENGLISH NOVEL  
3 cr. (3 and 0)
- ENGL 638    TWENTIETH CENTURY POETRY  
3 cr. (3 and 0)
- ENGL 639    TWENTIETH CENTURY FICTION  
3 cr. (3 and 0)
- ENGL 640    APPLIED LITERARY CRITICISM  
3 cr. (3 and 0)
- ENGL 643    SEVENTEENTH CENTURY POETRY AND PROSE  
3 cr. (3 and 0)
- ENGL 645    RENAISSANCE NON-DRAMATIC LITERATURE  
3 cr. (3 and 0)

- ENGL 646 TUDOR-STUART DRAMA  
3 cr. (3 and 0)
- ENGL 647 THE AMERICAN NOVEL  
3 cr. (3 and 0)
- ENGL 648 AMERICAN HUMOR  
3 cr. (3 and 0)
- ENGL 652 CREATIVE WRITING FOR TEACHERS  
3 cr. (3 and 0)
- ENGL 661 STUDIES IN ENGLISH LITERATURE TO 1700  
3 cr. (3 and 0)
- ENGL 662 STUDIES IN ENGLISH LITERATURE SINCE 1700  
3 cr. (3 and 0)
- ENGL 751 CHILDREN'S LITERATURE FOR TEACHERS  
3 cr. (3 and 0)  
Literature for grades pre-school through junior high.
- ENGL 761 ENGLISH LITERATURE FOR TEACHERS I  
3 cr. (3 and 0)  
English literature from *Beowulf* to 1700.
- ENGL 801 STUDIES IN THE TEACHING OF ENGLISH: MODERN  
GRAMMAR AND RHETORIC  
3 cr. (3 and 0)  
Principal theories and practices in modern grammar, rhetoric, stylistics and semantics related to teaching composition.
- ENGL 802 STUDIES IN MIDDLE ENGLISH LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1100-1500.
- ENGL 803 STUDIES IN RENAISSANCE ENGLISH LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1500-1700.
- ENGL 804 STUDIES IN NEO-CLASSIC AND ROMANTIC LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1700-1832.
- ENGL 805 STUDIES IN VICTORIAN AND MODERN ENGLISH LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1832 to present.
- ENGL 810 STUDIES IN COLONIAL AND REVOLUTIONARY AMERICAN  
LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1607-1830.

- ENGL 811     STUDIES IN ROMANTIC AND REALISTIC AMERICAN LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from 1830-1900.
- ENGL 812     STUDIES IN MODERN AMERICAN LITERATURE  
3 cr. (3 and 0)  
Principal works in verse and prose from c. 1900 to present.
- ENGL 820     STUDIES IN THEORETICAL AND APPLIED LITERARY CRITICISM  
3 cr. (3 and 0)  
Principal statements of literary critics from classical era to present.
- ENGL 825     STUDIES IN LITERARY GENRES  
3 cr. (3 and 0)  
Principal literary genres.
- ENGL 830     STUDIES IN LINGUISTICS  
3 cr. (3 and 0)  
Concepts of traditional and modern grammarians; development of English language.
- ENGL 831     SPECIAL TOPICS  
3 cr. (3 and 0)  
Topics not covered in other courses.
- ENGL 881     DIRECTED READING  
3 cr. (3 and 0)  
Tutorial work in linguistics or American, British, or European literature not offered in other courses. **Prerequisite:** Permission of department head.
- ENGL 890     INTRODUCTION TO RESEARCH  
1 cr. (1 and 0)  
Literary history and research; use of libraries and bibliographical tools; exposition of scholarship. Required of all candidates for the Master of Arts degree.
- ENGL 891     MASTER'S THESIS RESEARCH  
Credit to be arranged.

## HISTORY

A. Schaffer, Head, Department of History

Major  
History

Degree  
M.A.

The M.A. in history requires 30 credits in courses numbered 600 or above which must be divided as follows: (1) a minimum of 12 credits in courses numbered between 800 and 890; (2) a minimum of 12 elective credits selected with the approval of the director of the graduate program in history; (3) a minimum of 6 credits in graduate thesis research. Additionally, the student must write a thesis acceptable to the department and must demonstrate reading knowledge of a foreign language. A final

examination, which may be written or oral or a combination of the two forms, is required of all candidates.

Students holding an assistantship in the Department of History who receive a grade lower than B in any graduate course may have their assistantship terminated at the discretion of the director of the graduate program.

HIST 600 STUDIES IN UNITED STATES HISTORY  
3 cr. (3 and 0)

HIST 640 STUDIES IN LATIN AMERICAN HISTORY  
3 cr. (3 and 0)

HIST 650 STUDIES IN ANCIENT HISTORY  
3 cr. (3 and 0)

HIST 660 STUDIES IN BRITISH HISTORY  
3 cr. (3 and 0)

HIST 670 STUDIES IN EARLY EUROPEAN HISTORY  
3 cr. (3 and 0)

HIST 671 STUDIES IN MODERN EUROPEAN HISTORY  
3 cr. (3 and 0)

HIST 692 STUDIES IN DIPLOMATIC HISTORY  
3 cr. (3 and 0)

HIST 693 STUDIES IN SOCIAL HISTORY  
3 cr. (3 and 0)

HIST 694 STUDIES IN COMPARATIVE HISTORY  
3 cr. (3 and 0)

HIST 695 STUDIES IN THE HISTORY OF IDEAS  
3 cr. (3 and 0)

HIST 696 STUDIES IN LEGAL HISTORY  
3 cr. (3 and 0)

HIST 715 HISTORY OF THE BLACK AMERICAN  
3 cr. (3 and 0)

Relative position of the black American at various times in American history. For public school teachers; not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.

HIST 719 UNITED STATES HISTORY SINCE 1900  
3 cr. (3 and 0)

American history from 1900 to present, including current problems of ecology, race relations, automation and unemployment, education, domestic and foreign commerce, and social disorganization. Not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.



HIST 732 MODERNIZATION OF EAST ASIA  
3 cr. (3 and 0)

China, Japan and Korea in 20th century emphasizing social and political changes resulting from acceptance of Western ideas. Not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.

HIST 741 COMPARATIVE HISTORY OF THE AMERICAS  
3 cr. (3 and 0)

Concept of a unique Western Hemispheric identity through comparative analysis of common and divergent historical institutions and experiences emphasizing conquest and colonization, slavery and race relations, frontiers, land patterns, industrialization and urbanization, and 20th century reform movements. Not open to candidates for Master of Arts degree in history or Master of Education degree in secondary education, history.

HIST 811 INTRODUCTION TO HISTORICAL RESEARCH  
3 cr. (3 and 0)

Introduction to methodology of history and to the problem inherent in seeking historical objectivity.

HIST 814 MODERN EUROPEAN HISTORIOGRAPHY  
3 cr. (3 and 0)

Major historical works about European society since 1500.

HIST 821 STUDIES IN EIGHTEENTH CENTURY UNITED STATES HISTORY  
3 cr. (3 and 0)

Research in 18th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 822 STUDIES IN NINETEENTH CENTURY UNITED STATES HISTORY  
3 cr. (3 and 0)

Research in 19th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 823 STUDIES IN TWENTIETH CENTURY UNITED STATES HISTORY  
3 cr. (3 and 0)

Research in 20th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 824 SEMINAR IN THE AMERICAN SOUTH  
3 cr. (3 and 0)

Topics in Southern history emphasizing the South's distinctive features.

HIST 861 SEMINAR IN MEDIEVAL ENGLAND  
3 cr. (3 and 0)

Political and institutional development emphasizing government records. **Pre-requisites:** HIST 361, 363 or equivalents.

HIST 863 SEMINAR IN TUDOR ENGLAND  
3 cr. (3 and 0)

Selected topics in English history, 1485-1603.

- HIST 864 SEMINAR IN STUART ENGLAND  
3 cr. (3 and 0)  
Selected topics in English history in 17th century.
- HIST 865 SEMINAR IN MODERN ENGLAND SINCE 1715  
3 cr. (3 and 0)  
Selected topics emphasizing imperial politics. **Prerequisites:** HIST 361, 363 or equivalents.
- HIST 891 MASTER'S THESIS RESEARCH  
Credit to be arranged.
- POLITICAL SCIENCE**  
C. W. Dunn, Head, Department of Political Science  
Advanced degrees are not awarded in political science. Courses are offered to provide electives for students in other areas.
- POL SC 609 DIRECTED STUDY IN AMERICAN INSTITUTIONS  
3 cr. (3 and 0)
- POL SC 622 PROBLEMS OF PUBLIC ADMINISTRATION  
3 cr. (3 and 0)
- POL SC 623 MUNICIPAL ADMINISTRATION  
3 r. (3 and 0)
- POL SC 624 ADMINISTRATIVE LAW  
3 cr. (3 and 0)
- POL SC 625 GOVERNMENTAL BUDGETARY PROCESS  
3 cr. (3 and 0)
- POL SC 627 GOVERNMENT PERSONNEL ADMINISTRATION  
3 cr. (3 and 0)
- POL SC 628 AMERICAN DEFENSE POLICY ANALYSIS  
3 cr. (3 and 0)
- POL SC 629 AMERICAN POLITICS AND EDUCATION  
3 cr. (3 and 0)
- POL SC 632 AMERICAN CONSTITUTIONAL LAW I  
3 cr. (3 and 0)
- POL SC 633 AMERICAN CONSTITUTIONAL LAW II  
3 cr. (3 and 0)
- POL SC 642 POLITICAL PARTIES AND POLITICS  
3 cr. (3 and 0)
- POL SC 662 INTERNATIONAL ORGANIZATIONS  
3 cr. (3 and 0)

**PSYCHOLOGY**

J. D. Davenport, Head, Department of Psychology

Advanced degrees are not awarded in psychology. Courses are offered to provide electives for students in other areas.

- PSYCH 615 SYSTEMS AND THEORIES OF PSYCHOLOGY  
3 cr. (3 and 0)
- PSYCH 624 PHYSIOLOGICAL PSYCHOLOGY  
3 cr. (3 and 0)
- PSYCH 625 PHYSIOLOGICAL PSYCHOLOGY LABORATORY  
1 cr. (0 and 3)
- PSYCH 659 GROUP DYNAMICS  
3 cr. (3 and 0)
- PSYCH 670 THEORIES OF PERSONALITY  
3 cr. (3 and 0)
- PSYCH 683 ABNORMAL PSYCHOLOGY  
3 cr. (3 and 0)
- PSYCH 699 SEMINAR TOPICS IN CURRENT PSYCHOLOGY  
3 cr. (3 and 0)

**SOCIOLOGY**

R. F. Larson, Head, Department of Sociology

Advanced degrees are not awarded in sociology. Courses are offered to provide a minor for students majoring in other areas.

- SOC 621 CONTEMPORARY SOCIOLOGICAL THEORY  
3 cr. (3 and 0)
- SOC 631 APPLIED ORGANIZATIONAL SOCIOLOGY  
3 cr. (3 and 0)
- SOC 641 SOCIAL STRATIFICATION  
3 cr. (3 and 0)
- SOC 651 SOCIOLOGY OF HEALTH AND ILLNESS  
3 cr. (3 and 0)
- RS 601 HUMAN ECOLOGY  
3 cr. (3 and 0)
- RS 659 THE COMMUNITY  
3 cr. (3 and 0)
- RS 671 DEMOGRAPHY  
3 cr. (3 and 0)

RS 881 SPECIAL PROBLEMS IN RURAL SOCIAL RESEARCH

3 cr. (3 and 0)

Recent research problems and literature emphasizing research design, analysis, theoretical generalizations, and application programs. **Prerequisite:** Six semester hours of 600-level sociology and/or rural sociology courses or permission of instructor.

PSYCH 818	SYSTEMS AND THEORIES OF PSYCHOLOGY	3 cr. (3 and 0)
PSYCH 824	PHYSIOLOGICAL PSYCHOLOGY	3 cr. (3 and 0)
PSYCH 825	PHYSIOLOGICAL PSYCHOLOGY LABORATORY	1 cr. (0 and 3)
PSYCH 859	GROUP DYNAMICS	3 cr. (3 and 0)
PSYCH 870	THEORIES OF PERSONALITY	3 cr. (3 and 0)
PSYCH 883	ABNORMAL PSYCHOLOGY	3 cr. (3 and 0)
PSYCH 899	SEMINAR TOPICS IN CURRENT PSYCHOLOGY	3 cr. (3 and 0)

SOCIOLOGY

R. F. Larson, Head, Department of Sociology

Advanced degrees are not awarded in sociology. Courses are offered to provide a minor for students majoring in other areas.

SOC 821	CONTEMPORARY SOCIOLOGICAL THEORY	3 cr. (3 and 0)
SOC 831	APPLIED ORGANIZATIONAL SOCIOLOGY	3 cr. (3 and 0)
SOC 841	SOCIAL STRATIFICATION	3 cr. (3 and 0)
SOC 851	SOCIOLOGY OF HEALTH AND ILLNESS	3 cr. (3 and 0)
RS 801	HUMAN ECOLOGY	3 cr. (3 and 0)
RS 859	THE COMMUNITY	3 cr. (3 and 0)
RS 871	DEMOGRAPHY	3 cr. (3 and 0)



# COLLEGE OF NURSING

M. Coyle, Dean

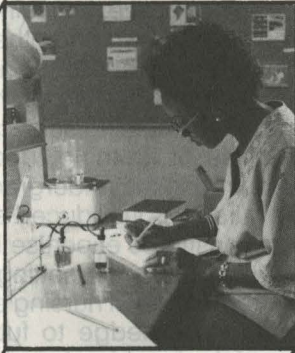
Degree  
M.S.

Major  
Family Health Nursing

## Philosophy:

# College Of Nursing

## FAMILY HEALTH NURSING



The graduate program in nursing is based on the belief that nursing is the continuum of human development and within the context of humanism. The program develops thinking scholars prepared to participate with professional disciplines. Graduate education is postulated on the belief that development of theoretical knowledge is the foundation for the development of nursing practice. Theoretical knowledge in nursing requires the development of understanding, insights, and professional values. Specialization within the profession of nursing requires the development of a variety of skills and at various stages of human development. The program provides opportunities to transmit knowledge through understanding of the teaching-learning process. The dynamic forces of family and community life require that graduate education in family health nursing provide opportunities for collaborative involvement in health promotion with the consumer, public and other professionals. Thus, an education milieu which supports scientific and liberal study, interdisciplinary collaboration, and involvement with the consumer public provides for educational experiences needed to practice humanistic nursing in a rural setting.

## Admission Requirements:

In addition to meeting University admission requirements, students applying to this program should be graduates of baccalaureate programs accredited by the National League for Nursing. Under unusual circumstances, this requirement may be waived by the Dean of the College of Nursing. The applicant should be licensed to practice in a state or territory and carry nurse's liability insurance. Every effort should be made to earn credits in basic statistics before admission. If not taken prior to admission, a course in statistics must be taken during the first semester of study.

## The Program:

The Master of Science degree program in nursing prepares students for a leadership role in family health nursing with emphasis on one of the following developmental levels: maternal-infant, child health, adult and gerontologic nursing, and rehabilitative nursing. The student is also



## COLLEGE OF NURSING

M. Lohr, Dean

Major	Degree
Family Health Nursing	M.S.

### Philosophy:

The graduate program in nursing is based on the belief that nursing is a responsible, searching, transactional relationship considering man along the continuum of human development and within the context of humanism. The program develops self-directive, critically thinking scholars prepared to participate with peers in their own and other disciplines.

Graduate education in nursing at Clemson University is postulated on the belief that development and testing of theoretical knowledge is the foundation for the discipline of nursing science. Theoretical knowledge in nursing requires the base of learning, understanding, insights, and professional values acquired in the undergraduate nursing major.

Specialization within nursing is introduced at the master's level at which time the practitioner demonstrates expertise in caring for individuals and families in a variety of environmental settings and at various stages of human development. Graduate level nursing education provides opportunities to transmit nursing knowledge to future generations of nurses through understanding of the teaching-learning process.

The dynamic forces brought to bear on family and community life require that graduate education in family health nursing provide opportunities for collaborative involvement in health promotion with the consumer public and other professionals. Thus, an education milieu which supports scientific and liberal study, interdisciplinary collaboration, and involvement with the consumer public provides for educational experiences needed to practice humanistic nursing in a rural setting.

### Admission Requirements:

In addition to meeting University admission requirements, students applying to this program should be graduates of baccalaureate programs accredited by the National League for Nursing. Under unusual circumstances, this requirement may be waived by the Dean of the College of Nursing. The applicant should be licensed to practice in a state or territory and carry nurse's liability insurance. Every effort should be made to earn credits in basic statistics before admission. If not taken prior to admission, a course in statistics must be taken during the first semester of study.

### The Program:

The Master of Science degree program in nursing prepares students for a leadership role in family health nursing with emphasis on one of the following developmental levels: maternal-infant, child health, adult and gerontologic nursing, and rehabilitative nursing. The student is also

prepared to conduct research, and those who select the nursing education option are prepared to be teachers of nursing. This program also provides the student with a foundation for continuing graduate study leading to the doctoral degree.

The family health nurse provides nursing care and education to families in health agencies and as an independent practitioner of nursing in collaboration with other professionals. Families are seen primarily in their homes, community agencies, clinics, family practice centers, physicians' offices, or hospitals. The College of Nursing Center includes facilities where the health assessment of clients may take place, nursing interventions may be initiated and evaluated, and from which referrals are made. Supporting course content covers the family, community, nursing role and process, structure of the health care system, research, and joint endeavors with another professional discipline, i.e., architecture. Courses in the humanities and social and biological sciences are selected in accordance with the student's needs.

Students who select the nursing education option are prepared to teach nursing in the clinical and community health settings. This nurse is able to function in curriculum development and as a role model in family health nursing within any setting.

The program can be completed within four sequential semesters but may take longer depending upon the student's needs or wishes. The degree is awarded upon satisfactory completion of 47 semester hours of approved graduate credit exclusive of credits earned in courses taken to meet deficiencies as determined by the major advisor. A thesis, amounting to six credits, is required.

#### NURS 701 HEALTH ASSESSMENT

2 cr. (1 and 3)

Develops skills in assessment of individuals and identification of common health problems; systematic appraisal of physical, emotional, and mental health status of individuals. Recommended for the graduate student in nursing whose undergraduate program did not include the wide range of health assessment skills which will be practiced in laboratory sessions.

#### NURS 801 FAMILY HEALTH NURSING

3 cr. (1 and 6)

Nursing assessment and application of modern concepts of care to nuclear and extended family; physiological and psychosocial nature of health and illness, forces for health and illness, dynamics of family health, helping relationship, crises intervention. Incorporates longitudinal analysis of care of selected families and clinical area of study.

#### NURS 804 NURSING THEORY

2 cr. (2 and 0)

Definition of theory and processes used to develop theory; selected models of

NOTE: The college reserves the right to limit enrollment of students in any course and not to offer a clinical option if enrollment is insufficient.

nursing are presented and evaluated to determine if they classify as theories and their relevance to family health nursing.

**NURS 807 SEMINAR**

1-3 cr.

Research methodology emphasizing research in clinical nursing; ethics in research with human subjects; selected original research papers and other topics and activities related to developments in nursing. Research activity does not include thesis advisement.

**NURS 812 THE DYNAMICS OF COMMUNITY HEALTH**

3 cr. (3 and 0)

Relation of family health to community; epidemiological appraisal of community health; significance of process in planning and decision making; values guiding use and availability of health resources.

**NURS 815 THE PROMOTION AND MAINTENANCE OF HEALTH**

3 cr. (1 and 6)

Incorporation of longitudinal analyses of study of families selected in NURS 801; continuity and coordination of health care; collaboration among professionals; continuing expansion of concepts of care; emerging system of health maintenance; definition of health. **Prerequisite:** NURS 801 and 812.

**NURS 827 FOUNDATIONS OF NURSING EDUCATION**

3 cr. (3 and 0)

Philosophies influencing development of nursing education; influence of experimentalism and existentialism; influences of contemporary theorists such as McGrath, Orem, Phoenix, M. Rogers, Skinner and Tyler.

**NURS 828 THE COLLEGE TEACHER OF NURSING**

3 cr. (3 and 0)

Role and responsibilities of the nurse-teacher in senior and community college nursing programs; curriculum development, use of teaching methods and materials, and clinical laboratory.

**NURS 831 ADULT NURSING I**

6 cr. (3 and 9)

Advanced concepts related to nursing care of young adults; current research related to common health problems of the young adult; role of nurse as primary care provider and family advocate. Clinical laboratory practice selected from among acute, ambulatory and community settings. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 832 ADULT NURSING II**

6 cr. (3 and 9)

Advanced concepts related to nursing care of middle-aged adults; current research related to common health problems of middle-aged adults; role of nurse as primary care provider and family advocate. Clinical laboratory practice selected from among acute, ambulatory and community settings. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 833 REHABILITATIVE NURSING I**

6 cr. (3 and 9)



Exploration of advanced concepts, principles and theories basic to therapeutic practice of professional rehabilitative nursing; phenomenon of human repatterning as conceptual and clinical framework for rehabilitative nursing. Clinical laboratory experience selected from among rehabilitation, ambulatory and community settings. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 834 REHABILITATIVE NURSING II**  
6 cr. (3 and 9)

Exploration of advanced body of knowledge concerned with neuromuscular and skeletal function common to normal human development and also seen in neuromuscular and skeletal injury; utilization of current research to propose innovative approaches for positive repatterning of long-term health alterations; maximizing role of professional nurse as member of interdisciplinary health team. **Prerequisite:** NURS 833.

**NURS 835 CHILD HEALTH NURSING I**  
6 cr. (3 and 9)

Exploration of physiological, psychological and developmental theories and practices relative to childhood (early years through adolescence) and their relationship to professional nursing. Interface of research in nursing and other disciplines is emphasized so as to potentiate the nurse as a teacher, an advocate and a primary care provider. Clinical laboratory experience selected from among acute, ambulatory, home, school and other community settings. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 836 CHILD HEALTH NURSING II**  
6 cr. (3 and 9)

Continuation of NURS 835 with concentration on health care of children (infant through school age) with abnormal responses including maladaptive responses to physiological, psychological, cultural and environmental stresses. Clinical laboratory experience selected from among acute, ambulatory, home, school and other community settings. **Prerequisite:** NURS 835.

**NURS 837 MATERNAL-INFANT NURSING I**  
6 cr. (3 and 9)

Theory and practice in care of parturient women and their newborns; concepts regarding theory development; analysis and evaluation of present theory development in this clinical specialty in nursing and in fields related to maternal and infant care; behavioral, psychoanalytic, maturational and cultural theories of growth and development of individuals. Clinical laboratory practice takes place in hospitals, community centers, physicians' offices and clients' homes. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 838 MATERNAL-INFANT NURSING II**  
6 cr. (3 and 9)

Continuation of NURS 837 with concentration on health care of infants born of the complicated pregnancy; care of infants whose complications stem from endocrinological and genetic problems. Theory is put into practice in primary care settings, neonatal care settings, acute care settings and genetic counseling clinics. **Prerequisite:** NURS 837.

**NURS 840 GERONTOLOGICAL NURSING I**

6 cr. (3 and 9)

Social and psychological research knowledge, theories, concepts and issues basic to therapeutic practice of professional gerontological nursing; phenomenon of human aging as reflection of change in specific patterns which are consistent for all individuals within the species over passage of time. Clinical laboratory experience selected from among gerontological, ambulatory and community settings. **Prerequisites:** NURS 801, 804, 812 and 815.

**NURS 841 GERONTOLOGICAL NURSING II**

6 cr. (3 and 9)

Biological and physiological research knowledge, theories, concepts and issues basic to therapeutic practice of professional gerontological nursing; maximizing role of the professional nurse as member of interdisciplinary health team. Clinical laboratory experience selected from among gerontological, ambulatory and community settings. **Prerequisite:** NURS 840.

**NURS 891 MASTER'S THESIS RESEARCH**

Credit to be arranged.

Research activities related to thesis; a minimum of six hours required.

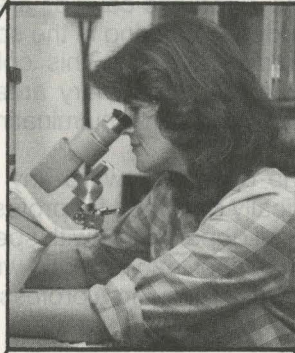


## COLLEGE OF SCIENCES

H. E. Vogel, Dean

- BIOCHEMISTRY
- BOTANY
- CHEMISTRY
- COMPUTER SCIENCE
- GEOLOGY
- MATHEMATICAL SCIENCES
- MICROBIOLOGY
- PHYSICS
- ZOOLOGY

# College Of Sciences



## BIOCHEMISTRY

J. M. Shively, Head, Department of Biochemistry

Major  
Biochemistry  
M.S., Ph.D.  
Degrees

Enrollment in the biochemistry program is open to students with baccalaureate degrees in agricultural, biological, or physical sciences, or engineering. Entering students must have satisfactory academic records in mathematical, physical, and biological sciences. Students with deficiencies may be admitted but will be required to correct these deficiencies during the first year.

Attendance and participation in departmental seminars is mandatory for all graduate students.

Biochemistry 622, 624, 625 and 626 (8 total cr. hrs.) constitute the core of the biochemistry program. All students are expected to complete these courses if they have not had their equivalent at another accredited institution.

In addition to core courses, the M.S. degree requires a minimum of 16 credit hours of course work. Twelve of the 16 credits must be in 800-level courses. A minimum of four credits must be in biochemistry courses. A thesis is required.

In addition to core courses, the Ph.D. degree requires a minimum of 27 credit hours of course work with 15 credits in 800-level biochemistry



## COLLEGE OF SCIENCES

H. E. Vogel, Dean

The College of Sciences offers the Master of Science degree in biochemistry, botany, chemistry, computer science, mathematics, microbiology, physics and zoology and the Doctor of Philosophy degree in biochemistry, chemistry, mathematics, physics and zoology.

Graduate programs leading to the Ph.D. with major emphasis in either botany or microbiology are available through an interdepartmental plant physiology program. In addition, the Ph.D. in management science is awarded jointly with the Departments of Industrial Management and Mathematical Sciences. Graduate courses are also offered in geology to provide a minor for students majoring in the sciences and other areas.

All graduate programs offered in this college emphasize a broad academic foundation in the disciplinary area combined with intensive study and research in a specific area culminating in a departmental report, thesis or dissertation.

Although the college does not award any professional graduate degrees, courses specifically designed for professional level graduate work are available in almost all departments with special attention being paid to secondary level public school teachers who wish to take a major concentration in the sciences while pursuing a professional degree in education.

### BIOCHEMISTRY

J. M. Shively, Head, Department of Biochemistry

**Major**  
Biochemistry

**Degrees**  
M.S., Ph.D.

Enrollment in the biochemistry program is open to students with baccalaureate degrees in agricultural, biological, or physical sciences, or engineering. Entering students must have satisfactory academic records in mathematical, physical, and biological sciences. Students with deficiencies may be admitted but will be required to correct these deficiencies during the first year.

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In addition to core courses, the M.S. degree requires a minimum of 16 credit hours of course work. Twelve of the 16 credits must be in 800-level courses. A minimum of four credits must be in biochemistry courses. A thesis is required.

In addition to core courses, the Ph.D. degree requires a minimum of 27 credit hours of course work with 15 credits in 800-level biochemistry

courses and 12 credits in an approved minor area. Successful completion of written and oral comprehensive exams (after three semesters in residence) will admit the student to candidacy for the Ph.D. degree.

**BIOCH 606 PHYSIOLOGICAL CHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 608 PHYSIOLOGICAL CHEMISTRY LABORATORY**  
1 cr. (0 and 3)

**BIOCH 622 A PHYSICAL APPROACH TO BIOCHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 623 PRINCIPLES OF BIOCHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 624 PRINCIPLES OF BIOCHEMISTRY**  
3 cr. (3 and 0)

**BIOCH 625 GENERAL BIOCHEMISTRY LABORATORY**  
1 cr. (0 and 3)

**BIOCH 626 GENERAL BIOCHEMISTRY LABORATORY**  
1 cr. (0 and 3)

**BIOCH 810 ADVANCED BIOCHEMICAL TECHNIQUES**  
1-3 cr. (0 and 3-9)

Physical and chemical techniques for analysis of biological materials. Emphasis is on instrumentation. **Prerequisites:** BIOCH 422/622 and 425/625; or 423/623 and 425/625; or 406/606 and 408/608; or permission of instructor.

**BIOCH 815 LIPIDS AND BIOMEMBRANES**  
3 cr. (3 and 0)

Isolation, chemical and physical properties, and metabolism of lipids; purification, structure, function, and biosynthesis of biomembranes. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

**BIOCH 817 CHEMISTRY AND METABOLISM OF HORMONES**  
3 cr. (3 and 0)

Isolation, assay, and chemistry of the various hormones. Hormonal control of metabolism and body functions as well as endocrinopathies of hormone imbalance. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

**BIOCH 819 REGULATION OF INTERMEDIARY METABOLISM**  
3 cr. (3 and 0)

Dynamic processes of intermediary metabolism emphasizing control of catabolism and anabolism in both plants and animals. Subject matter will be covered in lectures, guided reading of original current and classical literature, and in discussion. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

**BIOCH 820 NUCLEIC ACIDS AND PROTEIN BIOSYNTHESIS**

3 cr. (3 and 0)

Isolation, composition, structure, maturation and functions of nucleic acids; mechanisms of protein synthesis. Students review recent papers in literature, file reports, and write a potential experimental research proposal. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

**BIOCH 821 PROTEINS**

3 cr. (3 and 0)

Isolation, composition, structure, and properties of proteins; methods of isolation, analysis, characterization; properties of "unusual" protein systems. **Prerequisite:** BIOCH 422/622 or 423/623 or permission of instructor.

**BIOCH 822 ENZYMES**

3 cr. (3 and 0)

Kinetics, mechanism of action, inhibition and general properties of enzymes. **Prerequisite:** BIOCH 422/622 or 423/623.

**BIOCH 824 CELLULAR REGULATION AT THE MOLECULAR LEVEL**

3 cr. (3 and 0)

Cellular regulation at translational and transcriptional level. Students present recent papers from literature and write a research proposal. **Prerequisite:** BIOCH 820 or permission of instructor.

**BIOCH 825 NEUROCHEMISTRY**

3 cr. (3 and 0)

Morphological basis of neurochemistry, function of neural membranes, synaptic functions, brain metabolism, physiological integration of brain structure and function, related topics in medical and behavioral neurochemistry, experimental approaches, current and classical papers from neurochemical literature. **Prerequisite:** BIOCH 424/624.

**BIOCH 831 PHYSICAL BIOCHEMISTRY**

3 cr. (3 and 0)

Description and theory of physical methods and instrumentation used in analysis of biological macromolecules. **Prerequisites:** BIOCH 422/622 or 423/623 and one semester of physical chemistry with permission of instructor.

**BIOCH 851 BIOCHEMISTRY SEMINAR**

1 cr. (1 and 0)

Students review current topics in biochemistry.

**BIOCH 871 ADVANCED TOPICS**

1-3 cr. (1-3 and 0)

Course offerings include bioenergetics, metabolic control mechanisms, biochemistry of unusual systems and current advances in more traditional areas. Topic to be discussed each semester will be announced prior to registration. **Prerequisite:** Permission of instructor.

**BIOCH 891 MASTER'S THESIS RESEARCH**

Credit to be arranged.

BIOCH 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## BOTANY

C. R. Dillon, Head, Department of Botany

Major	Degree
Botany	M.S.
Plant Physiology	Ph.D.

Candidates for graduate work in botany or plant physiology should have a strong undergraduate background in the biological and physical sciences, especially botany and chemistry. Undergraduate curricula which may provide this background are botany, biology or chemistry, or one of the agricultural plant sciences such as agronomy, forestry or horticulture.

All candidates for the Master of Science degree must complete 24 semester hours of course work and six hours of research, and must present and defend a thesis based on original research. Research topics are generally selected from one of the following areas: taxonomy/biosystematics, cytology, development, ecology, mycology, phycology or physiology.

In addition to the Master of Science degree in botany, the department participates in an interdepartmental program awarding the Doctor of Philosophy degree with a major in plant physiology. This program offers considerable opportunity for doctoral research in botany. It is described under Plant Physiology in the College of Agricultural Sciences.

BOT 611	INTRODUCTORY MYCOLOGY 3 cr. (1 and 6) F
BOT 613	PHYCOLOGY 4 cr. (3 and 3) S (odd numbered years)
BOT 621	PLANT PHYSIOLOGY 4 cr. (3 and 3) F, S, SS
BOT 631	INTRODUCTORY PLANT TAXONOMY 3 cr. (2 and 3) F, SS
BOT 632	PLANT GEOGRAPHY 3 cr. (3 and 0) S
BOT 635	PLANT BIOSYSTEMATICS 3 cr. (3 and 0) S (odd numbered years)
BOT 637	PHYLOGENY OF ANGIOSPERMS 3 cr. (3 and 0) F (even numbered years)
BOT 641	PLANT ECOLOGY 4 cr. (3 and 3) F

- BOT 646**      **BIOLOGICAL OCEANOLOGY**  
3 cr. (3 and 0) S (even numbered years)
- BOT 651**      **PLANT ANATOMY**  
4 cr. (3 and 3) F
- BOT 655**      **VASCULAR PLANT MORPHOLOGY**  
4 cr. (3 and 3) S (odd numbered years)
- BOT 656**      **PLANT MICROTÉCHNIQUE**  
2 cr. (0 and 6) S (even numbered years)
- BOT 661**      **CYTOLOGY**  
3 cr. (3 and 0) S (even numbered years)
- BOT 701**      **EVOLUTIONARY BOTANY FOR TEACHERS**  
3 cr. (2 and 3) S, SS  
Survey of plant kingdom emphasizing evolutionary relationships of plant divisions based primarily on morphology; non-vascular plants; vascular plants. Restricted to students in secondary education.
- BOT 702**      **MODERN BOTANICAL CONCEPTS FOR TEACHERS**  
3 cr. (3 and 0) F, SS  
Topics stressing functional processes in plants; physiology, ecology, genetics, and evolution. Restricted to students in secondary education.
- BOT 805**      **SPECIAL PROBLEMS IN BOTANY**  
Credit to be arranged.  
Research in botany or plant physiology not related to a thesis. **Prerequisite:** Permission of instructor.
- BOT 807**      **SEMINAR**  
1 cr. (1 and 0) F, S  
Areas of botanical sciences not covered in other courses. Student reviews literature, organizes and presents material; may be taken for credit only twice.
- BOT 813**      **SPECIAL TOPICS IN MYCOLOGY**  
2-4 cr. (0-2 and 0-6) S  
Literature and current developments in a major group of fungi. Topics vary each semester and may include broader fields of mycological research such as fungal ecology and systematics. May be repeated for credit. **Prerequisite:** Permission of instructor.
- BOT 815**      **PHYCOLOGY COLLOQUIUM**  
1-3 cr. (1-3 and 0) F (odd numbered years)  
Phenomena associated with algae. Discussion topics, taken from current scientific literature, present to students a forum for criticizing research, for conceiving new ideas for research, for developing research outlines and proposals, and for incorporating knowledge gained from phycology into a more inclusive understanding of physical and biological systems. **Prerequisite:** BOT 413/613 or permission of instructor.



- BOT 821 INORGANIC PLANT METABOLISM**  
4 cr. (3 and 3) F (odd numbered years)  
Plant, soil, water, nutrient relations, permeability, uptake and translocation, transpiration, and mineral nutrition. **Prerequisite:** BOT 421/621 or permission of instructor.
- BOT 822 ORGANIC PLANT METABOLISM**  
3 cr. (3 and 0) S (even numbered years)  
Respiration and photosynthesis; synthesis, translocation, storage, transformation and degradation of organic materials, fats, carbohydrates, proteins, pigments, and nucleic acids. **Prerequisites:** BOT 421/621, general biochemistry, or permission of instructor.
- BOT 823 PLANT GROWTH & DEVELOPMENT**  
3 cr. (3 and 0) F (even numbered years)  
Vegetative and reproductive growth and development from seed to maturity, flowering, fruiting and senescence; natural and synthetic growth regulators, and morphogenesis. **Prerequisites:** BOT 421/621, organic chemistry, or permission of instructor.
- BOT 824 MODE OF ACTION OF GROWTH SUBSTANCES**  
4 cr. (3 and 3) S (odd numbered years)  
Physiology and biochemistry of both natural and synthetic growth regulators, hormones, growth retardants, herbicides, and other inhibitors; methodology and mechanism of action. **Prerequisites:** BOT 421/621 and general biochemistry or BOT 822 or permission of instructor.
- BOT 826 PHYSIOLOGY OF THE FUNGI**  
3 cr. (3 and 0) F (even numbered years)  
Fungal growth and cultivation, organic and inorganic metabolism, reproductive physiology, physiology as a taxonomic tool, and ecological interactions of fungi from a physiological viewpoint. **Prerequisites:** BOT 411/611, BOT 421/621, BIOCH 423/623, or permission of instructor.
- BOT 831 ADVANCED PLANT TAXONOMY**  
3 cr. (2 and 3) S (even numbered years)  
Principles of plant classification; relationships and characteristics of major groups of vascular plants. Student collects and identifies spring flora of area. **Prerequisite:** BOT 331/631 or permission of instructor.
- BOT 832 SPECIAL TOPICS IN PLANT SYSTEMATICS**  
1-4 cr. (1-3 and 0-3) S  
Special topics in classical and experimental approaches to plant systematics. May be repeated for credit. **Prerequisite:** BOT 331/631 or permission of instructor.
- BOT 841 THE BIOLOGY OF AQUATIC VASCULAR PLANTS**  
3 cr. (2 and 3) S (odd numbered years)  
Salient features of the aquatic environment relative to aquatic vascular plants and structural adaptations of the vegetative and reproductive organs of water plants; life histories of important aquatic plant families, their biological characteristics, ecological interactions and distribution. **Prerequisites:** BOT 331/631, ZOO 410/610 or permission of instructor.

**BOT 842      PHYSIOLOGICAL PLANT ECOLOGY**

3 cr. (3 and 0) F (odd numbered years)

Interactions between individual plants and their environment; plant adaptations in relation to influences of environmental factors upon gas exchange by plants, upon plant nutrient relations, upon plant water relations, and upon reproduction and establishment of plants. **Prerequisites:** BOT 421/621 and 441/641 or permission of instructor.

**BOT 843      PHYSIOLOGICAL PLANT ECOLOGY LABORATORY**

1 cr. (0 and 3) F (odd numbered years)

Methods and measurements used in physiological plant ecology research; equipment theory and "hands-on" work with equipment to measure photosynthesis, plant water status and other biological and environmental parameters. **Corequisite:** Concurrent enrollment in BOT 842.

**BOT 845      SPECIAL TOPICS IN PLANT ECOLOGY**

1-4 cr. (1-3 and 0-3) S

Methods in vegetation analysis, ecological instrumentation, unique vegetation systems, and other topics and advances in plant ecology. Applicable for all graduate students in ecology; may be repeated for credit. **Prerequisite:** BOT 441/641 or permission of instructor.

**BOT 861      PLANT CELL BIOLOGY**

3 cr. (3 and 0) F (even numbered years)

Structure, development and activities of plant cells; ultrastructural organization uniquely associated with dynamics of cellular growth and development in plants. **Prerequisite:** BOT 421/621 or 461/661 or permission of instructor.

**BOT 891      MASTER'S THESIS RESEARCH**

Credit to be arranged.

**BOT 991      DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged.

**CHEMISTRY**

R. A. Abramovitch, Head, Department of Chemistry and Geology

**Major**  
Chemistry

**Degrees**  
M.S., Ph.D.

Degree concentrations are offered in analytical, inorganic, organic, and physical chemistry. Research areas also include bio-organic chemistry, polymer chemistry and chemical physics. A Ph.D. degree in chemistry with a concentration in textile chemistry is offered jointly with the Textile Department.

Students in either degree program must present satisfactory research seminars and must be competent in computer programming. They must also pass a language requirement in French, German, or Russian.

Master of Science degree candidates must complete 24 hours of course work and six hours of research culminating in the presentation of a satisfactory thesis.

Doctor of Philosophy degree candidates must qualify to pursue the Ph.D. degree by completing a core of four courses with at least a B average during the first two years of study. The core courses are taken in four areas: one in organic, one in physical, and two selected from analytical, inorganic and biochemistry. Qualification requirements may also be satisfied by examination.

Admission to candidacy for the Ph.D. degree requires completion of either a cumulative or a comprehensive examination in the area of concentration. The examination, the type of which depends upon the area selected by the student, may be followed by an oral presentation before the advisory committee.

CH 602	INORGANIC CHEMISTRY 3 cr. (3 and 0)
CH 611	INSTRUMENTAL ANALYSIS 4 cr. (2 and 6)
CH 621	ADVANCED ORGANIC CHEMISTRY 3 cr. (3 and 0)
CH 627	ORGANIC SPECTROSCOPY 3 cr. (2 and 3)
CH 631	PHYSICAL CHEMISTRY 3 cr. (3 and 0)
CH 632	PHYSICAL CHEMISTRY 3 cr. (3 and 0)
CH 635	SPECTROSCOPY AND MOLECULAR STRUCTURE 3 cr. (3 and 0)
CH 639	PHYSICAL CHEMISTRY LABORATORY 1 cr. (0 and 3)
CH 640	PHYSICAL CHEMISTRY LABORATORY 1 cr. (0 and 3)
CH 654	CHEMICAL SYNTHESIS 3 cr. (1 and 6)
CH 691	INTRODUCTION TO RADIOCHEMISTRY 3 cr. (2 and 3)
CH 700	PHYSICAL SCIENCE IN ELEMENTARY SCHOOL — CHEMISTRY 3 cr. (2 and 3)

Basic chemical principles and their applications to everyday life; selecting, carrying out and discussing short, safe, inexpensive experiments to illustrate the principles. Restricted to graduate students in elementary education; graduate students in secondary education may take this course by special permission of instructor.

## CH 701 REVIEW OF GENERAL CHEMISTRY

3 cr. (3 and 0)

Basic principles encountered in a general chemistry course; explanation of observed facts in terms of modern atomic and molecular structure. Restricted to graduate students in elementary and secondary education.

## CH 702 CHEMISTRY FOR HIGH SCHOOL TEACHERS

3 cr. (2 and 3)

Modern chemical topics selected to meet needs of students; fundamental concepts in organic, bio-organic and physical chemistry. Laboratory provides experience in performance and interpretation of illustrative experiments. Restricted to graduate students in secondary education.

## CH 703 SPECIAL PROBLEMS IN CHEMISTRY FOR ELEMENTARY AND SECONDARY SCHOOL TEACHERS

3-6 cr. (2-6 and 6-0)

Directed, individual study in designing experiments and teaching materials or an in-depth study of one or more advanced topics. Seminars used as teaching and evaluation procedure; student completes project which can be used in his or her teaching situation. Restricted to graduate students in elementary and secondary education; may be repeated for additional credit.

## CH 805 THEORETICAL INORGANIC CHEMISTRY

3 cr. (3 and 0)

Application of modern theory to inorganic chemistry. **Prerequisites:** CH 402/602 and 435/635, or permission of instructor.

## CH 806 PHYSICAL METHODS IN INORGANIC CHEMISTRY

3 cr. (3 and 0)

Theory and application of infrared, Raman, visible, ultraviolet, NMR, ESR, NQR, Mössbauer and mass spectrometry to inorganic chemistry. **Prerequisites:** CH 402/602 and permission of instructor.

## CH 807 CHEMISTRY OF THE TRANSITION ELEMENTS

3 cr. (3 and 0)

Chemistry of transition elements emphasizing coordination compounds formed by these elements. **Prerequisite:** CH 402/602.

## CH 808 CHEMISTRY OF THE NON-METALLIC ELEMENTS

3 cr. (3 and 0)

Inorganic chemistry of non-metallic elements, especially boron, silicon, phosphorous, and sulfur. **Prerequisite:** CH 402/602.

## CH 811 ANALYTICAL CHEMISTRY

3 cr. (3 and 0)

Art of analytical chemistry; sample selection, sample treatment, practical aspects of instrumentation, analytical chemistry of 70 chemical elements and several organic functional groups; understanding of complete, economically feasible analytical procedures for determination of components of complex mixtures.

## CH 812 CHEMICAL SPECTROSCOPIC METHODS

3 cr. (2 and 3)

Emission and absorption spectroscopy, chemical microscopy, X-ray diffraction and fluorescence techniques in analytical chemistry; theory and operation of instruments.

CH 814 ELECTROANALYTICAL CHEMISTRY

3 cr. (2 and 3)

Theory and practical application of modern electrochemistry applied to analytical chemistry.

CH 821 ORGANIC CHEMISTRY I

3 cr. (3 and 0)

Theoretical concepts of organic chemistry, stereochemistry and mechanisms of organic reactions. **Prerequisites:** CH 224, 421 or 621, and permission of instructor.

CH 822 ORGANIC CHEMISTRY II

3 cr. (3 and 0)

Continuation of CH 821; mechanisms of organic reactions including photochemistry and Woodward-Hoffman rules; modern synthetic organic chemistry. **Prerequisite:** CH 821 or permission of instructor.

CH 824 FUNDAMENTAL PRINCIPLES OF POLYMER CHEMISTRY

3 cr. (3 and 0)

Organic chemistry of natural and synthetic macromolecules.

CH 825 CHEMISTRY OF HETEROCYCLIC COMPOUNDS

3 cr. (3 and 0)

Chemistry of heterocyclic compounds of nitrogen, oxygen, sulfur and other elements. **Prerequisites:** CH 821 and/or CH 822, or permission of instructor.

CH 830 FUNDAMENTALS OF PHYSICAL CHEMISTRY

3 cr. (3 and 0)

Principles of classical thermodynamics, chemical kinetics and quantum chemistry. **Prerequisite:** CH 331/631 or equivalent.

CH 831 CHEMICAL THERMODYNAMICS

3 cr. (3 and 0)

Classical thermodynamics emphasizing theory and significance of energetics and systems of variable composition. **Prerequisite:** CH 331/631 or its equivalent.

CH 834 STATISTICAL THERMODYNAMICS

3 cr. (3 and 0)

Statistical thermodynamics; ensemble method, ideal gases, internal degrees of freedom, solid state, imperfect gases, distribution function method in fluids, and time-dependent fluctuations. **Prerequisite:** CH 831.

CH 835 CHEMICAL KINETICS

3 cr. (3 and 0)

Rate processes and reaction mechanisms; order of reaction, theory of rate processes, relation of reaction rates to mechanism, homogenous and heterogenous catalysis, experimental methods, chain reactions, diffusion, and effects of solvent, temperature and pressure on reaction rates and mechanisms. Lectures supplemented by assigned problems, paper and oral examination of topic of special interest to student.

**CH 837 QUANTUM CHEMISTRY**

3 cr. (3 and 0)

Mathematical and conceptual formulation of quantum theory of electronic structure of atoms and molecules; eigenvalue solution of one-dimensional Schrodinger equation and application of this method to chemical problems.

**CH 840 TECHNIQUES OF EXPERIMENTAL CHEMISTRY**

3 cr. (1 and 6)

Theory and practice in major experimental techniques used in chemical research; chromatography; NMR, IR, visible, UV and ORD/CD spectrophotometry; glassblowing and high vacuum techniques; mass spectrometry; ESR; Mössbauer spectrometry and tracer analysis.

**CH 851 SEMINAR**

1-2 cr.

Students and faculty review current topics in chemistry. May be taken more than one semester.

**CH 861 PRINCIPLES OF BIOCHEMISTRY**

3 cr. (3 and 0) S

Rigorous, quantitative treatment of properties of biological molecules using modern techniques of organic, physical and analytical chemistry to study structural relationships and biological activity. **Prerequisites:** Satisfactory performance on placement examinations in organic and physical chemistry.

**CH 891 MASTER'S THESIS RESEARCH**

Credit to be arranged.

**CH 900 ADVANCED TOPICS IN INORGANIC CHEMISTRY**

1-4 cr. (1-4 and 0)

Metal-metal bonding, homogeneous catalysis, photochemistry, bioinorganic chemistry. Topics vary with interests of students; may be taken for additional credit.

**CH 910 SPECIAL TOPICS IN ANALYTICAL CHEMISTRY**

1-4 cr. (1-4 and 0)

Separation methods, advanced electrochemistry, new techniques in analytical chemistry, organic analytical reagents, data acquisition and processing, instrument-computer interfacing. Topics vary with interests of students; may be taken for additional credit.

**CH 920 ADVANCED TOPICS IN ORGANIC CHEMISTRY**

1-4 cr. (1-4 and 0)

Heterocyclic compounds; stereochemistry, natural products, organometallic chemistry, photochemistry. Topics vary with interests of students; may be taken for additional credit.

**CH 930 ADVANCED TOPICS IN PHYSICAL CHEMISTRY**

1-4 cr. (1-4 and 0)

Special problems in molecular spectroscopy, molecular orbital treatments, applications of group theory to chemical structure, irreversible thermodynamics, special topics in statistical mechanics. Topics vary with interest of students; may be taken for additional credit.

CH 950 MICROANALYTICAL TECHNIQUES  
3 cr. (1 and 6)

Procedures for analyzing organic compounds for elemental composition. Student perfects laboratory techniques.

CH 991 DOCTORAL DISSERTATION RESEARCH  
Credit to be arranged.

## COMPUTER SCIENCE

A. J. Turner, Jr., Head, Department of Computer Science

Major	Degree
Computer Science	M.S.

The following are required for unconditional admission to graduate study in computer science:

1. The ability to design, code, test and document computer programs written in a high-level programming language. (This implies programming experience considerably beyond that obtained in most beginning programming courses.)

2. Basic mathematics including calculus, elementary probability and statistics, and discrete mathematics or logic.

3. Intermediate-level computer science, including computer organization and data representation, machine and assembly language programming, data structures, file organization and processing, and programming systems.

An applicant with minimal deficiencies may be admitted provisionally, while one with several deficiencies may be required to satisfactorily complete prerequisite work as a post-baccalaureate student prior to admission as a graduate student.

All students must demonstrate proficiency in computer organization, operating systems and systems programming, database systems, programming languages and compilers, and theory of computation either prior to or during study for the M.S. in computer science. Both thesis and non-thesis options are permitted, with the choice to be determined by a student's advisory committee. The non-thesis option requires the completion of a scholarly paper, and no hours of research credit may be counted toward the degree requirements.

CP SC 622 SYSTEMS PROGRAMMING  
3 cr. (3 and 0)

CP SC 623 INTRODUCTION TO OPERATING SYSTEMS  
3 cr. (3 and 0)

CP SC 628 DESIGN AND IMPLEMENTATION OF PROGRAMMING  
LANGUAGES  
3 cr. (3 and 0)

CP SC 629 TRANSLATION OF PROGRAMMING LANGUAGES  
3 cr. (3 and 0)

CP SC 630 COMPUTER PERFORMANCE EVALUATION  
3 cr. (3 and 0)

CP SC 635 MICROPROGRAMMING  
3 cr. (3 and 0)

CP SC 650 THEORY OF COMPUTATION  
3 cr. (3 and 0)

CP SC 662 TELEPROCESSING AND DATA BASE MANAGEMENT  
SYSTEMS  
3 cr. (3 and 0)

CP SC 670 SOFTWARE DEVELOPMENT METHODOLOGY  
3 cr. (3 and 0)

CP SC 680 FUNDAMENTALS OF COMPUTER SCIENCE  
3 cr. (3 and 0)

CP SC 681 SPECIAL TOPICS IN COMPUTER SCIENCE  
1-3 cr. (1-3 and 0)

CP SC 823 OPERATING SYSTEMS DESIGN  
3 cr. (3 and 0)

Analytic, simulation and conceptual models of operating systems and their application to the design and implementation of actual systems; kernel design and its implementation in systems such as MULTICS and UNIX; models of concurrent processes, processor scheduling and memory management. **Prerequisites:** MTH SC 301/601 and CP SC 423/623.

CP SC 828 THEORY OF PROGRAMMING LANGUAGES  
3 cr. (3 and 0)

Syntax and semantics of programming languages; finite state and pushdown processors, context-free models of syntax, parsing algorithms and semantic models. **Prerequisite:** CP SC 428/628 or equivalent.

CP SC 840 DESIGN AND ANALYSIS OF ALGORITHMS  
3 cr. (3 and 0)

Basic techniques for design and analysis of algorithms; models and techniques for obtaining upper and lower time and space bounds, time/space trade-offs and inherently difficult problems. **Prerequisite:** MTH SC 419/619 or E&CE 352 or equivalent.

CP SC 862 DATABASE MANAGEMENT SYSTEM DESIGN  
3 cr. (3 and 0)



Concepts and structures for design and implementation of a DBMS, theoretical foundations for query systems, data modeling and information representation, user interface and internal system design considerations, system performance modeling and measurement, topics from the literature. **Prerequisites:** CP SC 340 and 462/662.

CP SC 881 SPECIAL TOPICS

1-3 cr. (1-3 and 0)

Advanced topics from current problems of interest in computer science; topics vary from semester to semester. May be repeated for credit. **Prerequisite:** Permission of instructor.

CP SC 891 MASTER'S THESIS RESEARCH

Credit to be arranged.

**GEOLOGY**

P. K. Birkhead, Program Coordinator, Department of Chemistry and Geology

Advanced degrees are not awarded in geology. Courses are offered as a minor or as interdisciplinary support for students in other areas.

GEOL 600 ENVIRONMENTAL GEOLOGY

3 cr. (3 and 0)

GEOL 602 STRUCTURAL GEOLOGY

3 cr. (2 and 2)

GEOL 603 INVERTEBRATE PALEONTOLOGY

3 cr. (2 and 3)

GEOL 604 ECONOMIC GEOLOGY

3 cr. (3 and 0)

GEOL 605 GEOMORPHOLOGY

4 cr. (3 and 3)

GEOL 606 MINERALOGY

3 cr. (2 and 3)

GEOL 607 QUATERNARY GEOLOGY

3 cr. (2 and 2)

GEOL 608 GEOHYDROLOGY

3 cr. (3 and 0)

GEOL 609 PETROLOGY

3 cr. (2 and 3)

GEOL 610 OPTICAL MINERALOGY

3 cr. (1 and 4)

GEOL 611 RESEARCH PROBLEMS

1-3 cr. (0 and 3-9)

GEOL 613 STRATIGRAPHY AND SEDIMENTATION  
3 cr. (3 and 0)

GEOL 615 GEOLOGY PRACTICED IN INDUSTRY AND GOVERNMENT  
3 cr. (3 and 0)

GEOL 700 EARTH SCIENCE I  
3 cr. (2 and 3)

Physical geology for secondary school teachers of earth science and physical sciences; materials of earth's crust, processes of formation and change, geologic features of earth. Field trips provide observation of materials, operating processes, and results of processes in nature. Restricted to secondary school teachers.

GEOL 750 EARTH SCIENCE II  
3 cr. (2 and 3)

Historical geology for secondary school teachers of earth science and physical sciences; record of change of earth, both physical and biological, through geologic time to present. Lab demonstration and field trips illustrate methods used in deciphering record as presented. Restricted to secondary school teachers.

### **MATHEMATICAL SCIENCES**

J. D. Fulton, Head, Department of Mathematical Sciences

#### **Major**

Mathematical Sciences

#### **Degrees**

M.S., Ph.D.

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Entering students are expected to have a background in linear algebra, differential equations, a computer language, and statistics.

Students seeking the master's degree may choose a thesis or non-thesis option. Either prior to or during the program, the following general distribution requirements must be met: advanced calculus; modern algebra; probability and a subsequent applied statistics course; mathematical programming; an additional course in statistics or operations research; a numerical computer science course; a discrete computing science course; two core courses beyond advanced calculus and modern algebra; and an applied models course.

In addition, six courses (to be approved by the advisory committee) must be selected from or to complement one of the following specialty areas: algebra/combinatorics, analysis, computational mathematics, operations research, probability and statistics.

A minimum of 36 graduate hours is required for the master's degree. Students in the non-thesis option are required to complete a project.

Students are admitted to candidacy for the Ph.D. degree upon the successful completion of a written comprehensive examination on the subject matter of the major and minor fields.

The Departments of Industrial Management and Mathematical Sciences jointly offer and administer a Ph.D. program in management science. It is described under Management Science in the College of Industrial Management and Textile Science.

MTH SC 601	STATISTICAL THEORY AND METHODS I	3 cr. (3 and 0)
MTH SC 602	THEORY OF PROBABILITY	3 cr. (3 and 0)
MTH SC 603	STATISTICAL INFERENCE	3 cr. (3 and 0)
MTH SC 604	INTRODUCTION TO STOCHASTIC PROCESSES	3 cr. (3 and 0)
MTH SC 605	STATISTICAL THEORY AND METHODS II	3 cr. (3 and 0)
MTH SC 607	PARTIAL DIFFERENTIAL EQUATIONS	3 cr. (3 and 0)
MTH SC 608	TOPICS IN GEOMETRY	3 cr. (3 and 0)
MTH SC 609	STATISTICAL THEORY AND METHODS III	3 cr. (3 and 0)
MTH SC 611	LINEAR ALGEBRA	3 cr. (3 and 0)
MTH SC 612	INTRODUCTION TO MODERN ALGEBRA	3 cr. (3 and 0)
MTH SC 615	INTRODUCTION TO TOPOLOGY	3 cr. (3 and 0)
MTH SC 619	DISCRETE MATHEMATICAL STRUCTURES I	3 cr. (3 and 0)
MTH SC 620	DISCRETE MATHEMATICAL STRUCTURES II	3 cr. (3 and 0)
MTH SC 625	ORTHOGONAL FUNCTIONS AND BOUNDARY VALUE PROBLEMS	3 cr. (3 and 0)
MTH SC 628	NUMERICAL LINEAR ALGEBRA	3 cr. (3 and 0)
MTH SC 630	ACTUARIAL FINITE DIFFERENCES	3 cr. (3 and 0)
MTH SC 631	THEORY OF INTEREST	3 cr. (3 and 0)
MTH SC 635	COMPLEX VARIABLES	3 cr. (3 and 0)

- MTH SC 652 LINEAR PROGRAMMING  
3 cr. (3 and 0)
- MTH SC 653 ADVANCED CALCULUS I  
3 cr. (3 and 0)
- MTH SC 654 ADVANCED CALCULUS II  
3 cr. (3 and 0)
- MTH SC 657 APPLIED MATHEMATICS I  
3 cr. (3 and 0)
- MTH SC 658 APPLIED MATHEMATICS II  
3 cr. (3 and 0)
- MTH SC 660 INTRODUCTION TO NUMERICAL ANALYSIS I  
3 cr. (3 and 0)
- MTH SC 661 INTRODUCTION TO NUMERICAL ANALYSIS II  
3 cr. (3 and 0)
- MTH SC 663 MATHEMATICAL ANALYSIS I  
3 cr. (3 and 0)
- MTH SC 664 MATHEMATICAL ANALYSIS II  
3 cr. (3 and 0)
- MTH SC 671 APPLIED STATISTICAL DECISION THEORY  
3 cr. (3 and 0)
- MTH SC 673 INTRODUCTION TO NONLINEAR OPTIMIZATION  
3 cr. (3 and 0)
- MTH SC 701 NUMBER SYSTEMS FOR THE ELEMENTARY GRADES  
3 cr. (3 and 0)  
Sets and cardinal numbers; development of base ten number system; other ancient and modern number systems including other number bases; formation of mathematical sentences; arithmetic properties of whole numbers; primes and composites; fractions and decimals. Restricted to graduate students in elementary and secondary education.
- MTH SC 702 NUMBER SYSTEMS FOR THE MIDDLE GRADES  
3 cr. (3 and 0)  
Integers; rational numbers; properties and operations of the real number system; logic; relations, functions and graphs; calculators. Restricted to graduate students in elementary and secondary education.
- MTH SC 703 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS — GEOMETRY  
3 cr. (3 and 0)  
Concepts of geometry; informal geometry, measurement of geometric figures, metric measurements, deductive geometry, functions in geometry, coordinate and vector geometry. Open to all graduate students in education except those majoring in secondary education.

**MTH SC 705 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS — ALGEBRA, PROBABILITY, & STATISTICS**

3 cr. (3 and 0)

Fundamentals of elementary algebra, elementary probability, and descriptive statistics. Open to all graduate students in education except those majoring in secondary education.

**MTH SC 710 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT**

3 cr. (3 and 0)

Topics selected from origins of calculus, limits of sequences and functions, the derivative, maxima and minima, continuous functions, composite and inverse functions, calculus of special functions, area and the integral. Intended for high school calculus teachers. May not be included in the degree program for mathematics education majors. **Prerequisite:** MTH SC 108 or its equivalent.

**MTH SC 712 MODERN ALGEBRAIC CONCEPTS**

3 cr. (3 and 0)

Topics may include groups, rings, Boolean algebras, integral domains, fields, Galois theory. Restricted to graduate students in secondary education.

**MTH SC 721 MATRIX ALGEBRA I**

3 cr. (3 and 0)

Determinants, matrices, vectors, vector spaces, and linear transformations; introduction of matrices by systems of equations. Restricted to graduate students in secondary education.

**MTH SC 722 MATRIX ALGEBRA II**

3 cr. (3 and 0)

Continuation of MTH SC 721; linear transformations, similarity, polynomials and polynomial matrices, and matrix analysis. Restricted to graduate students in secondary education.

**MTH SC 725 COMBINATORIAL MATHEMATICS FOR TEACHERS**

3 cr. (3 and 0)

Permutations, combinations, generating functions, recurrence relations, principle of inclusion-exclusion, partitions, Latin squares, block designs, finite geometries, graphs, codes, Polya's theorem, recreational mathematics. Restricted to graduate students in secondary education.

**MTH SC 730 MODERN GEOMETRY FOR TEACHERS**

3 cr. (3 and 0)

Concepts of Euclidean geometry reviewed and extended by means of coordinates, vectors, matrices and conic sections. Restricted to graduate students in secondary education.

**MTH SC 731 NON-EUCLIDEAN GEOMETRY**

3 cr. (3 and 0)

Euclid's fifth postulate, discovery of non-Euclidean geometry, hyperbolic plane geometry. Restricted to graduate students in secondary education.

**MTH SC 732 PROJECTIVE GEOMETRY**

3 cr. (3 and 0)

Analytic and synthetic development of properties of projective geometry and subgeometries, ranging from affine to Euclidean geometry. Restricted to graduate students in secondary education.

**MTH SC 741 INTRODUCTION TO LINEAR PROGRAMMING WITH APPLICATIONS**

3 cr. (3 and 0)

Development of mathematical theory of simplex algorithm; survey of mathematical background required including matrix algebra, systems of linear equations, vector spaces; problem formulation emphasized. Restricted to graduate students in secondary education.

**MTH SC 751 FUNDAMENTAL CONCEPTS OF CALCULUS I**

3 cr. (3 and 0)

Set theory, real number system, functions and relations, metric sets and continuity and differentiation, integration. Restricted to graduate students in secondary education. **Prerequisite:** One year of undergraduate calculus.

**MTH SC 752 FUNDAMENTAL CONCEPTS OF CALCULUS II**

3 cr. (3 and 0)

Vector and Euclidean space, topology of Euclidean  $n$ -space, differential calculus of functions of several variables, integral calculus of functions of several variables. Restricted to graduate students in secondary education. **Prerequisite:** MTH SC 751.

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**MTH SC 761 PROBABILITY AND STATISTICS**

3 cr. (3 and 0)

Probability, conditional probability, descriptive statistics, random variables, probability functions, binomial distribution, normal distribution, sampling, estimation, decision making. Restricted to graduate students in secondary education.

**MTH SC 771 NUMERICAL METHODS IN SECONDARY MATHEMATICS I**

3 cr. (3 and 0)

Update of traditional techniques for teaching high school mathematics through introduction of computer methods for investigation of processes and reinforcement of concepts; development of programs requiring participants to "invent" algorithms to solve problems in typical high school mathematics course; use of general purpose programming language; methods of teaching this language to high school students. Restricted to graduate students in secondary education.

**MTH SC 772 NUMERICAL METHODS IN SECONDARY MATHEMATICS II**

3 cr. (3 and 0)

Continuation of MTH SC 771. Restricted to graduate students in secondary education. **Prerequisite:** MTH SC 771.

**MTH SC 781 HISTORY OF MATHEMATICS**

3 cr. (3 and 0)

Development of mathematics beginning with ancient numeration systems, continuing through origins of geometry and irrational numbers in classical Greek periods and extending through development of calculus, Cantor's set theory; controversy over Euclid's fifth postulate; completeness of

Analytic and synthetic development of properties of projective geometry and its subgeometries, ranging from affine to Euclidean geometry. Restricted to graduate students in secondary education.

**MTH SC 741 INTRODUCTION TO LINEAR PROGRAMMING WITH APPLICATIONS**

3 cr. (3 and 0)

Development of mathematical theory of simplex algorithm; survey of mathematical background required including matrix algebra, systems of linear equations, and vector spaces; problem formulation emphasized. Restricted to graduate students in secondary education.

**MTH SC 751 FUNDAMENTAL CONCEPTS OF CALCULUS I**

3 cr. (3 and 0)

Set theory, real number system, functions and relations, metric sets and limits, continuity and differentiation, integration. Restricted to graduate students in secondary education. **Prerequisite:** One year of undergraduate calculus.

**MTH SC 752 FUNDAMENTAL CONCEPTS OF CALCULUS II**

3 cr. (3 and 0)

Vector and Euclidean space, topology of Euclidean  $n$ -space, differential calculus of functions of several variables, integral calculus of functions of several variables. Restricted to graduate students in secondary education. **Prerequisite:** MTH SC 751.

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**MTH SC 761 PROBABILITY AND STATISTICS**

3 cr. (3 and 0)

Probability, conditional probability, descriptive statistics, random variables, probability functions, binomial distribution, normal distribution, sampling, estimation, decision making. Restricted to graduate students in secondary education.

**MTH SC 771 NUMERICAL METHODS IN SECONDARY MATHEMATICS I**

3 cr. (3 and 0)

Update of traditional techniques for teaching high school mathematics through introduction of computer methods for investigation of processes and reinforcement of concepts; development of programs requiring participants to "invent" algorithms to solve problems in typical high school mathematics course; use of general purpose programming language; methods of teaching this language to high school students. Restricted to graduate students in secondary education.

**MTH SC 772 NUMERICAL METHODS IN SECONDARY MATHEMATICS II**

3 cr. (3 and 0)

Continuation of MTH SC 771. Restricted to graduate students in secondary education. **Prerequisite:** MTH SC 771.

**MTH SC 781 HISTORY OF MATHEMATICS**

3 cr. (3 and 0)

Development of mathematics beginning with ancient numeration systems, continuing through origins of geometry and irrational numbers in classical and Alexandrian Greek periods and extending through development of calculus; Cantor's set theory; controversy over Euclid's fifth postulate; completeness of real

numbers; mathematics of the infinite and its applications; origins of probability and statistics, abstract algebra, topology, computing machines and mathematical logic. Restricted to graduate students in education. **Prerequisite:** One year of calculus at the college level.

#### MTH SC 783 THEORY OF NUMBERS

3 cr. (3 and 0)

Properties of integers, divisors and prime numbers, fundamental properties of congruence, polynomial and primitive roots, quadratic residues. Restricted to graduate students in secondary education. **Prerequisite:** One year of calculus at the college level.

#### MTH SC 791 MATHEMATICAL PROBLEMS IN THE CURRICULUM

3 cr. (3 and 0)

Mathematical problems in curriculum of elementary or secondary school. Restricted to graduate students in elementary or secondary education.

#### MTH SC 801 GENERAL LINEAR HYPOTHESIS I

3 cr. (3 and 0)

Least-square estimates, Gauss-Markov theorem, confidence ellipsoids and confidence intervals for estimable functions, tests of hypotheses, one-two and higher-way layouts, analysis of variance for other models. **Prerequisites:** MTH SC 403/603 and 411/611.

#### MTH SC 802 GENERAL LINEAR HYPOTHESIS II

3 cr. (3 and 0)

Continuation of MTH SC 801.

#### MTH SC 803 STOCHASTIC PROCESSES I

3 cr. (3 and 0)

Theory and analysis of time series, recurrent events, Markov chains, random walks, renewal theory, application to communication theory, and operation research. **Prerequisite:** MTH SC 402/602.

#### MTH SC 804 STOCHASTIC PROCESSES II

3 cr. (3 and 0)

Continuation of MTH SC 803. Renewal theory; branching processes; Brownian motion. Special topics selected from: queuing theory, Markov decision processes, semi-Markov processes, point processes, applications to statistics, and others. **Prerequisite:** MTH SC 803.

#### MTH SC 805 DATA ANALYSIS

3 cr. (3 and 0)

Methodology in analysis of statistical data emphasizing applications to real problems using computer-oriented techniques; computer plots, transformations, criteria for selecting variables, error analysis, multiple and stepwise regression, analysis of residuals, model building in time series and ANOVA problems, jackknife and random subsampling, multidimensional scaling, clustering. **Prerequisites:** MTH SC 301, 402/602.

#### MTH SC 806 NONPARAMETRIC STATISTICS

3 cr. (3 and 0)



Order statistics, tolerance limits, rank-order statistics, Kolmogorov-Smirnov one-sample statistics, Chi-square goodness-of-fit test, two-sample problem, linear rank statistics, asymptotic relative efficiency. **Prerequisite:** MTH SC 402/602.

#### MTH SC 807 APPLIED MULTIVARIATE ANALYSIS

3 cr. (3 and 0)

Applied multivariate analysis: computer plots of multivariate observations; multidimensional scaling; multivariate tests of means, covariances and equality of distributions; univariate and multivariate regressions and their comparisons; MANOVA; principal components analysis; factor analysis; analytic rotations; canonical correlations. **Prerequisites:** MTH SC 403/603 and 805, or permission of instructor.

#### MTH SC 809 TIME SERIES ANALYSIS, FORECASTING AND CONTROL

3 cr. (3 and 0)

Modeling and forecasting random processes; autocorrelation functions and spectral densities; model identification, estimation and diagnostic checking; transfer function models; feedforward and feedback control schemes. **Prerequisites:** MTH SC 402/602, 405/605, or equivalent.

#### MTH SC 811 NONLINEAR PROGRAMMING

3 cr. (3 and 0)

Theoretical development of nonlinear optimization with applications; classical optimization, convex and concave functions, separable programming, quadratic programming, and gradient methods. **Prerequisites:** MTH SC 452/652, 453/653.

#### MTH SC 812 DYNAMIC PROGRAMMING

3 cr. (3 and 0)

Deterministic and stochastic multistage decision processes; Mitten sufficiency, existence and uniqueness theorems, approximation in policy space, multistage games, Markovian decision processes, surveillance theory, and Pontryagin maximum principle. **Prerequisites:** MTH SC 452/652, 454/654.

#### MTH SC 813 ADVANCED LINEAR PROGRAMMING

3 cr. (3 and 0)

Development of linear programming theory using inequality systems, convex cones, polyhedra and duality; solution algorithms and computational considerations for large scale and special structured problems using techniques of upper bounded variables, decomposition, partitioning and column generation; game theory; chance constraints; nonlinear representations. **Prerequisite:** MTH SC 452/652 or equivalent.

#### MTH SC 814 NETWORK FLOWS AND INTEGER PROGRAMMING

3 cr. (3 and 0)

Max flow-min cut theorem, combinatorial applications, minimum cost flow problems (transportation, shortest path, transshipment), solution algorithms (including the out-of-kilter), integer programming including problems with network and special structure and general integer solution methods (branch and bound, cutting plane, group theoretic). **Prerequisite:** MTH SC 452/652 or equivalent.

#### MTH SC 815 DATA STRUCTURES

3 cr. (3 and 0)

Representation and transformation of information; formal descriptions of processes and data structures; tree and list structures, push-down stacks, string and formula manipulation, hashing techniques; interrelation between data structure and program structure; storage allocation methods. **Prerequisites:** Computational maturity and permission of instructor.

**MTH SC 817 STOCHASTIC MODELS IN OPERATIONS RESEARCH I**

3 cr. (3 and 0)

Stochastic control, structure of sequential decision processes; stochastic inventory models, recursive computation of optimal policies; discrete parameter finite Markov decision processes, various optimality criteria, computation by policy improvement and other methods, existence of optimal stationary policies, stopping-rule problems; examples from financial management, maintenance and reliability, search, queuing and shortest path. **Prerequisites:** MTH SC 402/602-404/604.

**MTH SC 818 STOCHASTIC MODELS IN OPERATIONS RESEARCH II**

3 cr. (3 and 0)

Introduction to queuing theory; Markovian queues; repairman problems, queues with an embedded Markov structure, the queue GI/G/1, queues with a large number of servers, decision making in queues; introduction to reliability theory; failure distributions, stochastic models for complex systems, maintenance and replacement policies, reliability properties of multi-component structures. **Prerequisites:** MTH SC 402/602, 803.

**MTH SC 821 REAL ANALYSIS I**

3 cr. (3 and 0)

Hausdorff and metric spaces, cardinal and ordinal numbers, rings and algebras of sets, exterior and interior measure, completion of measures, Borel and Lebesgue measures in Euclidean  $n$ -space, integration theory associated with a measure, types of convergence, derivatives. **Prerequisite:** MTH SC 454/654.

**MTH SC 822 REAL ANALYSIS II**

3 cr. (3 and 0)

Continuation of MTH SC 821.

**MTH SC 823 COMPLEX ANALYSIS I**

3 cr. (3 and 0)

Topological concepts, complex integration, local and global properties of analytic functions, power series, representation theorems, calculus of residues. Designed for non-engineering majors. **Prerequisite:** MTH SC 464/664.

**MTH SC 824 COMPLEX ANALYSIS II**

3 cr. (3 and 0)

Continuation of MTH SC 823 including introductory topological analysis.

**MTH SC 825 ORDINARY DIFFERENTIAL EQUATIONS I**

3 cr. (3 and 0)

Techniques of analysis of systems of differential, difference and integral equations including existence and uniqueness theorems, sensitivity analysis, stability, control and linear systems. **Prerequisites:** MTH SC 454/654 or 464/664 and 411/611.

**MTH SC 826 ORDINARY DIFFERENTIAL EQUATIONS II**

3 cr. (3 and 0)

Perturbations of systems having periodic solution, stability, Poincare-Bendixson theory, use of fixed point theorems, almost periodic solutions and integral manifolds. **Prerequisite:** MTH SC 825.

**MTH SC 831 FOURIER SERIES**

3 cr. (3 and 0)

Fourier series with applications to solution of boundary value problems in partial differential equations of physics and engineering; introduction to Bessel functions and Legendre polynomials. **Prerequisite:** MTH SC 464/664.

**MTH SC 833 OPERATIONAL MATHEMATICS**

3 cr. (3 and 0)

Operational properties of Laplace and other integral transforms; applications to problems in engineering and physics involving differential equations and boundary value problems in partial differential equations. **Prerequisite:** MTH SC 454/654.

**MTH SC 837 CALCULUS OF VARIATIONS**

3 cr. (3 and 0)

Fundamental theory of the calculus of variations, variable end points, the parametric problem, the isoperimetric problem, fundamental sufficiency theorems. **Prerequisite:** MTH SC 454/654 or 464/664.

**MTH SC 839 INTEGRAL EQUATIONS**

3 cr. (3 and 0)

Basic theory, relationships to linear differential initial value problems, Fredholm theory, linear Fredholm integral equations of the first and second kind, Hilbert-Schmidt theory, Volterra equations. **Prerequisite:** MTH SC 464/664.

**MTH SC 841 APPLIED MATHEMATICS I**

3 cr. (3 and 0)

Linear spaces, spectral theory of operators, Green's function, eigenvalue problems of ordinary differential equations, partial differential equations. **Prerequisites:** MTH SC 464/664 and 853.

**MTH SC 842 APPLIED MATHEMATICS II**

3 cr. (3 and 0)

Continuation of MTH SC 841.

**MTH SC 850 COMPUTATIONAL PROBLEMS IN DISCRETE STRUCTURES**

3 cr. (3 and 0)

Digital representation and application of basic discrete structures; sets, relations, graphs, diagraphs, automata, unary algebras; computational analog of product structure in each case. **Prerequisites:** Computational maturity and permission of instructor.

**MTH SC 851 ABSTRACT ALGEBRA I**

3 cr. (3 and 0)

Topics selected from fundamental theory of modern algebra; finite groups including permutation groups, p-groups, Sylow theorems and structure of finite abelian groups; groups with chain conditions, Krull-Schmidt and Jordan-Holder theorems; solvable, nilpotent and free groups; Galois theory; finite fields; Wedderburn theorem.

**MTH SC 852 ABSTRACT ALGEBRA II**

3 cr. (3 and 0)

Continuation of MTH SC 851 including structure of rings and other algebraic systems.

**MTH SC 853 ADVANCED LINEAR ALGEBRA**

3 cr. (3 and 0)

Properties of finite dimensional vector spaces; bases, dimensions, transformations, projections and orthogonality. **Prerequisites:** MTH SC 411/611, 412/612.

**MTH SC 854 THEORY OF GRAPHS**

3 cr. (3 and 0)

Connectedness, path problems, trees, matching theorems, directed graphs, fundamental numbers of the theory of graphs, groups and graphs. **Prerequisite:** Permission of instructor.

**MTH SC 855 COMBINATORIAL ANALYSIS**

3 cr. (3 and 0)

Topics selected from combinations, permutations, permutations with restricted position, Polya's theorem, principle of inclusion and exclusion, partitions, recurrence relations, generating functions, Mobius inversion, enumeration techniques, Ramsey numbers, finite projective and affine geometrics, Latin rectangles, orthogonal arrays, block designs, error detecting and error correcting codes. **Prerequisite:** MTH SC 411/611.

**MTH SC 856 APPLICABLE ALGEBRA**

3 cr. (3 and 0)

Applied algebraic ideas in lattice theory and Boolean Algebra, finite-state sequential machines, group theory as applied to network complexity and combinatorial enumeration, and algebraic coding theory. Topics vary with background and interests of students. **Prerequisites:** MTH SC 851 and 853 or permission of instructor.

**MTH SC 861 ADVANCED NUMERICAL ANALYSIS I**

3 cr. (3 and 0)

Interpolation and approximation, numerical quadrature, numerical solution of functional differential equations, integral equations and overdetermined linear systems, eigenvalue problems, approximation using splines. **Prerequisites:** MTH SC 428/628 and digital computer experience.

**MTH SC 862 ADVANCED NUMERICAL ANALYSIS II**

3 cr. (3 and 0)

Continuation of MTH SC 861.

**MTH SC 863 DIGITAL MODELS I**

3 cr. (3 and 0)

Experimental mathematics, pseudo-stochastic processes, analytical and algebraic formulations of time-independent simulation, continuous-time simulation and discrete-time simulation, digital optimization, Fibonacci search, ravine search, gradient methods, current research in digital analysis. **Prerequisites:** MTH SC 411/611, 453/653 and digital computer experience.

## MTH SC 864 DIGITAL MODELS II

3 cr. (3 and 0)

Continuation of MTH SC 863.

## MTH SC 867 SYSTEMS AND SOFTWARE

3 cr. (3 and 0)

Systems organization and software design of the IBM 370; working knowledge of machine organization, basic assembler language, operating systems overview, program support facilities, job control language, data management, library management, interactive system concepts. **Prerequisites:** CP SC 205 and MTH SC 411/611 or 419/619.

## MTH SC 868 AN INTRODUCTION TO NUMERICAL PROCESSES

3 cr. (3 and 0)

Numerical solution of linear algebraic systems and systems of ordinary differential equations; computational problems in discrete event simulation. **Prerequisites:** MTH SC 208, 301, and 411/611.

## MTH SC 871 GENERAL TOPOLOGY I

3 cr. (3 and 0)

Definitions and elementary properties of topological space, subspaces, quotient and product spaces, Moore-Smith convergence, separation axioms and consequences, metrization theorems; homotopy theory uniformities and axiomatic boundedness. **Prerequisite:** MTH SC 454/654.

## MTH SC 872 GENERAL TOPOLOGY II

3 cr. (3 and 0)

Continuation of MTH SC 871.

## MTH SC 891 MASTER'S THESIS RESEARCH

Credit to be arranged.

## MTH SC 901 PROBABILITY THEORY I

3 cr. (3 and 0)

Axiomatic theory of probability, distribution functions; expectation; cartesian product of infinitely many probability spaces and the Kolmogorov consistency theorem; modes of convergence; weak and strong laws of large numbers. **Prerequisites:** MTH SC 402/602 and 822, or permission of instructor.

## MTH SC 902 PROBABILITY THEORY II

3 cr. (3 and 0)

Continuation of MTH SC 901; characteristic functions, infinitely divisible distributions, central limit theorems, laws of large numbers; conditioning and limit properties of sums of dependent random variables; conditioning, martingales. **Prerequisite:** MTH SC 901.

## MTH SC 907 MULTIVARIATE ANALYSIS

3 cr. (3 and 0)

Multivariate normal distribution, Wishart distribution, Hotellings  $T^2$  distribution, estimation of parameters, test of hypotheses on vector means and covariance matrices. **Prerequisite:** MTH SC 802.

**MTH SC 920 INTRODUCTION TO HARMONIC ANALYSIS**

3 cr. (3 and 0)

Trigonometric functions and series, summability methods, convergence and summability of Fourier series, Fourier integrals, Fourier transforms, Banach algebra  $L^1(R)$  and ideals in  $L^1$ . **Prerequisites:** MTH SC 822 and 824.

**MTH SC 927 FUNCTIONAL ANALYSIS I**

3 cr. (3 and 0)

Hilbert, normed and Banach spaces and topological linear operators in these spaces; Hahn-Banach, uniform boundedness, and closed graph-theorems; application to problems in analysis, spectral theory for linear operators. **Prerequisite:** MTH SC 821.

**MTH SC 928 FUNCTIONAL ANALYSIS II**

3 cr. (3 and 0)

Continuation of MTH SC 927.

**MTH SC 981 SPECIAL TOPICS IN MATHEMATICAL STATISTICS**

1-3 cr. (1-3 and 0)

Advanced topics in mathematical statistics from current problems of interest.

**MTH SC 982 SPECIAL TOPICS IN ANALYSIS**

1-3 cr. (1-3 and 0)

Advanced analysis topics from current problems of interest.

**MTH SC 984 SPECIAL TOPICS IN APPLIED MATHEMATICS**

1-3 cr. (1-3 and 0)

Advanced topics in applied mathematics from current problems of interest.

**MTH SC 985 SPECIAL TOPICS IN ALGEBRA**

1-3 cr. (1-3 and 0)

Advanced topics in algebra from current problems of interest.

**MTH SC 986 SPECIAL TOPICS IN CONVEXITY**

1-3 cr. (1-3 and 0)

Advanced topics in convexity from current problems of interest.

**MTH SC 987 SPECIAL TOPICS IN NUMERICAL PROCESSES**

1-3 cr. (1-3 and 0)

Advanced topics in numerical processes from current problems of interest.

**MTH SC 988 SPECIAL TOPICS IN OPERATIONS RESEARCH**

1-3 cr. (1-3 and 0)

Advanced topics in operations research from current problems of interest.

**MTH SC 991 DOCTORAL DISSERTATION RESEARCH**

Credit to be arranged.

**MICROBIOLOGY**

M. J. B. Paynter, Head, Department of Microbiology

**Major**  
Microbiology

**Degrees**  
M.S., Ph.D.

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

All students will complete a curriculum which will assure a sound knowledge of the basic areas of microbiology, including at least three of the following: bacterial physiology and metabolism; pathogenic microbiology; virology; immunology; microbial genetics; and applied and environmental microbiology. The program is selected by the student with the guidance and approval of an advisory committee. Each candidate must present and defend a thesis based upon original research.

Research disciplines include pathogenic, food, environmental, and marine microbiology; microbial ecology; bacterial and plant virology; molecular biology; microbial genetics; microbial physiology and metabolism; and anaerobic microbiology.

MICRO 600	PUBLIC HEALTH MICROBIOLOGY 3 cr. (3 and 0) S
MICRO 601	ADVANCED BACTERIOLOGY 4 cr. (2 and 6) F
MICRO 603	MARINE MICROBIOLOGY 3 cr. (2 and 3)
MICRO 605	GENERAL MICROBIOLOGY 4 cr. (3 and 3) F, S, SS
MICRO 607	FOOD AND DAIRY MICROBIOLOGY 4 cr. (3 and 3)
MICRO 610	SOIL MICROBIOLOGY 3 cr. (2 and 3) S (even numbered years)
MICRO 611	PATHOGENIC BACTERIOLOGY 4 cr. (3 and 3) S
MICRO 612	BACTERIAL PHYSIOLOGY 4 cr. (3 and 3) S
MICRO 613	INDUSTRIAL MICROBIOLOGY 3 cr. (2 and 3) F
MICRO 614	BASIC IMMUNOLOGY 3 cr. (2 and 3) F
MICRO 615	MICROBIAL GENETICS 4 cr. (3 and 3) S

- MICRO 616 INTRODUCTIONARY VIROLOGY**  
3 cr. (3 and 0) F
- MICRO 617 MOLECULAR MECHANISMS OF CARCINOGENESIS AND AGING**  
3 cr. (3 and 0)
- MICRO 802 BACTERIOLOGICAL TECHNIC**  
4 cr. (2 and 6) F  
Analytical and experimental procedures used in bacteriology, including techniques for studying bacterial cytology, physiology, and metabolism. Designed to give students experience in more advanced methods of investigation.
- MICRO 803 SPECIAL PROBLEMS IN MICROBIOLOGY**  
Credit to be arranged.  
Research not related to thesis.
- MICRO 804 CURRENT TOPICS IN MICROBIOLOGY**  
1 cr. (1 and 0)  
Evaluation of current research literature in various areas of microbiology; critical evaluation of specific publications in terms of their merit. Required of all microbiology graduate students; may be repeated for credit.
- MICRO 806 PATHOGENESIS AND INFECTIOUS DISEASE**  
3 cr. (3 and 0)  
Medically important host-parasite relationships at the cellular and sub-cellular levels, with emphasis on bacterial and viral infections in man. **Prerequisite:** MICRO 411/611 or permission of instructor.
- MICRO 807 SEMINAR**  
1 cr. (1 and 0)  
Topics not covered in other courses. Students review literature, organize and present material; may be taken for credit twice.
- MICRO 810 RECOMBINANT DNA AND GENETIC ENGINEERING IN MICROBES**  
4 cr. (2 and 6)  
Principles and applications of recombinant DNA technology, including recombinant DNA techniques, restriction endonucleases, DNA modifying enzymes, cloning vectors, gene isolation techniques, and molecular cloning techniques. **Prerequisites:** MICRO 305 and GEN 305 or permission of instructor.
- MICRO 811 BACTERIAL CYTOLOGY AND PHYSIOLOGY**  
4 cr. (4 and 0) S (odd numbered years)  
Structure, chemistry and physiology of the various bacterial cell components; physiology of bacterial growth and reproduction in batch, continuous and synchronous cultures; economy of the bacterial cell, including endogenous metabolism and maintenance requirements; physiology of bacterial death; regulation of enzyme and nucleic acids syntheses. **Prerequisites:** MICRO 305/605; BIOCH 423/623 and 424/624 or concurrent registration in BIOCH 424/624; MTH SC 206 or permission of instructor.



**MICRO 812 BACTERIAL METABOLISM**  
3 cr. (3 and 0) S (even numbered years)

Various biochemical pathways occurring in bacterial cells; fermentations of carbohydrates and related compounds and of nitrogenous organic compounds; anaerobic and aerobic respiration, including electron transport systems and oxidative phosphorylation; bacterial photosynthesis; nitrogen fixation; biosyntheses of amino acids, purines, pyrimidines, lipids, proteins, nucleic acids and polysaccharides. **Prerequisites:** MICRO 305/605; BIOCH 423/623 and 424/624 or concurrent registration in BIOCH 424/624; MTH SC 206 or permission of instructor.

**MICRO 815 ADVANCED MICROBIAL GENETICS**  
3 cr. (3 and 0) S (odd numbered years)

Current developments in microbial genetics; integration of genetics and biochemistry; analysis of genetic fine structure in microorganisms; nature of bacterial variation and expression of mutations; population dynamics; physio-chemical mechanisms of heredity; regulation of gene action in microorganisms; physiology and genetics of virulent and lysogenic bacteriophages. **Prerequisite:** MICRO 415/615.

**MICRO 891 MASTER'S THESIS RESEARCH**  
Credit to be arranged.

**MICRO 991 DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

## PHYSICS

J. P. McKelvey, Head, Department of Physics and Astronomy

**Major**  
Physics

**Degrees**  
M.S., Ph.D.

### For the Master of Science degree:

A student is admitted to candidacy for the M.S. degree upon completion of a written preliminary examination covering topics determined by the faculty. This examination must be completed one semester before the date on which the degree is expected.

It is usually recommended that students submit a thesis to fulfill the requirements for the M.S. degree; however, a non-thesis option is available. In the non-thesis option, a minimum of 36 credit hours is required, including six credit hours of PHYS 890, Directed Activities in Applied Physics. A written report must be submitted in connection with this activity.

A final oral examination is required on the student's general area of study, and on the thesis or the directed activities report.

A program leading to the M.S. degree in physics with a concentration in health physics is available. A different selection of course work, including six credits of health physics or biophysics and nine credits of courses in biology, biochemistry, or chemistry is prescribed.

### For the Doctor of Philosophy degree:

Students who enter with a bachelor's degree will take the preliminary

examination for the M.S. degree. Students whose performance is satisfactory to the faculty may by-pass the master's degree. Otherwise, the M.S. degree must be awarded as an integral part of the doctoral program.

Students are admitted to candidacy for the Ph.D. degree upon the successful completion of a written comprehensive examination on topics determined by the faculty. This examination must be completed at least one academic year prior to the date on which the degree is expected.

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

PHYS 617 INTRODUCTION TO BIOPHYSICS I  
3 cr. (3 and 0)

PHYS 618 INTRODUCTION TO BIOPHYSICS II  
3 cr. (3 and 0)

PHYS 620 ATMOSPHERIC PHYSICS  
3 cr. (3 and 0)

PHYS 621 MECHANICS I  
3 cr. (3 and 0)

PHYS 622 MECHANICS II  
3 cr. (3 and 0)

PHYS 625 EXPERIMENTAL PHYSICS I  
4 cr. (2 and 6)

PHYS 626 EXPERIMENTAL PHYSICS II  
4 cr. (2 and 6)

PHYS 632 OPTICS  
3 cr. (3 and 0)

PHYS 640 ELECTRICITY AND MAGNETISM I  
3 cr. (3 and 0)

PHYS 641 ELECTRICITY AND MAGNETISM II  
3 cr. (3 and 0)

PHYS 646 SOLID STATE PHYSICS  
3 cr. (3 and 0)

PHYS 652 NUCLEAR AND PARTICLE PHYSICS  
3 cr. (3 and 0)

PHYS 655 QUANTUM PHYSICS I  
3 cr. (3 and 0)

PHYS 656 QUANTUM PHYSICS II  
3 cr. (3 and 0)

PHYS 657 BASIC HEALTH AND RADIOLOGICAL PHYSICS I  
3 cr. (3 and 0)

PHYS 658 BASIC HEALTH AND RADIOLOGICAL PHYSICS II  
3 cr. (3 and 0)

PHYS 660 CONTEMPORARY PHYSICS FOR HIGH SCHOOL TEACHERS  
3 cr. (3 and 0)

PHYS 665 THERMODYNAMICS AND STATISTICAL MECHANICS  
3 cr. (3 and 0)

PHYS 671 ELECTRON MICROSCOPY  
3 cr. (2 and 3)

PHYS 673 X-RAY CRYSTALLOGRAPHY  
3 cr. (2 and 3)

PHYS 700 PHYSICAL SCIENCE IN ELEMENTARY SCHOOL — PHYSICS  
3 cr. (3 and 0)

Physical sciences as appropriate for teaching elementary school students; demonstrations and experiments that can be conducted with equipment available to elementary school teachers; topics mainly involve physics and astronomy. Restricted to students in elementary education.

PHYS 703 MODERN PHYSICS FOR HIGH SCHOOL TEACHERS  
3 cr. (3 and 0)

Rutherford model of the atom, molecular description of matter, quantum theory of matter, nuclear forces, radioactivity, special relativity. Restricted to students in secondary education.

PHYS 711 ORIGINS OF PHYSICAL SCIENCE  
3 cr. (3 and 0)

Historical development of concepts in physical science emphasizing the alternative and perhaps conflicting explanations of physical phenomena which led to our present understanding. Examples drawn from physics and astronomy. Restricted to students in secondary education.

PHYS 716 EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS  
4 cr. (2 and 4)

Experimental techniques employed in determination of fundamental quantities in classical and modern physics; experiments which may be demonstrated in the classroom and which broaden concepts of physics. Restricted to students in secondary education.

PHYS 723 WEATHER SCIENCE FOR SCIENCE TEACHERS  
3 cr. (3 and 0)

Meteorological phenomena emphasizing non-mathematical descriptions of atmospheric physics principles; solar and terrestrial radiation, adiabatic processes and cloud formation, local severe storms, global circulation patterns, air mass motions and fronts. Restricted to students in secondary education.

- PHYS 811 METHODS OF THEORETICAL PHYSICS I**  
3 cr. (3 and 0)  
Analytical methods and techniques used in theoretical physics; vector and tensor analysis as applied to physical problems, use of matrices and groups in classical and quantum mechanics, complex variables and partial differential equations of physics.
- PHYS 812 METHODS OF THEORETICAL PHYSICS II**  
3 cr. (3 and 0)  
Continuation of PHYS 811; use of integral transforms, integral equations, special functions, calculus of variations and numerical approximations in solution of physical problems.
- PHYS 813 ADVANCED THERMODYNAMICS AND STATISTICAL MECHANICS I**  
3 cr. (3 and 0)  
Thermodynamics including thermodynamic potentials, phase transitions, and very low temperatures; Boltzmann integrodifferential equation and kinetic theory of gases and plasmas; classical statistical mechanics.
- PHYS 814 ADVANCED THERMODYNAMICS AND STATISTICAL MECHANICS II**  
3 cr. (3 and 0)  
Quantum statistical mechanics; microcanonical, canonical, and grand canonical ensemble theories; ideal Fermi gas and ideal Bose gas; special topics in advanced statistical mechanics.
- PHYS 821 CLASSICAL MECHANICS I**  
3 cr. (3 and 0)  
Dynamics of particles, variational principles and Lagrange's equations; two-body central force problems; dynamics of rigid bodies. Matrix formulations freely used.
- PHYS 822 CLASSICAL MECHANICS II**  
3 cr. (3 and 0)  
Special relativity in classical mechanics, Hamilton's equations, canonical transformations, Hamilton-Jacobi theory, small oscillations.
- PHYS 841 ELECTRODYNAMICS I**  
3 cr. (3 and 0)  
Field theory of electromagnetism; Maxwell's equations and their application to study of electromagnetic wave production and propagation, wave optics and theories of interference and diffraction.
- PHYS 842 ELECTRODYNAMICS II**  
3 cr. (3 and 0)  
Production and propagation of electromagnetic waves beginning with use of Maxwell's equations; discussions of wave guides, diffraction phenomenon, and boundary effects; theory of electrons and microscopic phenomena.
- PHYS 845 SOLID STATE PHYSICS I**  
3 cr. (3 and 0)

Physical properties of crystalline solids; crystalline state determination by diffraction methods, theories of specific heat, properties of metallic lattices and alloys, lattice energy and ferroelectrics.

**PHYS 846      SOLID STATE PHYSICS II**

3 cr. (3 and 0)

Continuation of PHYS 845; electronic properties of solids; band theory of solids, physics of semiconductors, theories of magnetism and magnetic resonance phenomena.

**PHYS 853      NUCLEAR PHYSICS**

3 cr. (3 and 0)

Nuclear structure, nuclear forces and nuclear interaction processes; shell structure, spins, and magnetic moments of nuclear particles.

**PHYS 875      SEMINAR IN CONTEMPORARY PHYSICS**

1-3 cr. (1-3 and 0)

Students and interested faculty study areas of physics currently being extensively investigated.

**PHYS 890      DIRECTED ACTIVITIES IN APPLIED PHYSICS**

1-6 cr.

Training and work on practical problems. Activities are supervised by departmental faculty or by appropriate adjunct professor; written description of student's activities must be submitted to course supervisor at completion of activity. Maximum credit limits are six credit hours in a semester and three credit hours in a single summer session; graded on a pass-fail basis.

**PHYS 891      MASTER'S THESIS RESEARCH**

Credit to be arranged.

**PHYS 951      QUANTUM MECHANICS I**

3 cr. (3 and 0)

Review of wave mechanics; operator algebra and theory of representation; approximate methods for stationary problems; theory of scattering applied to atomic and nuclear problems.

**PHYS 952      QUANTUM MECHANICS II**

3 cr. (3 and 0)

Continuation of PHYS 951 including time dependent perturbations, radiation absorption and emission, relativistic quantum mechanics, introduction to quantum electrodynamics.

**PHYS 966      RELATIVITY**

3 cr. (3 and 0)

Special and general theory of relativity including tensor calculus, Lorentz transformation and three experimental tests of general theory: (1) planetary motion and advance of perihelion of Mercury, (2) bending of light rays in gravitational fields, and (3) gravitational shift of spectral lines.

**PHYS 971      ADVANCED QUANTUM THEORY I**

3 cr. (3 and 0)

Development of quantum theory as encountered in systems with an infinite number of degrees of freedom and in systems where relativistic effects are important; advanced scattering theory, quantization of relativistic field theories, and development of covariant forms of perturbation theory and other timely subjects. **Prerequisite:** PHYS 951 or permission of instructor.

**PHYS 972 ADVANCED QUANTUM THEORY II**  
3 cr. (3 and 0)

Continuation of PHYS 971; application of relativistic quantum field theory to various electromagnetic processes, need for renormalization of quantum field theories and its implementation. **Prerequisite:** PHYS 971 or permission of instructor.

**PHYS 991 DOCTORAL DISSERTATION RESEARCH**  
Credit to be arranged.

### Astronomy

Students may specialize in astronomy or astrophysics, although their M.S. or Ph.D. degrees will be awarded in physics.

**ASTR 601 STELLAR ATMOSPHERES**  
3 cr. (3 and 0)

**ASTR 602 STELLAR INTERIORS AND EVOLUTION**  
3 cr. (3 and 0)

**ASTR 603 GALACTIC STRUCTURES**  
3 cr. (3 and 0)

**ASTR 610 COSMOLOGY**  
3 cr. (3 and 0)

**ASTR 612 PRACTICAL ASTRONOMY**  
3 cr. (3 and 0)

**ASTR 701 SOLAR SYSTEM ASTRONOMY FOR HIGH SCHOOL TEACHERS**  
3 cr. (3 and 0)

A lecture and observation course introducing concepts and descriptions basic to modern astronomy. The solar system is surveyed, with fundamental physical principles introduced as needed. Planetarium demonstrations and observing sessions are included. Restricted to students in secondary education.

**ASTR 711 STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS**  
3 cr. (3 and 0)

Lecture and observation course; stellar and galactic astronomy, energy sources, other topics of current interest. Planetarium programs and observing sessions are included. Restricted to students in secondary education.

**ASTR 875 SEMINAR IN CONTEMPORARY ASTRONOMY**  
1-3 cr. (1-3 and 0)

Students and faculty study areas of astronomy of current interest.

**ZOOLOGY**

C. W. Helms, Head, Department of Zoology

**Major**  
Zoology

**Degrees**  
M.S., Ph.D.

Requirements for the M.S. degree include 24 semester hours of course work, six hours of research, an acceptable thesis, and satisfactory performance in a final oral examination.

Requirements for the Ph.D. degree include a written and oral comprehensive examination, research, a dissertation, and satisfactory performance in a final oral defense. While there are no required numbers of hours of course work for the doctorate beyond 18 semester hours of research, breadth and depth of preparation in the life sciences will be expected of each candidate.

ZOOL 603	PROTOZOOLOGY 3 cr. (2 and 3) S
ZOOL 605	ANIMAL HISTOLOGY 4 cr. (3 and 3)
ZOOL 610	LIMNOLOGY 4 cr. (3 and 3) F
ZOOL 611	ANIMAL ECOLOGY 4 cr. (3 and 3) F, S
ZOOL 612	AQUATIC ECOLOGY 4 cr. (3 and 3)
ZOOL 615	INTRODUCTION TO MATHEMATICAL ECOLOGY 3 cr. (3 and 0)
ZOOL 620	PRINCIPLES OF EVOLUTION 4 cr. (4 and 0)
ZOOL 621	ADVANCED INVERTEBRATE ZOOLOGY 4 cr. (3 and 3)
ZOOL 650	COMPARATIVE VERTEBRATE EMBRYOLOGY 4 cr. (3 and 3)
ZOOL 656	PARASITOLOGY 4 cr. (3 and 3) S
ZOOL 657	COMPARATIVE PHYSIOLOGY 4 cr. (3 and 3)
ZOOL 658	CELL PHYSIOLOGY 4 cr. (3 and 3)
ZOOL 659	SYSTEMS PHYSIOLOGY I 4 cr. (3 and 3)

- ZOOL 662 HERPETOLOGY  
3 cr. (2 and 3) F
- ZOOL 663 ICHTHYOLOGY  
3 cr. (2 and 3) S
- ZOOL 664 MAMMALOLOGY  
3 cr. (2 and 3) F
- ZOOL 665 ORNITHOLOGY  
3 cr. (2 and 3) S
- ZOOL 670 ANIMAL BEHAVIOR  
3 cr. (3 and 0)
- ZOOL 671 ANIMAL BEHAVIOR LABORATORY  
1 cr. (0 and 3)
- ZOOL 675 VERTEBRATE ENDOCRINOLOGY  
3 cr. (3 and 0)
- ZOOL 676 EXPERIMENTAL VERTEBRATE ENDOCRINOLOGY  
2 cr. (0 and 6)
- ZOOL 680 ANALYSIS OF DEVELOPMENT  
3 cr. (3 and 0)
- ZOOL 701 MAN'S IMPACT ON ECOLOGY  
3 cr. (3 and 0) SS  
Fundamental relationship of man to his environment as it developed from prehistoric time to present; current overpopulation and pollution. Restricted to graduate students in secondary education.
- ZOOL 803 POPULATION DYNAMICS  
4 cr. (2 and 6) S (even numbered years)  
Fundamental mechanisms basic to regulation of natural animal populations. Laboratory research project in population dynamics complements theory.
- ZOOL 810 BEHAVIORAL ECOLOGY  
3 cr. (3 and 0) F (odd numbered years)  
Behavior of animals and the ecological context in which various behaviors are shown; empirical and theoretical aspects of behavioral ecology at individual, population and community levels. **Prerequisites:** ZOOL 411/611, 470/670, or permission of instructor.
- ZOOL 812 SEMINAR  
1 cr. (1 and 0) F, S, SS  
Current literature on zoology.
- ZOOL 813 EVOLUTION  
2 cr. (2 and 0)  
Theoretical topics of current interest to evolutionary biologists. **Prerequisite:** ZOOL 420/620 or permission of instructor.



**ZOOL 815     PHYSIOLOGICAL ECOLOGY**

4 cr. (3 and 3) F (even numbered years)

Physiological and biochemical adaptations of invertebrates and vertebrates toward various natural environmental parameters. Field trips acquaint student with natural macro- and micro-environments of individual species; field measurements of parameters of the environment will be undertaken and laboratory studies will furnish detailed knowledge of various physiological adaptations to these parameters.

**ZOOL 816     ADVANCED ECOSYSTEM I**

4 cr. (3 and 3)

Description and analysis of ecological systems; biogeochemical, physicochemical, and ecological principles emphasizing fundamental unity of ecosystems and their abiotic environment. Laboratory focuses on application of theory to actual field and laboratory research problems. **Prerequisites:** MTH SC 210 and 405/605, ZOOL 411/611 or BOT 441/641, ZOOL 415/615, or permission of instructor.

**ZOOL 817     ADVANCED ECOSYSTEM ANALYSIS II**

4 cr. (3 and 3)

Thermodynamic principles that permit the persistence of ecosystems in time and space are examined based upon specific descriptions developed in ZOOL 816. Laboratory focuses on application of these stability theories to actual field and laboratory research problems. **Prerequisite:** ZOOL 816.

**ZOOL 818     COMMUNITY ECOLOGY**

4 cr. (3 and 3)

Structure and function of ecological communities, emphasizing description of natural communities and evolutionary rules by which they are organized. Laboratory applies theory to field problems. **Prerequisites:** MTH SC 108 and 405/605, ZOOL 411/611 or BOT 441/641, or permission of instructor.

**ZOOL 835     INTERPRETIVE ELECTRON MICROSCOPY**

3 cr. (3 and 0)

Cell structure as viewed through the electron microscope. Characteristic structural features of cells from various tissues and from various organisms at different phylogenetic levels will be stressed. **Prerequisite:** AN PH 801 or ZOOL 405/605, or permission of instructor.

**ZOOL 852     PRINCIPLES AND METHODS OF SYSTEMATIC ZOOLOGY**

2 cr. (2 and 0) F

Problems confronting taxonomists in zoological sciences and conventional practices developed to handle them.

**ZOOL 856     HELMINTHOLOGY**

3 cr. (2 and 3)

Symbiotic helminths emphasizing structure, life histories, ecology, physiology and biochemistry. **Prerequisite:** ZOOL 456/656 or permission of instructor.

**ZOOL 861     SPECIAL TOPICS**

1-4 cr. (1-4 and 0)

Current areas of active research interest in zoological sciences.

**ZOOL 863 SPECIAL PROBLEMS**

1-4 cr. F, S, SS

Research not related to thesis. **Prerequisite:** Permission of instructor.**ZOOL 865 ADVANCED ORNITHOLOGY**

3 cr. (3 and 0)

Orders and families of birds; fossils, zoogeography, anatomy, physiology, behavior, and ecology. **Prerequisite:** ZOOL 465/665 or permission of instructor.**ZOOL 881 METHODS IN DEVELOPMENTAL BIOLOGY**

2 cr. (0 and 6)

Observations and experiments conducted on an individual basis will involve a variety of developmental systems, various techniques used to study development, and critical interpretation of results. **Prerequisites:** ZOOL 480/680 or equivalent and permission of instructor.**ZOOL 883 SPECIAL TOPICS IN EVOLUTIONARY BIOLOGY**

1-4 cr. (1-3 and 0-3)

Recent advances in evolutionary biology and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.**ZOOL 884 SPECIAL TOPICS IN PHYSIOLOGY**

1-4 cr. (1-3 and 0-3)

Recent advances in physiology and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.**ZOOL 885 SPECIAL TOPICS IN ECOLOGY**

1-4 cr. (1-3 and 0-3)

Recent advances in ecology and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.**ZOOL 886 SPECIAL TOPICS IN ANIMAL BEHAVIOR**

1-4 cr. (1-3 and 0-3)

Recent advances in animal behavior and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.**ZOOL 887 SPECIAL TOPICS IN CELLULAR AND DEVELOPMENTAL BIOLOGY**

1-4 cr. (1-3 and 0-3)

Recent advances in cellular and developmental biology and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.**ZOOL 888 SPECIAL TOPICS IN ORGANISMAL BIOLOGY**

1-4 cr. (1-3 and 0-3)

Recent advances in organismal biology and other topics of select interest to graduate students in the biological sciences. May be repeated for credit. **Prerequisite:** Permission of instructor.

ZOOL 891 MASTER'S THESIS RESEARCH  
 Credit to be arranged.

ZOOL 991 DOCTORAL DISSERTATION RESEARCH  
 Credit to be arranged.

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## DIRECTORY FOR CORRESPONDENCE

### **Mailing Address**

Clemson University, Clemson, South Carolina 29631.

### **University Switchboard**

(803) 656-3311.

### **Graduate Study**

Address the Dean of Graduate Studies and University Research, telephone (803) 656-3195.

### **Registration and Class Schedules**

Address the Registrar, telephone (803) 656-2171.

### **Assistantships**

Address the head of the department of proposed major.

### **Transcripts**

Address the Registrar, telephone (803) 656-2171.

### **Veterans Affairs**

Address the Registrar, telephone (803) 656-2171.

### **International Student Affairs**

Address the International Services Office, Holtzendorff YMCA Center, telephone (803) 654-2361 or 656-2457.

### **Housing**

Married Students — Address the Housing Office, telephone (803) 656-2295.

Single Students — Address the Housing Office, telephone (803) 656-2295.

### **Public School Teachers Information**

Agricultural Education, telephone (803) 656-3300.

Elementary and Secondary Education, telephone (803) 656-3484.

Industrial Education, telephone (803) 656-3447.

Off-Campus Courses — Office of Educational Services, telephone (803) 656-2497, 2498.

The business and administrative offices of the University are open 8 a.m. to 4:30 p.m. Monday through Friday for 12 months of the year except for official University holidays.



CLEMSON  
UNIVERSITY

CLEMSON, SOUTH CAROLINA 29631