

Wilkinson



CLEMSON
UNIVERSITY
GRADUATE SCHOOL
ANNOUNCEMENTS
1991-1992

S.C.
LD1055
.C6
1991/92



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 GS2) 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 that 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 Undergraduate 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.

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 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
Clemson University
Clemson, South Carolina 29634-5002

or

Director
Office for Civil Rights
Department of Education
Washington, D.C. 20201

DEADLINE DATES

August 10, 1991

May 10, 1991-2000

June 10, 1991-2000

July 15, 1991-2000

October 25, 1991-2000

August 5, 1991-2000

ORGANIZATION

1. Apply for admission to candidacy for a degree and order forms from GSA after completing at least half the prescribed coursework. (See page 41.)

2. Submit completed thesis (if required) or dissertation to research advisor and arrange for final examination by the advisory committee. (See pages 41-50, 54 and 55.)

3. Arrange for review of thesis or dissertation with the Graduate School. Pay binding fee to the publisher and submit approved copies of thesis or dissertation to the Graduate School. Doctoral candidates pay for copies of dissertation in Dissertation Abstracts International and microfilm of dissertation. (See page 50.)

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

Although Form GSA will be accepted up through the deadline date listed, students who submit their form after the time frame suggested under "Filing of a Graduate Degree Certificate" on page 40. The final date for submission to the Graduate School Office is 12:00 p.m. on the day indicated. A "work-in-progress" form is submitted after the deadline.

Thesis/dissertation dates refer to filing with the Graduate School. Of course, sending all required forms to the Graduate School is a prerequisite to the final submission of the dissertation.

A \$25 fee will be assessed a student whose form is submitted after the deadline.

CLEMSON UNIVERSITY GRADUATE SCHOOL ANNOUNCEMENTS 1991-1992

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DEADLINE DATES

For those who expect to receive a graduate degree on:

August 10, 1991

Last day for:

Filing Form GS2, Graduate Degree Curriculum*	May 10, 1991
Filing Form GS4, Admission to Candidacy and Diploma Order †	June 10, 1991
Oral and/or written examination	July 19, 1991
Review of completed and signed theses and dissertations by the Graduate School. Duplication requires one week.	July 26, 1991
Submission of duplicated copies of theses and dissertations to the Graduate School Office. Date on Approval Page.	August 2, 1991

CHECKLIST ON GRADUATE SCHOOL PROCEDURES

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

1. Select (in consultation with the appropriate department head) a major advisor and advisory committee. (See page 40.)
2. Submit Graduate Degree Curriculum (Form GS2). (See page 40.)
3. Satisfy any prescribed language requirement and comprehensive examination prerequisite to admission to candidacy. (See pages 53, 56-57.)
4. Apply for admission to candidacy for a degree and order diploma (Form GS4) after completing at least half the prescribed course work. (See page 41.)
5. Submit completed thesis (if required) or dissertation to research advisor and arrange for final examination by the advisory committee. (See pages 49-50, 54 and 58.)
6. Arrange for review of thesis or dissertation with the Graduate School prior to duplication. (See page 50.)
7. 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 International* and microfilming of dissertation. (See page 50.)

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 40. The filing dates are deadlines for signed forms to be in the Graduate School Office. A \$25 late fee will be assessed a student whose form is submitted after the deadline.

†These deadline dates refer to filing, with the Graduate School, of forms carrying all required signatures. A \$25 late fee will be assessed a student whose form is submitted after the deadline.

December 19, 1991	May 8, 1992	August 8, 1992
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August 9, 1991	December 19, 1991	May 8, 1992
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September 11, 1991	January 28, 1992	June 8, 1992
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November 27, 1991	April 17, 1992	July 17, 1992
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December 5, 1991	April 24, 1992	July 24, 1992
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December 12, 1991	May 1, 1992	July 31, 1992
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ORGANIZATION OF THIS PUBLICATION

The first 59 pages of the Graduate School Announcements are confined to a description of the University, a listing of academic and administrative officers, and a description of Graduate School policies and procedures. Beginning on page 61 are the graduate programs and courses offered under the colleges of Agricultural Sciences, Architecture, Commerce and Industry, Education, Engineering, Forest and Recreation Resources, Liberal Arts, Nursing, and Sciences. The programs and courses are listed alphabetically within each college.

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Animal Physiology	M.S., Ph.D.	78
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Aquaculture, Fisheries and Wildlife Biology	M.S.	82
Entomology	M.S., Ph.D.	85
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Environmental Science	Minor	87
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Food Science	Minor	89
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Industrial Engineering	M.S., Ph.D.	223
Mechanical Engineering	M.Engr., M.S., Ph.D.	228
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CLEMSON UNIVERSITY CALENDAR

SUMMER 1991—SUMMER 1992

FIRST SIX-WEEKS SUMMER SESSION 1991

May 20, M	Registration
May 21, Tu	Classes begin; late registration fee applies
May 22, W	Last day to register or add a class
May 28, Tu	Last day to withdraw from class or the University without record
June 10, M	Last day to order diploma for August graduation (GS4)
June 13, Th	Last day to withdraw from class or the University without final grades
June 25, Tu	Examinations

SECOND SIX-WEEKS SUMMER SESSION 1991

July 1, M	Orientation
July 2, Tu	Registration
July 3, W	Classes begin; late registration fee applies
July 4, Th	Holiday
July 5, F	Last day to register or add a class
July 6, S	Classes meet
July 10, W	Last day to withdraw from class or the University without record
July 26, F	Last day to withdraw from class or the University without final grades
July 31, W	Last day to preregister for fall semester
August 7, W	Examinations
August 9, F	Last day to submit GS2 for December graduation
August 10, S	Graduation

FALL SEMESTER 1991

August 19, M	Orientation
August 20, Tu	Registration
August 21, W	Late registration
August 22, Th	Classes begin; late registration fee applies
August 28, W	Last day to register or add a class
September 11, W	Last day to order diploma for December graduation (GS4)
September 18, W	Last day to withdraw from class or the University without record
October 21-22, M-Tu	Fall break
October 30, W	Last day to withdraw from class or the University without final grades
November 4-15, M-F	Preregistration
November 28-29, Th-F	Thanksgiving holidays
December 6, F	Last day to preregister for spring semester
December 9-14, M-S	Examinations
December 19, Th	Last day to submit GS2 for May commencement
December 19, Th	Graduation

SPRING SEMESTER 1992

January 6, M	Orientation; registration
January 7, Tu	Late registration
January 8, W	Classes begin; late registration fee applies
January 14, Tu	Last day to register or add a class
January 28, Tu	Last day to order diploma for May commencement (GS4)
February 4, Tu	Last day to withdraw from class or the University without record
March 13, F	Last day to withdraw from class or the University without final grades
March 16-20, M-F	Spring break
April 6-17, M-F	Preregistration
April 11, S	Honors and Awards Day
April 27-May 2, M-S	Examinations
May 8, F	Last day to submit GS2 for August graduation
May 8, F	Commencement

FIRST SIX-WEEKS SUMMER SESSION 1992

May 18, M	Registration
May 19, Tu	Classes begin; late registration fee applies
May 20, W	Last day to register or add a class
May 26, Tu	Last day to withdraw from class or the University without record
June 8, M	Last day to order diploma for August graduation (GS4)
June 10, W	Last day to withdraw from class or the University without final grades
June 23, Tu	Examinations

SECOND SIX-WEEKS SUMMER SESSION 1992

June 29, M	Orientation
June 30, Tu	Registration
July 1, W	Classes begin; late registration fee applies
July 2, Th	Last day to register or add a class
July 6, M	Holiday
July 9, Th	Last day to withdraw from class or the University without record
July 11, S	Classes meet
July 24, F	Last day to withdraw from class or the University without final grades; last day to preregister for fall semester
August 5, W	Examinations
August 7, F	Last day to submit GS2 for December graduation
August 8, S	Graduation

THE UNIVERSITY

INTRODUCTION

Clemson University was founded in 1889 when the General Assembly accepted the terms of the will of Thomas Green Clemson, conveying land and other property to the state for the purpose of establishing a technical and scientific institution. The college opened its doors in 1893 as Clemson Agricultural College, a land-grant institution and military school. It has evolved to its present status as a university emphasizing the sciences and technology.

Enrollment at Clemson was initially limited to men; women were admitted as residential students for the first time in 1955. The Graduate School was formally organized in 1947. In 1964 the college was renamed Clemson University, a formal recognition of the school's expanded academic offerings and research pursuits.

Clemson University is a land-grant, publicly assisted institution under the terms of the Morrill Act of 1862. It serves the state, the nation and the international community through teaching, research and public service activities. Clemson University is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award the bachelor's, master's, specialist and doctoral degrees.

The University is assigned the responsibility for the S.C. Agricultural Experiment Station under the provisions of the Hatch Act of 1887, as well as for the operation of the Cooperative Extension Service authorized by the Smith-Lever Act of 1914. Agricultural research is conducted not only on campus, but at four substations. Regulatory programs provide technical assistance, continuing education, technology transfer and extension activities.

In accordance with the conditions set forth in the will of Thomas Green Clemson and the Act of Acceptance by the General Assembly, Clemson University is governed by a Board of Trustees consisting of 13 members. Of these, six are elected by the General Assembly and seven are life members who elect their own successors.

Clemson University is organized into nine colleges: Agricultural Sciences, Architecture, Commerce and Industry, Education, Engineering, Forest and Recreation Resources, Liberal Arts, Nursing, and Sciences. Programs leading to baccalaureate degrees in 70 fields of study and 98 graduate programs in 61 areas of study are offered through all of the nine colleges. Doctoral programs are currently authorized in 32 specialties in the colleges of Agricultural Sciences, Commerce and Industry, Education, Engineering, Forest and Recreation Resources, and Sciences. Research is an indispensable part of most postbaccalaureate education, and Clemson provides research opportunities in all fields in which graduate instruction is offered. The institution's mandate in agriculture and natural resources, architecture, engineering, textiles, basic sciences and technologies is extended to address the state's cultural and economic needs through the health sciences, business, education and the liberal arts.

The 1,400-acre campus is located on the shores of Lake Hartwell in the northwestern part of South Carolina. It is surrounded by 20,860 acres of University farms and woodlands devoted to research. Clemson is approximately two and one-half hours' driving time from both Atlanta, Georgia, and Charlotte, North Carolina.

UNIVERSITY VISITORS CENTER

The University Visitors Center is located in 103 Tillman Hall. Walking tours are provided by the University Guide Service to answer questions and to acquaint visitors with the Clemson campus. Tours last approximately one hour and are preceded by a 10-minute videotape highlighting Clemson University. Thirty-minute cassette self-guided tours also are available.

The center is open Monday through Friday from 8 a.m. to 5 p.m. From February through November the center also is open on weekends. The office is closed for selected University holidays.

For additional information and to verify tour times, call the Visitors Center at (803) 656-4789.

ENROLLMENT OPPORTUNITIES

On-campus

On-campus enrollment for the fall semester of 1990 was 16,303. Of this number, 3,293 were graduate students. Approximately 1,480 are classified as full-time graduate students and 1,810 as part-time students. The number of male students is 1,803, and 1,490 are female students. Every degree program offered by the University is available on campus.

Off-campus

By virtue of its land-grant mission and at the direction of the state Legislature and/or the South Carolina Commission on Higher Education, Clemson University serves the entire state in certain academic disciplines, such as agriculture, architecture, industrial education and others. Courses in these disciplines are offered at various off-campus locations across the state. In addition, the University serves South Carolina by offering some master's degree programs at evening off-campus centers.

Master of Business Administration	Greenville
Master of Education (various majors)	Greenville
Master of Education (various majors)	Greenwood
Master of Industrial Education	Greenville
Master of Industrial Education	Greenwood
Master of Engineering (Civil Engineering)	Charleston
Master of Professional Accountancy	Greenville
Specialist in Education (Educational Administration)	Greenville

For complete details, please refer to the individual college descriptions.

Telecampus

The University Telecampus program coordinates the development and delivery of graduate-credit courses through electronic media. This service is provided to increase the educational opportunities of adults who want professional development or continuing education courses but cannot attend classes on the main campus on a regular basis. Through a closed-circuit television network of South Carolina ETV, classes are broadcast live from the Clemson campus to viewing sites in Aiken, Beaufort, Charleston, Columbia, Florence, Greenville, Greenwood and Rock Hill. A two-way audio linkage via telephone is provided so that students at remote sites may interact with the instructor and students on campus.

Information on courses and registration is available at the Telecampus Office, E-205 Martin Hall, Clemson, SC 29634-5121; and by calling 1-800-922-8316 or, in the local area, (803) 656-4227.

UNIVERSITY GOVERNANCE AND ADMINISTRATION

The University is governed by a board of 13 members, six selected 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 adopting long-range objectives of the University and the basic policies for achieving them, for electing the president of the University, and for approving budgets and expenditures.

The president is the chief executive officer of the University. The day-to-day operations of the University are administered by the president and executive officers for administration, business and finance, institutional advancement, research, student affairs and human resources.

The provost and vice president for academic affairs is the chief academic officer of the University. The provost is responsible directly to the president for all academic matters and administrative jurisdiction over teaching and computing services. Vice provosts assist in administering and performing duties in coordinating graduate and undergraduate curricula; supervising computer information services, the libraries, scholarship and award programs; and other duties assigned by the provost.

Academic deans are the chief administrative officers of their individual colleges and report directly to the provost. They provide leadership in formulating and carrying out educational policy, review and recommend on personnel matters, and carry out and administer the academic and financial affairs of their colleges.

The dean of the Graduate School coordinates all graduate programs and advises the provost on policies and regulations pertaining to graduate study. 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.

Board of Trustees

Louis P. Batson, Jr., Chairman of the Board	Greenville, S.C.
Bill L. Amick	Batesburg, S.C.
J.J. Britton	Sumter, S.C.
William Green DesChamps, Jr.	Bishopville, S.C.
Lawrence M Gressette, Jr.	Columbia, S.C.
H. Douglas Kingsmore	Aiken, S.C.
Louis B. Lynn	Columbia, S.C.
Thomas B. McTeer, Jr.	Columbia, S.C.
Buck Mickel	Greenville, S.C.
William J. Neely, Jr.	Taylors, S.C.
Philip H. Prince	Pawleys Island, S.C.
Joseph D. Swann	Greenville, S.C.
Allen P. Wood	Florence, S.C.

Executive Officers and Deans

Max Lennon, Ph.D.	President
W. David Maxwell, Ph.D.	Provost and Vice President for Academic Affairs
Hugh J. Clausen, LL.B.	Vice President for Administration and Secretary of the Board of Trustees
Milton B. Wise, Ph.D.	Vice Provost and Vice President for Agriculture and Natural Resources
David R. Larson, M.B.A., C.P.A.	Vice President for Business and Finance

Gary A. Ransdell, Ed.D.	Vice President for Institutional Advancement
G. Jay Gogue, Ph.D.	Vice President for Research
Manning N. Lomax, B.S.	Vice President for Student Affairs
Frank Mauldin, M.Ed.	Assistant Vice President of Human Resources
Farrell B. Brown, Ph.D.	Acting Dean of the Graduate School
Jerome V. Reel, Ph.D.	Vice Provost and Dean of Undergraduate Studies
Christopher J. Duckenfield, Ph.D.	Vice Provost for Computing and Information Technology
DeWitt B. Stone, Jr., Ph.D.	Assistant Vice President for Academic Affairs
Benjamin W. Anderson, J.D.	University Legal Counsel
Wade A. Green	Director of the Office of Public Affairs, Columbia
T. Ross Wilkinson, Ph.D.	Dean, Academic Affairs, College of Agricultural Sciences
James F. Barker, M. Arch.	Dean, College of Architecture
Ryan C. Amacher, Ph.D.	Dean, College of Commerce and Industry
Gordon W. Gray, Ed.D.	Dean, College of Education
J. Charles Jennett, Ph.D.	Dean, College of Engineering
Benton H. Box, D.F.	Dean, College of Forest and Recreation Resources
Robert A. Waller, Ph.D.	Dean, College of Liberal Arts
Opal S. Hipps, Ed.D.	Dean, College of Nursing
Bobby G. Wixson, Ph.D.	Dean, College of Sciences

Graduate School Administration

Farrell B. Brown, Ph.D.	Acting Dean of the Graduate School
A. DeWayne Brooks, Ed.D.	Assistant Dean of the Graduate School
Frankie O. Felder, Ed.D.	Associate Dean of International Programs and Services

COMMISSION ON GRADUATE STUDIES

The Commission on Graduate Studies examines and recommends to the Academic Council policies and procedures concerning graduate studies and graduate student academic affairs. Areas of specific concern include admission standards and procedures; financial assistance and awards through fellowships and assistantships; library resources; housing; graduate requirements; and other matters relating to the academic environment of graduate students. The commission also is concerned with outreach programs and other public educational efforts related to graduate studies.

The Commission on Graduate Studies is chaired by the dean of the Graduate School. Its members include two academic administrators from two different colleges recommended by the provost and appointed by the president; one elected college dean; one elected faculty representative from each college; a faculty senator; and three graduate student representatives.

THE GRADUATE SCHOOL

The Graduate School formulates policies and standards and unifies administrative procedures concerning all graduate work at Clemson University. This includes graduate admission policies, graduate programs and the granting of degrees.

The aims of the graduate programs at Clemson are to provide comprehensive education 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 therefore should 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 acts for the faculty in reviewing all proposals for curricular changes and recommends such changes to the provost. It is comprised of a nonvoting chairperson from the provost's staff, plus the chairpersons of the graduate curriculum committees of the academic colleges. The committee is guided by all applicable University rules and regulations and by the policies established by the Academic Council.

The provost and vice president for academic affairs takes 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 then transmits his or her recommendations to the president for final approval and informs the Academic Council, in summary form, of those curricular changes the president has approved.

Graduate students and faculty who are not members of the Graduate 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.

RESEARCH RESOURCES

Office of University Research

The Office of University Research coordinates these activities:

- sponsored research;
- educational services;
- public service proposals to outside agencies;
- patent disclosures, applications and negotiations of licensing agreements;
- facility security clearance;
- the University radioactive waste management program.

Information and assistance are available on applications for research support from federal and state agencies, industrial organizations, foundations and institutes, as well as fellowships of interest to the faculty.

University committees under the Office of University Research include the Research Advisory Committee, University Research Grant Committee, Biomedical Research Support Grant Committee, Patent Committee, Committee for Laboratory Animal Welfare, Committee for the Protection of Human Subjects and Institutional Biosafety Committee.

The associate vice president for research administration reports to the vice president for research, providing advice on University research activities and administrative support for the internal funding of annual faculty research grants and awards.

Oak Ridge Associated Universities. Clemson University is a member of the Council of Sponsoring Institutions of Oak Ridge Associated Universities (ORAU), a not-for-profit consortium of 49 colleges and universities and a management and operating contractor for the U.S. Department of Energy. The principal offices are located in Oak Ridge, Tennessee.

Founded in 1946, ORAU identifies and helps solve problems in science, engineering, technology, medicine and human resources. This organization conducts research and educational programs in energy, health and the environment for DOE, ORAU's member institutions, other colleges and universities, and other private and governmental organizations. ORAU manages competitive programs to bring precollege through postgraduate students, as well as university and other faculty members, into federal and private research laboratories. ORAU selects the recipients of fellowships and research grants as well as the facilities in which appointments are served. These facilities may include Oak Ridge National Laboratory; the Atmospheric Turbulence and Diffusion Division in Oak Ridge; Savannah River Laboratory and Savannah River Ecology Laboratory in Aiken, South Carolina; the Center for Energy and Environment Research in Rio Piedras and Mayaguez, Puerto Rico; the Morgantown, West Virginia, and Pittsburgh, Pennsylvania, Energy Technology Centers; the U.S. Bureau of Mines Pittsburgh Research Center; and the National Center for Toxicological Research at Jefferson, Arkansas.

Qualified students and faculty members may participate in programs in ORAU's Institute for Energy Analysis; Medical and Health Sciences Division; Manpower Education, Research and Training Division; Special Projects Division; and University Isotope Separator at Oak Ridge (UNISOR). Of particular interest are short, specialized courses for scientists, engineers, educators and students in nuclear-related fields developed and conducted by ORAU's Professional Training Programs.

The ORAU Laboratory Graduate Participation Program enables graduate students to perform full-time thesis or dissertation research under the joint direction of the major professor and a DOE staff member at a participating site. To participate, students must be in degree programs in the life, physical or social sciences; mathematics or engineering; and they must have completed all degree requirements except the thesis or dissertation research.

The ORAU Student Research Participation Program allows undergraduate students to work 10 weeks during the summer in directed research programs in federal laboratories and private industry. Students must have completed their junior year and have a major in one of the disciplines previously listed for the graduate student program.

Clemson University faculty members, under the ORAU Faculty Research Participation Program, can participate in ongoing energy research. During the research project, the faculty have access to modern research facilities for 10 weeks to three

months, usually in the summer. Some 12-month sabbatical appointments are available.

Student stipends vary but usually include adequate living allowance, tuition and fees. Faculty stipends usually are based on current institutional salary.

The programs described above are only a few of the 46 fellowships and research programs managed by ORAU. For more information, contact Clemson University's representative on the ORAU Council of Sponsoring Institutions, G. Jay Gogue, Vice President for Research, 107 Tillman Hall, Clemson University, Clemson, SC 29634-5701, telephone (803) 656-4538, or write to the University Programs Division, P.O. Box 117, Oak Ridge, Tennessee 37831-0117.

Research Facilities

Electron Microscope Facility. The Electron Microscope Facility is equipped with two transmission electron microscopes, two scanning electron microscopes and an Auger microprobe with a secondary ion mass spectrometer. The facility is equipped to prepare biological as well as thin films. Secondary equipment includes microtomes, a sputter coater and a dual ion milling machine. The stage capacity on the JEOL 848 SEM can handle an entire six-inch sample and has an energy dispersive X-ray unit attached. Applications such as voltage contrast and EBIC are available. Preparation areas for negatives and photographic printing are housed here as well. The laboratory is located on the ground floor of Jordan Hall.

Department of Experimental Statistics. The Department of Experimental Statistics provides a statistical consulting service to faculty, staff and graduate students. Advice and assistance are provided in the design, analysis and interpretation of research. Entry and computer analysis of data are available. Collaborative relationships should be established in the planning stage of research projects.

Electronic and Photographic Services. The Department of Electronic and Photographic Services (Communications Center) produces professional-quality video and audio tapes, multi-image presentations, and still and motion picture photography. Staff artists provide administrative and instructional graphics support. Various types of projectors, screens, and audio and video recorder/players are available for loan. The unit can produce and receive state and nationwide audio or video teleconferences.

SOUTH CAROLINA AGRICULTURAL EXPERIMENT STATION

Since 1886, researchers at the South Carolina Agricultural Experiment Station (SCAES) have been addressing the problems of agriculture in the state. The Experiment Station began when the General Assembly established the Agricultural Farms and Station at the University of South Carolina in Columbia. In 1889 this research facility was renamed the South Carolina Agricultural Experiment Station and was moved to Clemson Agricultural College. Within a year, substations were created to address the wide variation of soils, climate and growing conditions in the state. In addition to the major activities of the SCAES in the departments and colleges on the Clemson University campus, research facilities are located in Blackville, Florence, Charleston and Pontiac.

The mission of the SCAES is to develop knowledge through research that will provide the data base of information South Carolina citizens require to make intelligent decisions on matters concerning agriculture, natural resources and the rural environment. Scientists cooperate with researchers in every state to create better standards of living for people through the best possible use of natural resources. Over the years, scientists have worked in food development and improvement,

farming techniques and food packaging. They continue to work in the new scientific areas of genetic engineering and biotechnology.

The SCAES has an annual budget of almost \$21 million, which finances the efforts of 96 research scientists and 259 support personnel. Nearly 12,000 acres are involved in research activities. Graduate students in several colleges use these facilities for their research and education.

DCIT COMPUTING FACILITIES

The Clemson University Division of Computing and Information Technology (DCIT) supports graduate student course work and research through a network of on-campus computers. This network consists of an HDS AS/EX-80 with 128 megabytes of main memory, a vector processor and 32 I/O channels running the MVS/XA operating system, and several VAX computers ranging in size from the MicroVAX II to the VAX 8820. Three VAXes (an 8820, 8650 and a 6000-410), along with intelligent disk and tape controllers, form what is known as a VAXcluster running the VAX/VMS operating system. A VAX 8810 computer running the Ultrix operating system also is available.

Remote sites containing a variety of computers, terminals and peripheral equipment are maintained in Martin, Daniel, Lee, Lowry, Jordan and Sistine halls, Kinard and Hunter Chemistry laboratories, and Cooper Library. Among these, the facilities in Daniel, Martin, Lee, Lowry and Jordan halls contain large laboratories of microcomputers. Dial-up telephone numbers are available for use with suitably equipped personal computers.

An extensive campus Ethernet connects all major buildings and computers on campus. Terminals and workstations attached to this network allow interactive access to all DCIT computers on campus. There is also an extensive network that supports the MVS mainframe system. Terminals attached to this network allow interactive access to the MVS mainframe system only. TCP/IP allows file transfer among all DCIT systems. A variety of national and international networks is accessible. The division supports connections to BITNET, UUCPnet, CSnet, SURAnet and Telenet. The first three provide national and international electronic mail. SURAnet is comprised of major southeastern universities and is a subnet of the NSFnet. It provides researchers access to supercomputing facilities. Telenet is a public packet-switching data network that provides access to other off-campus computers and services, as well as a link back to the University's systems when away from campus (with the proper equipment and authorization). Upon enrollment, DCIT issues all students a computer ID on the MVS mainframe. This allows student access to a wide range of computing services, including electronic mail, on-line preregistration for class schedules and an on-line housing system.

Consulting and Technical Services (CTS) offers free short courses to teach students to use the Clemson systems. CTS maintains a Help Desk to assist users with their computer-related questions and problems. Handout material can be obtained free of charge at the Help Desk, or individuals can print their own documentation on the MVS mainframe using the PRINTDOC facility. CTS also provides typesetting and graphics services through its Graphics and Document Design (GADD) group. In addition, CTS provides microcomputing support and sales through the Micro Center.

The administrative offices of the DCIT are located in the Information Technology Center (ITC) at the Clemson Research Park. Consulting and Technical Services, The Micro Center, GADD and the Help Desk are located in the basement of Poole Agricultural Center. Except for adjustments in scheduling during holiday periods, Poole Computer Center is open Monday-Thursday 7:45 a.m.-11:00 p.m., Friday 7:45

a.m.-8:00 p.m., Saturday 10:00 a.m.-6:00 p.m. and Sunday 1:00 p.m.-10:00 p.m. The Micro Center is open Monday-Friday 9:00 a.m.-4:30 p.m., except on the first Friday of every month, when it opens at noon. The hours for the remote facilities in Surrine, Lowry, Lee, Daniel and Martin halls, and Hunter Chemistry Laboratory are similar to those for Poole. Library terminals are available whenever the library is open. Current schedules for all facilities are available on the MVS mainframe system by using the HELP HOURS command.

Computer Misuse Policy

Use of University computing resources, including account numbers, interactive terminals, data storage media, other peripherals, microcomputer systems and software, for computing activities other than those authorized by the University is strictly prohibited.

If the need for other uses develops, the appropriate authorization must be obtained in advance of this additional use. Use of such resources other than as authorized by the University is regarded as a criminal act in the nature of theft and will require restitution for any theft of computing resources and for any cost incurred by the University due to misuse by users.

Unauthorized duplication or alteration of software licensed by the University is strictly prohibited.

In any investigation of misuse of computing resources, the University reserves the right to inspect, without notice, the contents of computer files, regardless of storage medium, and system output, such as computer output.

CLEMSON UNIVERSITY LIBRARIES

Current resources and facilities of the Clemson University Libraries make it one of the most important research institutions in the Southeast. Today, the libraries have a collection of more than 7,000 serial titles and 1,500,000 volumes and volume equivalences. Outstanding collections of journals, books, government documents 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, U.S. Supreme Court Justice James F. Byrnes, U.S. Senator Strom Thurmond and S.C. 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 libraries have an on-line catalog, LUIS (Library User Information System), which permits access by any terminal tied to the University's mainframe computer and by remote dial-up access. DORIS (Document Online Retrieval Information Systems) is one of the few systems in the country providing access to periodical literature by electronic data bases housed on the University's mainframe. DORIS currently houses 11 bibliographic data bases, seven locally created full-text data bases, and the full text of the Academic American Encyclopedia. EDDIE (E-Mail Document Delivery and Information Service) permits faculty and remote users to check out materials via electronic mail, allows others to request interlibrary loans, books and journals to be purchased, as well as to submit electronically reference questions and make suggestions about the libraries. In addition, the Robert M. Cooper Library is linked electronically by OCLC, Inc., to more than 11,000 other libraries around the world for cataloging and interlibrary loan services. The Do-It-Yourself Searching Service is available at night and on weekends free of charge to access bibliographic data bases located on the

Lockheed Knowledge Index and BRS After Dark systems.

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

The main library (Cooper) consists of six floors that occupy 145,000 square feet of usable floor space. Almost 70,000 linear feet of shelving provide space for 1.25 to 1.5 million items. Seating space accommodates about 1,300 readers.

In addition to the Cooper 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, more than 30,000 volumes, 260 serial titles and seating for 60 users. A second branch, housing the libraries' manuscripts, rare books and University archives, is located in the Strom Thurmond Institute Building. This space, specifically designed to house and protect these special items, also provides user space. A departmental library in the Department of Chemistry, located in the Howard L. Hunter Chemistry Laboratory, contains the primary periodical literature in chemistry.

Except for adjustments in scheduling during holiday periods, the Cooper Library is open Monday-Thursday 7:45 a.m.-1:00 a.m., Friday 7:45 a.m.-11:00 p.m., Saturday 10:00 a.m.-6:00 p.m., Sunday 10:00 a.m.-1:00 a.m.

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

1. 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 courtesy to the borrower, failure to receive such a notice does not excuse the borrower from the payment of fines. Circumstances may prevent the library from sending overdue notices.
2. If a book is recalled, regulations apply the same as for undergraduate students. The due date is changed; higher fines are assessed when the books are not returned by the new date; and borrowing privileges can be suspended.

INTERNATIONAL PROGRAMS AND SERVICES

The Office of International Programs and Services (OIPS) assists all international students and visiting scholars in academic, financial, social and personal matters. It also serves as the official liaison between Clemson University and the U.S. Immigration and Naturalization Service (INS). Upon arrival at Clemson University, international students and visitors should immediately contact OIPS. The office is located in E-208 Martin Hall, telephone (803) 656-2457.

Students

Among the primary services to international students provided by OIPS are (1) preparing and issuing credentials for securing visas before they come to the United States; (2) advising students on INS regulations and procedures, and assisting with completion and forwarding of paper work to INS to maintain legal status while enrolled at Clemson; (3) providing registration assistance; (4) determining employment and practical training eligibility; (5) generally interpreting University policy and procedures to the international community; and (6) facilitating a smooth adjustment

to Clemson University and the city through initial orientations and ongoing workshops.

Admission services for international students are jointly provided by the Graduate School and OIPS. International students who have come from abroad or transferred from another school must meet academic, language and financial qualifications as determined by Clemson University. The general portion of the Graduate Record Examination (GRE), Graduate Management Admission Test (GMAT), 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. Financial qualifications are determined by the submission of financial assessment and bank statements verifying adequate funding. These documents must be received by the University before credentials are issued for entrance into the United States.

Application Deadlines

1. Students from Abroad. Completed applications for admission of prospective international students from abroad must be received by the Graduate School by May 1 and October 1 for registration in the subsequent fall and spring semesters, respectively. Every required item in support of the application must be on file with the Graduate School by these dates. Thus, international applicants living outside the United States should complete the required standardized tests at least three months prior to May 1 or October 1, as appropriate. Credentials for a student visa will be issued no later than June 15 and November 15 for registration in the fall and spring semesters, respectively. Initial enrollment of international students in the summer sessions is strongly discouraged and is permitted only on rare occasions.

The information below applies to all international students from abroad.

	<i>For enrollment in:</i>	
	<i>Fall Semester</i>	<i>Spring Semester</i>
Completed application	May 1	October 1
Issuance of credentials*	June 15	November 15

2. Students Living in the United States. International students living in the United States do not require visa credentials from OIPS until they arrive on the Clemson University campus. Consequently, slightly more time is allowed for international students living in the United States to complete their applications for admission to the University.

The information below applies only to international students living in the United States who are applying to Clemson University's graduate programs.

	<i>For enrollment in:</i>	
	<i>Fall Semester</i>	<i>Spring Semester</i>
Completed application**	July 1	December 1
Issuance of credentials for visa***	N/A	N/A

* Action taken by the Office of International Programs and Services (OIPS) after review by the department and acceptance by the Graduate School. Evidence of funding must be available to OIPS at this time.

** Every required item in support of the application must be on file with the Graduate School by these dates.

*** Visa credentials are not sent to international students living in the United States. The procedures established by the U.S. Immigration and Naturalization Service allow this paper work process to occur once the students have arrived at the universities they will attend. However, financial verifications must be clearly documented by July 1 and December 1 for enrollment in the fall and spring semesters, respectively.

Application Fee and Time Limit

International applicants must submit a \$25 nonrefundable application fee along with the application. This fee must be received before the application will be processed. **No application fee waivers are granted by Clemson University.** Generally, the application is valid for one year beyond the initial date desired for enrollment. However, in instances where applicants are unable to enroll because of documented circumstances beyond their control, the application may be valid for one year from the date of the first registration period following the date of the letter of acceptance. Application materials are kept for two years beyond the desired initial date of enrollment. After that time has elapsed, a student must reapply to the University by submitting a new application, including the required fee. Students may also need to resubmit all academic supporting materials requested in the application.

Employment and Financial Assistance

Generally, financial assistance is not available to Clemson's international students; however, a limited number of instructional and research assistantships are available for highly competitive students. Assistantships are awarded by individual departments (see "Departmental Graduate Assistantships" on page 30), and the student must write directly to the department regarding the availability of assistantships.

Special employment regulations for international students are determined by INS. Thus, to ensure compliance with these regulations, international students must obtain permission from the Office of International Programs and Services before gaining employment at Clemson. It is important to note that off-campus employment is prohibited for students who remain in the United States in F-1 status for one year or less. Off-campus employment is also prohibited during the first year for students who intend to remain in the United States in F-1 status for more than one year.

Visa Requirements

International students must at all times have the type of visa required by their sponsor (government, agency or local department providing funds for study at Clemson). If the sponsor has no such requirement and no clear guidelines otherwise are available, the student may choose his or her own visa type. Status changes must be made through U.S. Consulate offices. In addition, international students sponsored by their governments or by an agency promoting international education cannot change degree objectives without the written consent of the sponsor.

Fees and Expenses

The amount of funds students must have on hand to enter the United States (one-third of the annual cost) is indicated on the visa credentials issued by Clemson to international students from abroad. Health care and related medical expenses in the United States are costly. Therefore, health and accident insurance is required of all international students and accompanying family members.

Students from abroad will pay these estimated annual costs to attend Clemson University.

	<i>Graduate Students</i>	<i>Graduate Assistants</i>
Academic fees	\$ 3,390	\$ 800
Medical fee	216	216
Insurance (annual)	179	179
Living expenses	7,800	7,800
Total costs	\$11,585	\$8,995
(Required funds in hand)	\$ 3,858	\$2,000

These costs are for the 1990-91 calendar year and are subject to change without notice. Credentials for obtaining a visa (I-20s or IAP-66s) indicate that students must, as a minimum, have in hand the amounts indicated above before entering the United States. Housing is arranged directly by the student with the University Housing Office. Applications for housing are sent by OIPS to the student along with the letter of acceptance.

The estimated semester costs for international transfer students (i.e., residing in the United States) are indicated below.

	<i>Graduate Students</i>	<i>Graduate Assistants</i>
Academic fees	\$ 1,155	\$ 300
Medical fee	80	80
Insurance (annual)	179	179
Living expenses	2,925	2,925
Total costs	<u>\$4,339</u>	<u>\$3,484</u>

Visiting Scholars

The visiting international scholar (hereafter referred to as a visitor) is a foreign national associated with an academic department of the University for purposes other than employment or the attainment of a degree or academic credits. Typically, the association is for a period of three to twenty-four months and may begin at any time during the year. The visitor status is formalized by approval of a Visitor Application secured from and approved by OIPS. Confirmation of English ability and academic degree is required prior to admission.

An administration fee of \$200 per month is required. The established University health fee and accident insurance are also required.

Services provided by OIPS include assisting the visitor with INS requirements; advising visitors regarding insurance; serving as a liaison on program objectives between program agency sponsors, academic departments and the visitor; and providing updated progress reports when requested.

STUDENT SERVICES

CAREER CENTER

The Career Center coordinates campus visits for hundreds of representatives from business, industry and government who are interviewing graduate students for permanent employment and summer internships. Recruiters are scheduled from September through April. Clemson University has one of the most sophisticated placement systems in the country, which allows students to research employers and sign up for interviews from any campus terminal connected to the mainframe.

Graduate students are encouraged to attend seminars on writing resumes, interviewing and job-search techniques. Individual career counseling and a computer-assisted career information system are available. All graduate students are encouraged to register with the Placement Office one year before their expected graduation date.

The Career Center is in Room 804 University Union.

FOOD SERVICE

The University provides several economical meal plans, which are outlined in the food service brochure. Harcombe and Schilletter dining halls feature an unlimited seconds policy, while the Clemson House dining room and the Canteen serve meals on an a la carte basis. Students dining at the Clemson House may use the meal card as a cash equivalency or for a predesignated meal at no additional cost. Meals may also be purchased on a cash basis or with a declining balance account.

Meal plans begin immediately after a student obtains a meal plan at the beginning of the semester and end after the evening meal on the day of graduation at the end of each semester. The meal card is personal and may not be transferred or sold.

No meal plan refunds will be allowed until after the last day to register for classes, except for students who withdraw from the University. After the last day to register, meal plan changes creating a refund will be allowed only in the case of marriage, medical reasons, change in dormitory assignments to a room with kitchen facilities, conflict with working hours or class schedule, or other circumstances determined by the University to be beyond the student's control. All changes creating a refund must be approved by the Card Access Office located in Harcombe Dining Hall. Written documentation must be provided. Meal plan refunds, when authorized, will be prorated on a weekly basis.

HANDICAPPED STUDENTS

Clemson University is committed to providing equal educational opportunities to all students and assisting students in making their college experience successful and positive. The Office of Student Development Programs serves the special needs of students with permanent disabilities. Individuals requesting services should provide current (within the last two years) documentation of their disability from their physician or other professional. This information should be forwarded to the Office of Student Development Programs by July 1 or within 10 days of acceptance to the University. Prospective students are encouraged to visit the campus and schedule a meeting with the coordinator of handicapped student services to discuss special needs.

Clemson University recognizes a handicapped student as anyone who has a physical or mental impairment that substantially limits one or more of his or her major life activities. In compliance with Section 504 of the Rehabilitation Act of 1973, Clemson University has appointed a coordinator of handicapped student services as well as a University Committee on the Handicapped. One of the primary responsibilities of the coordinator and the committee is to help integrate the handicapped student into the normal academic process. In addition, the committee identifies problem areas, develops solutions to these problems, monitors the effectiveness of the programs for the handicapped, and makes recommendations where actions or policies are needed. Additional details are available in the Office of Student Development Programs located at 103 Holtzendorff, or call (803) 656-0511.

HEALTH SERVICES

All graduate students living in University residence halls, all graduate students enrolled in 12 or more semester hours and paying the full-time rate, irrespective of their residence, and all international graduate students are required to subscribe to the University health plan. The University health service is not available to students enrolled solely in the M.B.A. program on the Furman University campus. The health plan offers a variety of services including infirmary care, outpatient treatment for illnesses and injury, mental health counseling, dermatology and gynecological care.

The \$80 per semester medical fee (summer session fees are on a prorated basis) covers the services of the University physicians, nurse practitioners and nursing staff for most illnesses and injuries. It also includes complete X-ray services and laboratory work done in the health service laboratory.

Items not covered by the health service fee include pharmaceuticals, allergy injections, physical examinations for employment or transfer to another school, consultation with referral physicians, laboratory tests that must be sent to a reference laboratory, and medical or surgical services performed away from campus. Dental care is not offered by the health service but can be obtained locally at the student's expense.

The University offers a plan of accident and sickness insurance designed to cover major medical expenses not covered by the health plan. Information on this insurance plan is sent to all students prior to the beginning of the fall semester. The health center strongly encourages students to purchase the additional health insurance.

The health service is housed in Redfern Health Center and is complete with an outpatient department and an 11-bed infirmary. The outpatient clinic is open 8:00 a.m.-4:30 p.m. weekdays. Saturday office hours are 9:00-11:00 a.m. On Sunday, physicians' hospital rounds are the only service provided other than emergency treatment. Intercom boxes are stationed at each entrance for emergency use after hours. Nurses are on duty at all times, and a doctor is on call at all times.

The student health service has the basic function of providing medical care for the ill and injured; however, it strongly emphasizes health rather than illness. This emphasis begins with the entrance medical questionnaire designed to obtain information regarding medical history to better equip the staff in providing medical care and to serve as a guide for the care of preexisting medical problems. Immunization requirements are enforced prior to enrollment.

HOUSING

Single Student Housing

Residence halls and apartments are located on the main campus and provide accommodations at economical rates for graduate and undergraduate students. All University housing is air-conditioned and furnished with clothes lockers, study desks, chairs and beds. Two students are assigned to a room. Apartments have two bedrooms, a living room and a kitchen. Four students are assigned to each unit.

Graduate students interested in single student accommodations should write directly to the Housing Office, 200 Mell Hall, Clemson University, Clemson, South Carolina 29634-4075, to obtain information regarding assignments. This should be accomplished promptly because there is a critical shortage of on-campus housing. To request a space, applicants should contact the Housing Office at least six months prior to the date scheduled for enrollment. A \$95 advance payment is required to reserve a room in University housing. 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, but all apartments are open for occupancy for an interim housing charge.

Rental rates per semester are shown below.

Residence Halls

Johnstone Hall: Sections A,D, E, F	\$650
Donaldson, Bowen, Wannamaker, Bradley, Norris, Johnstone Annexes A and F, Benet, Young, Cope, Geer and Sanders	\$745
Mauldin, Barnett, Smith, Manning, Lever and Byrnes	\$825
Clemson House (room)	\$815

Apartments

New East Campus Complex (4 occupants)	\$1,030
Calhoun Courts (4 occupants)	\$1,005
Thornhill Village (4 occupants)	\$895
Clemson House (3 or 4 occupants)	\$845

Nine-month Graduate Student Housing. An on-campus graduate housing area in Thornhill Village Apartments is available for single graduate students and consists of seven duplex units. Each duplex has two bedrooms, a bathroom, a complete kitchen, a living room, and houses four students. All bedrooms are furnished, and all utilities are included in the rental cost.

A nine-month lease contract is required prior to occupancy of this particular University housing. Release from the contract is allowed only in extreme situations, with the cost prorated for the nine-month lease.

Students interested in occupying one of these units should specify the graduate housing area, units 40-43, on their housing application

Family/Faculty Housing

The University provides comfortable and economical housing with 100 apartments conveniently located near campus. Applications and booklets describing these facilities are available upon request from the University Family Housing Office. Monthly rental fees range from \$220 to \$395. Students must have a graduate assistantship or fellowship to qualify for family/faculty housing. Students must submit applications to the University Family Housing Office.

Off-campus Housing

Commercial housing in the surrounding community accommodates the majority of graduate students, both married and single. A complimentary listing of real estate companies and other contacts is available upon request from the University Renter's Information Center located in the Clemson House.

International Students and Visiting Scholars

The Office of International Programs and Services works with the University Housing and Off-campus Housing offices to help international students find housing in the 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. Housing arrangements for visiting scholars are made with the assistance of the hosting academic department.

GRADUATE EXPENSES

ACADEMIC EXPENSES, 1991-92

Academic Fees

1. *Graduate Students.* Semester charges for graduate students are determined by the credit load, with no distinction between graduate and undergraduate credits. Actual charges for 1991-92 are not known when the catalog is printed. The charges reflected below are for 1990-91 and are subject to change as conditions warrant.

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

Academic Fee	\$1,155
Medical Fee	80
Semester Total (excluding room and board)	\$1,235

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:

Academic Fee (per semester hour)	\$90
Medical Fee (optional for nondormitory domestic students)	\$80
Fike Recreation Center Fee (optional)	\$20

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. Students enrolled solely in the M.B.A. program on the Furman University and Lander College campuses will pay \$125* per credit hour and are ineligible for medical or athletic privileges previously described.

2. *Graduate Assistants.* Graduate assistants pay a flat fee of \$300* per semester and \$100* for each summer session. Graduate assistants may elect to sign a payroll deduction agreement at the time of registration. Details on the deferred payment schedule may be found on page 28 under the heading "Fiscal Policy."

Use of Fike Recreation Center facilities by graduate assistants during the fall and spring semesters is available at employee rates. Graduate assistants using the student health service must pay the medical fee of \$80 per semester. Season athletic tickets may be purchased at the faculty-employee rate.

A graduate assistant is defined as a student with at least a bachelor's degree who is enrolled in a degree program, devotes a minimum of 10 and a maximum of 30 hours of service per week to the University, and satisfies the minimum enrollment described on page 31. For the graduate assistant to qualify for the above academic fee structure, the assistantship appointment must be in effect on or before the last day of regular registration and must remain 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 graduate students.

* Subject to change.

3. Postbaccalaureate Students. Postbaccalaureate students pay the same academic fees as undergraduate students and are subject to out-of-state fees, if applicable.

4. Permanent University Faculty and Staff. Permanent University staff members and faculty pay the following:

Academic Fee (per semester hour) \$45

A permanent employee (as defined by the Clemson University Office of Business and Finance) is a person employed full time (37.5-40 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 39.

Auditing Fees

Full-time students or graduate assistants may audit courses as part of their schedule. Part-time students are charged according to the following schedule:

Academic Fee (per semester hour) \$45

Refer to page 44 for the policy on auditing.

Graduation Fees

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

Diploma Case \$ 8.00*

Mailing fee \$ 4.00*

Apparel for Graduation (attendance optional)

Master's or Education Specialist

Degree Candidates \$26.20*

Doctoral Degree Candidates \$29.95*

Binding Fees for Theses or Dissertations

(if applicable) \$20.55*

Publication of Dissertation Abstract

(if applicable) \$45.00*

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.

Athletic Contests and University Concerts

Departmental graduate assistants and graduate resident assistants (see pages 30-31) will be eligible to purchase two season tickets per sport at the faculty-employee rates. Applications must be completed at the Jervy 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 \$1,235* entitling them to the same restrictions and privileges as undergraduate students.

* Subject to change.

Graduate students enrolled for less than 12 hours may attend University concerts upon purchase of season tickets. The privileges just described do not apply to students enrolled solely in the M.B.A. program on the Furman University campus.

Vehicle Registration

Vehicles must be registered immediately upon being brought to campus. The cost of vehicle registration is \$18* for one year, August 15 to August 15. The cost is \$12* for the spring semester and summer, January 1 to August 15. Each additional vehicle is \$5. Parking permits and further information may be obtained from the Department of Parking and Vehicle Registration, Unit 228, University Square, (803) 656-2270.

FISCAL POLICY

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 and 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 the total of the graduate assistant fees for the semester. Payment of the amount deferred is to be made in six equal installments through payroll deductions beginning with the first full 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.

Refund of Fees

Regular Semester. No refunds will be made on a semester's academic and medical fees after four weeks from the last day to register. In the case of a withdrawal from school, the refund will be based on the effective date of withdrawal as shown on the official University withdrawal form. Refunds for full-time students who drop to part time and part-time students who drop credit hours will be based on the date the Schedule Change Form is returned to the Registrar's Office. To be eligible for a refund, the request must be received by the Office of Business Affairs prior to the beginning of the next fall or spring semester. **Beginning with the day following the last day to register**, refunds for periods of four weeks or less during a semester shall be made on the schedule shown below.

* Subject to change.

<i>Period of Enrollment After Last Day to Register</i>	<i>Percent Refunded</i>
One week or less	80%
More than 1 but not more than 2 weeks	60%
More than 2 but not more than 3 weeks	40%
More than 3 but not more than 4 weeks	20%
More than 4 weeks	0%

Summer Session. No refunds of academic and medical fees will be made after three weeks from the last day to register. In the case of a withdrawal from school, the refund will be based on the effective date of withdrawal as shown on the official University withdrawal form. Refunds for students who drop credit hours will be based on the date the Schedule Change Form is returned to the Registrar's Office. To be eligible for a refund, the request must be received by the Office of Business Affairs prior to the beginning of the fall semester. **Beginning with the day following the last day to register,** refunds for summer school sessions shall be made on the schedule indicated below.

<i>Period of Enrollment After Last Day to Register</i>	<i>Percent Refunded by Length of Summer Sessions</i>			
	<i>Less than 3 wks.</i>	<i>3 wks</i>	<i>5 or 6 wk. session</i>	<i>More than 6 wks.</i>
One week or less	0%	40%	60%	60%
More than 1 but not more than 2 weeks	0%	0%	20%	40%
More than 2 but not more than 3 weeks	0%	0%	0%	20%
More than 3 weeks	0%	0%	0%	0%

Past Due Student Accounts

Any indebtedness to the University that 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 a transcript or diploma.

Establishment of University Fees

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

STUDENT EMPLOYMENT AND FINANCIAL ASSISTANCE

GRADUATE APPOINTMENTS

Approximately 1,300 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 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 described in each section below and the credit load requirements found on page 44. The University reserves the right to withdraw the appointment at any time because of failure to meet these requirements.

Departmental Graduate Assistantships

Assistantships are available in instruction, research or extension. Such appointments may be made on an annual basis or an academic year basis (40 weeks) with work periods and duties assigned by the department. Application forms may 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 academic and other fees and enjoy certain other benefits provided for University staff personnel.

1. Eligibility and Stipends. 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). Multiple employment of graduate students by the University (graduate appointment 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 44.

The current minimum graduate assistantship rate is established commensurate with \$5 per hour. Most stipends are at least twice this amount.

2. Minimum Enrollment. A minimum enrollment is required for appointment as a departmental graduate assistant. During the academic year, students enrolled in a doctoral program or a thesis-option master's program must enroll in at least 12 semester hours each semester. Students enrolled in a master's program not requiring a thesis must enroll in nine semester hours each semester. Minimum enrollment in the summer sessions is three semester hours per session irrespective 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 be included in the minimum in unusual cases cleared in advance with the Graduate School.

Graduate students should understand that the assistantship may be withdrawn at any time for failure to maintain satisfactory academic status as described under "Academic Standards" on page 41.

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 are required, and compensation for such employment amounts to a room or apartment, partial remission of academic and other fees, and approximately \$1,000 per semester. Graduate resident assistants are subject to the credit load limitation found on page 44, 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 and Traineeships

Approximately 140 outstanding graduate students hold fellowships or traineeships at Clemson University. These awards, received from a variety of alumni, foundation, governmental, individual or industrial sources, require no services. Payment in excess of actual educational costs is subject to federal and state taxes.

Graduate Alumni Fellowships, R.C. Edwards Research Fellowships and George R. MacDonald Fellowships are University-wide awards administered by the Graduate School. These awards, of \$5,000 each for the academic year, are made on a competitive basis to nominees selected by the departments. Scholarly potential and academic excellence are the sole criteria for the awards.

Two H. W. Close Graduate Fellowships of \$12,000 each are awarded annually to two outstanding students applying to master's programs. The fellowships, renewable for a second year, require the student to rank in the top 10 percent of his or her class. The fellowships also emphasize extracurricular activities indicative of potential leadership. One award is made to a student enrolling in the College of Commerce and Industry and the other is open on a University-wide basis.

Most fellowships and traineeships are administered by the individual colleges and departments. Some awards, such as the Industrial Graduate Residency Fellowships, may limit the student's research to areas of interest to the donor and require a period of residency at the industrial site. Detailed information is available in the colleges or departments.

South Carolina Graduate Incentive Fellowships of \$5,000 for master's students or \$10,000 for doctoral students are available to minority graduate students. These awards are renewable. Master's students must be citizens of South Carolina. Preference is given to new applicants and those who express a commitment to remain and be employed in the state for two years. These fellowships are administered by the Office of Human Resources.

Unless stipulated otherwise by the grantor and/or donor, holders of fellowships or traineeships are required to enroll in the same minimum credit load as is applicable

to departmental graduate assistants. Continued receipt of any fellowship or traineeship is contingent on the student's maintaining a satisfactory academic status. A student cannot hold concurrently two or more full fellowships or traineeships (or the equivalents thereof) administered by the University.

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

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 44. 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 used to qualify students for benefits afforded those on graduate assistantship appointments.

OTHER FUNDS

The Student Financial Aid Office coordinates and administers loan assistance available to graduate students. The primary loan program is the Stafford Loan (GSL), with loan amounts up to \$7,500 per year. Students seeking loan assistance through the Stafford Loan must establish financial need by submitting the Financial Aid Form (FAF) to College Scholarship Service. The Supplemental Loan for Students (SLS) is available for students who need additional funds or who do not establish financial need through the FAF. Further information and the appropriate forms are available in the Student Financial Aid Office, G-01 Sikes Hall, Clemson University, Clemson, S.C. 29634-4023.

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 begin 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, 212 Hardin Hall, where application forms and additional information are available.

SPECIAL EMPLOYMENT RESTRICTIONS

Current South Carolina law prohibits the employment by state agencies or institutions of persons who have willfully defaulted on a Perkins Loan (NDSL), a Stafford Loan (GSL), a Nursing Student Loan, a Health Professions Student Loan or a Law Enforcement Education Loan. Graduate students who are employed in programs administered directly or indirectly by Clemson University and are found to be in willful default on payment of these loans, will have such employment terminated unless they can provide a written agreement with the lender whereby the payments on the loans may be deferred under certain conditions, such as completion of their graduate program.

ADMISSION PROCEDURES AND REQUIREMENTS

PROCEDURES

Application Deadlines

Application for admission of United States citizens and residents should be submitted four weeks prior to registration (see the calendar on pages 8-9 for dates). Applicants to programs requiring standardized test scores should complete these examinations at least 12 weeks before registration and make arrangements for official results to reach the Graduate School four weeks prior to registration. Unless all admission credentials reach the Graduate School at least four weeks prior to registration, an acceptance decision cannot be guaranteed. Students applying to a graduate major significantly different from their undergraduate major may anticipate a longer period of time for a decision.

Applications for admission of prospective international students must be completed by May 1 and October 1 for registration in the fall and spring semesters, respectively. This means that every required item in support of the application must be on file with the Graduate School by these dates and that the actual application must have been on file at least four weeks in advance of these dates. Thus, international applicants living outside the United States should complete the required standardized tests at least three months prior to May 1 or October 1, as appropriate. Issuance of Form IAP-66 for a student visa will be completed no later than June 15 and November 15 for registration in the fall and spring semesters, respectively. These dates apply to international applicants from abroad. Initial enrollment of international students in the summer sessions is strongly discouraged and is permitted only on rare occasions.

Application Fee and Time Limit

For applicants wishing to enroll in the Graduate School for the first time, a nonrefundable fee of \$25 payable to Clemson University via a money order or a check drawn on a United States bank must accompany the application before it will be processed. The application is valid for one year beyond the initial date desired for enrollment, inclusive. Applicants who enroll within this time period pay the fee only once regardless of the number or date of future enrollments. Applicants who do not enroll within this time period and who subsequently wish to be admitted must reapply and repay the fee (nonrefundable) and may be required to resubmit all supporting materials.

Disposition of Application Materials

Credentials or supporting materials submitted for admission to the Graduate School become the property of the University and are not returned. Furthermore, no copies will be provided to a third party outside the University even if the applicant requests this release. Copies will be provided to appropriate offices at the University in the interest of academic matters or financial awards relative to the applicant.

ACADEMIC REQUIREMENTS

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 and Doctor of Philosophy Degrees.* Criteria for admission to these University-wide degrees include satisfactory scores on the general portion of the Graduate Record Examination (GRE).*

Applicants to the M.S. degree program in industrial management must submit satisfactory scores on the Graduate Management Admission Test (GMAT)* in lieu of GRE scores.

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 general scores.* Specifically, the professional programs in accounting and business administration require satisfactory scores on the GMAT* in lieu of the GRE.

International students, in addition to meeting the minimum and general requirement stated previously, must submit satisfactory scores on the general portion of the Graduate Record Examination* regardless of the degree objective. (However, see items 1 and 2 above for the master's programs in industrial management, accounting and business administration.) 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. The Graduate School may waive this requirement if the applicant has a demonstrated command of the English language.

Admission in all programs is restricted to those students whose academic records clearly indicate they are prepared to benefit from graduate study. 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.

Assessment of Previous Academic Work

The grade point ratio representing an assessment of an applicant's undergraduate work will be based on the last half of the course work listed on the transcript or transcripts. In conventional cases, this will equate to the full junior and senior years. As a minimum, 60 semester hours (or 90 quarter hours) will be examined, and in no cases will a partial term, session or enrollment period be utilized. Excluded in the computation are courses graded P/F and certain electives having no relationship to a curriculum. Departments are at liberty to discount still other courses in assessing an applicant's academic record. Certain professional programs may use the total undergraduate grade point average to satisfy accreditation standards. In evaluating the grade point ratio of an applicant's graduate work, all graduate course work will be used except research and/or courses graded P/F.

* GRE or GMAT 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.

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 or GMAT 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 degrees 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 38.

Applicants Presently Enrolled in 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 a doctoral program after completing their initial degree objective may apply by submitting the normal application, color-coded green. 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 of major and/or degree without submitting a new application. Instead, the student must submit to the Graduate School Form GS14 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.

Readmission

A former graduate student who has not maintained continuous enrollment (summers excluded), but who is academically eligible to continue in the graduate degree program where he or she was most recently enrolled, may be permitted to return. The procedures are dictated by the period of absence from enrollment as follows:

1. *Less Than Two Years.* The student simply notifies the Graduate School and the program coordinator of his or her plans to return.
2. *Two to Six Years.* A new application must be submitted and endorsed by the program coordinator and the Graduate School. The application must show any intervening graduate work, and appropriate official transcripts of the work may be required by the Graduate School.
3. *Six or More Years.* A new application and all supporting materials will be required; that is, such persons are considered to be new applicants.

Former graduate students described above who wish to return to Clemson University to pursue an undergraduate degree and/or course work with no immediate plans for graduate work should contact the Registrar's Office for procedures.

Academic Renewal

The student who was dismissed from the Graduate School for a grade point deficiency and who has not enrolled for a period of four or more academic years may apply to the Graduate School for readmission under special conditions known as academic renewal. Under these conditions, the previous graduate credits attempted and quality point deficit will not constitute a liability in a new grade point computation. However, no credits passed or their attending quality points will be available to the student for a degree at Clemson, and any courses previously passed may not be revalidated by special examination. The previous record will appear on the permanent record as well as the notation of readmission under the policy of academic renewal.

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 another master's degree in the same field at Clemson.

MEDICAL REQUIREMENTS

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 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 complete 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, documentation of two Red measles vaccines since the age of 12 months, and results of a PPD (screening for tuberculosis) within the past year. Students will not be allowed to register without a completed immunization record.

ADMISSION CLASSIFICATIONS

Admission to a Degree Program

Candidates for admission to a degree program will be admitted 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 the 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 not graded pass/fail. An academic year is defined as the total of two academic semesters.

3. Conditional Acceptance. At least one item required for admission is not available.

In addition to meeting the minimum requirements for degree programs listed under "Degree Requirements" (page 52), the student must be recommended for admission by the program coordinator or department head and must meet any special departmental requirements.

Admission as a Nondegree 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 recertification. 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.

Nondegree 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 (nondegree and/or transfer) may be applied toward the degree. In all cases the nondegree student must receive permission from the head of the department before enrolling in graduate courses. This classification is not open to international students.

Students enrolled in a nondegree status are subject to the same academic regulations regarding continuous enrollment as apply to those in a degree program. Refer to page 43.

Admission as a Postbaccalaureate Student

An applicant may be accepted by the Graduate School as a postbaccalaureate student if he or she applies to a specific graduate degree program and does not have the appropriate academic background. The applicant must be recommended by the department head or program chairperson and must meet all the other requirements for admission to that degree program regarding grade point ratio and standardized test scores. A change in major between the undergraduate and graduate levels may require a longer review time by the department. A student in this category who is denied admission because of failure to meet the minimum requirements has access to the same appeal procedure as any other student applying to the Graduate School.

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

At the time a postbaccalaureate 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 used by the department and the Graduate School for all other applicants to the particular degree program. The postbaccalaureate student is expected to maintain a B average and receive no grade lower than a C to qualify for admission to a graduate program.

Postbaccalaureate students may enroll in the same number of credits per semester as any undergraduate student but cannot enroll in graduate courses (600 level or above) or receive a graduate assistantship. No degree or certificate shall be awarded to students in the postbaccalaureate status, and 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. Academic and other fees for postbaccalaureate students shall be those applicable to undergraduates with the exception of the application fee and admissions deposit.

A student possessing an undergraduate or 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 postbaccalaureate 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 School. This approval is required prior to registration and may be obtained by completing and returning to the Graduate School office the appropriate form (Form GS6, available at the Graduate School office). The total course work load for the semester must not exceed 18 hours, and the cumulative graduate credits earned by seniors shall 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 cannot be counted later toward an advanced degree. Alternatively, such students may take 600-, 700- or 800-level courses in excess of the requirements for their undergraduate degrees and 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. Courses at the 600 level cannot be taken if their 300- and 400-level counterparts appear on the undergraduate transcript.

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 35. If accepted, the student may enroll in graduate courses for inclusion in a future graduate program, subject to approval of Form GS6. The form must be turned in and accepted by the Graduate School before a student can preregister or register for graduate courses.

In all cases, the credits and quality points associated with senior enrollment in graduate courses will be part of the undergraduate record.

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 nondegree student in graduate courses on receipt of Form GS8, Transient Graduate Student Status, 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 44.

Teacher Certification or Recertification

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 postgraduate 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 recertification for public school teachers. The Graduate School gives no assurance that a program for a graduate degree and a program for a certificate, or recertification 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. 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 36) or as a nondegree student (page 37), or must have been granted conditional acceptance as described on page 35.

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.

GENERAL GRADUATE SCHOOL REGULATIONS

Graduate students are subject to the usual procedures and regulations of the University, and in particular to those dealing with academic dishonesty (see page 48), except as these procedures and regulations apply to undergraduate students only.

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 factors encountered during the process.

The Major Advisor

Before registering, a student must, with the aid and approval of the department head or program coordinator, select a major advisor. This advisor must be a member of the program faculty offering the degree and meet the requirements for advisory committee membership described below. In departments or programs 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 final doctoral oral examination, and initiate the recommendation for the awarding of the degree. Additionally, the advisory committee may administer qualifying or preliminary and/or final comprehensive examinations. One member of the committee will be designated as chairperson 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 or program coordinator. Concurrently with submission of the graduate degree curriculum, the department head or program coordinator will forward recommendations to the dean of the college, who will, if he or she approves, then transmit the recommendations 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. The majority of the advisory committee, including the major advisor, must be comprised of Clemson University faculty from the department offering the particular degree and who hold full-time positions carrying eligibility for tenure. Committee members of interdepartmental programs shall be appointed according to bylaws, formulated by the program faculty and endorsed by the Graduate School, that assure appropriate representation of the participating departments.

Part-time and visiting faculty employed by Clemson University may serve on the committee. Persons not employed by the University may serve if they have been appointed to an adjunct faculty status. Part-time, visiting and adjunct faculty may serve as research advisors and will have full voting status on the outcomes of all examinations given by the committee. Inclusion of part-time, visiting and adjunct faculty must not compromise the majority requirements defined above.

The student and committee members are notified of the appointments by the graduate dean.

Filing of a Graduate Degree Curriculum

A graduate degree curriculum (Form GS2) must be filed with the Graduate School by those students who are in degree programs. Since fixed curricula 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; 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 stipulation described under "Acceptance of Transfer Credit" on page 45.

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 the 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 (Form GS4) 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 the comprehensive examination (page 57).

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 (Form GS2).

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 (Form GS4). This order is submitted to the graduate dean and must be resubmitted should the student not graduate on the anticipated date. A \$25 late fee will be assessed a student whose Form GS4 is submitted after the deadline dates shown on pages 2 and 3.

ACADEMIC REGULATIONS

Permanent Academic Records

The student's permanent academic record is a historical record of the student's academic progress. It is maintained in the Registrar's Office and contains personal identifying information, grades and credits. Where appropriate, statements of a corrective nature, withdrawals, suspension for failure to meet academic standards, suspension for disciplinary reasons and graduation data are added.

Academic Standards

Most graduate courses are graded on an A-B-C-F scale. Thesis and dissertation research and several other graduate 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 apply toward the number of credit hours required for the degree. The

* An academic semester is defined as a minimum of nine credit hours of course work not graded pass/fail. An academic year is defined as the total of two academic semesters.

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 those taken on a pass/fail basis. See "Enrollment on a Pass/Fail Basis," page 44. Students who fail to meet these requirements become ineligible for graduation and are placed on academic probation. The probationary status will remain in effect until nine additional semester hours of graduate credit have been attempted. Students who fail to remove the probationary status as prescribed are subject to academic dismissal and will not be permitted to continue in the Graduate School without the recommendation of the program coordinator and written approval of the Graduate School. Withdrawal from a course while on probation will not be allowed unless prior approval is obtained from the Graduate School. Any unauthorized withdrawal will be considered as an unsatisfactory academic performance.

The cumulative B average requirements described above apply independently to graduate degrees sought at Clemson University; that is, the grade point ratio computation begins anew after the student has completed the first degree. The only exceptions are those instances in which a doctoral degree is pursued after completion of a master's degree in the same major.

A grade lower than the specified minimum can be raised to count toward an advanced degree only by repetition of the course. Reexamination 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.

Final Examinations in Graduate Courses

Graduate course work specifications vary widely between disciplines. Evaluation of graduate work is based upon a number of observations, presentations, tests, papers and/or other measures. The final evaluation includes an examination at the conclusion of the course, which in most cases will be written, but may take on other forms.

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 unfinished 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 purpose 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 scheduled session, excluding summers and irrespective of the student's enrollment status. 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 endorsed by the instructor and head of the department responsible for the course, stating the reason for the request and the length of time needed. Form GS12, available in the academic departments or the Graduate School, is the preferred mechanism for requesting an extension. 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. At the discretion of the instructor, the deadline for removal of these incomplete grades may be less than those just described.

A graduate student will not be permitted to repeat any portion or reregister 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

Withdrawal from graduate course work beyond the first few weeks of class is strongly discouraged, particularly from those courses listed on a student's Form GS2. Withdrawals after the first few weeks of class should only be made for unusual academic reasons or for pressing medical or personal reasons. 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 (withdrew) entered on the official records. Students may not withdraw within the last five weeks of classes.

Permission to withdraw should be obtained from the faculty advisor on the Schedule Change Form available from the Office of Admissions and Registration. If the advisor does not grant permission to withdraw, the student may appeal to the department head. A refusal by the department head may be appealed to the dean of the Graduate School. The date on which the approval form is filed with the registrar is the official date of withdrawal.

The withdrawal dates described above apply to the regular semesters only. Reference should be made to pages 8-9 for the appropriate dates for the summer sessions.

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.

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 use 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 use facilities or human resources may enroll in GS 799 (page 59) 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.

<i>Student Category</i>	<i>Semester</i>	<i>Maximum Credit Hours For:</i>	
		<i>6 Weeks Session</i>	<i>3 Weeks Session*</i>
Full-Time Students	18	6	3
Graduate Assistants (1/4 time)	15	5	3
Graduate Assistants (1/2 time)	12	4	2
Graduate Assistants (3/4 time)	12	3	1
Persons Employed Full Time	6	3	1

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). A graduate student who becomes employed full time while the assistantship is in force must notify the Graduate School and the department providing the assistantship. Graduate students paid solely on an hourly basis are not classified as graduate assistants but are subject to the same limitation in credit loads previously described.

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.

Enrollment on a Pass/Fail Basis

The only graduate courses that may be taken on a pass/fail basis are thesis and dissertation research and a small number of unstructured courses in which the pass/fail grading system appears directly in the course description.

Graduate students shall not enroll on a pass/fail basis or audit any course required by the department or program as an undergraduate deficiency. All other undergraduate courses may be taken on a pass/fail basis. This decision must be made by the last day to add a class and is implemented by the student's major advisor or department head forwarding a request to the Graduate School.

Auditing by Graduate Students

Permission for a student to audit a particular graduate course is at the discretion of the head of the department or the coordinator of the program offering the course. The principal factors involved in granting permission are that the auditor must possess the necessary academic background and space must be available.

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

* 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.

discretion, may demand or deny the auditor's participation in class to whatever extent deemed desirable.

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 nondegree status at Clemson University are considered as transfer because they were earned prior to admission to a degree program. 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, internship or courses graded P/F, 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 that 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 (see "Time Limit" on page 52 for clarification). Valid transfer credits will appear on the student's transcript as credits earned.

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.

Independence of Graduate Degrees

The requirements for a graduate degree at Clemson University cannot be met with credits used to satisfy the requirements of another graduate degree earned at Clemson University or elsewhere. Thus, the degrees are independent, implying that the formal curriculum for the degree at Clemson University can contain no credits used for an earlier graduate degree.

Appeals and Grievances

The Commission on Graduate Studies hears appeals regarding admission, degree requirements or other policy decisions affecting the welfare of graduate students. The appeal must be presented in writing to the dean of the Graduate School or to members of the commission.

The Graduate Student Academic Grievance Committee hears all grievances involving the following: (a) graduate student academic dishonesty; (b) allegations by graduate students against faculty or staff of discrimination in academics on the basis of race, color, national origin, sex, age, handicap or veterans' rights (except in those cases where the grievance involves graduate student employment, in which case

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

the grievance falls under the jurisdiction of the Student Nonacademic Grievance Committee); (c) grievances of a personal or professional nature involving an individual student and a faculty member; and (d) the claim by a student that the final grade in a course was inequitably awarded. In all unresolved cases, the committee makes its recommendations to the president through the provost. All proceedings of the committee are confidential.

If there is a question as to whether the Graduate Student Academic Grievance Committee or the Student Nonacademic Grievance Committee has jurisdiction over a particular grievance, the provost and the vice president for student affairs decide which, if either, committee has jurisdiction, and the student is so notified. If the provost and vice president for student affairs cannot agree, the matter will be referred to the president of the University for final determination of which committee has jurisdiction. The committee is comprised of five members as follows: (a) two members of the faculty appointed for two-year staggered terms by the respective college dean in collegiate rotation; (b) two graduate students, representing two colleges other than those represented by the faculty, nominated and approved by the Graduate Student Association and appointed by the provost for one-year terms; and (c) the dean or associate dean of the Graduate School. The chairperson is the faculty member in the senior year of service on the committee. Rules and procedures for the filing and hearing of grievances are as follows:

1. Any complaint should first be taken to the faculty or staff member involved for resolution. If no resolution is reached, the graduate student should consult with the department head and the dean or the immediate superior of the staff member to hear the grievance and act as a referee. The student, dean of the college, department head and faculty or staff member should make every effort to reach a solution.
2. If the grievance remains unresolved, the student may bring it before the Graduate Student Academic Grievance Committee by a written statement detailing the grievance. All issues to be grieved must be delineated in the written statement. The statement must be delivered in a sealed envelope to the Office of the Dean of the Graduate School within 60 calendar days of the date the graduate student alleges to have been aggrieved, except as provided in rule three below. The dean of the Graduate School (or the dean's designee) shall attempt to resolve the grievance. If no resolution is reached, then the dean of the Graduate School (or the dean's designee) shall advise the graduate student in assembling the necessary information for presenting his or her complaint to the Graduate Student Academic Grievance Committee. The dean will forward this letter to the chairperson of the Graduate Student Academic Grievance Committee. Failure of the student to file a grievance within the 60-day time period will result in forfeiture of the right to file a grievance under this procedure.
3. In cases involving academic dishonesty, the Policy on Academic Dishonesty (see page 48) shall be applied, and the grievance shall be filed within seven days from the date a written charge is made by the professor. A copy of the charge is to be given to the department head or dean. In cases involving a protest of a final grade, the grievance must be filed within 120 calendar days from the date printed on the grade report for the term in which the student alleged an inequitable grade was recorded.
4. The committee will attempt to gather all pertinent information in separate meetings with all individuals able to give information concerning the grievance.

5. The Graduate Student Academic Grievance Committee will, if at all possible, handle each case as a confidential matter.
6. The committee will formulate its findings in writing and seek to obtain signed approval for the recommended solution from all parties involved.
7. If the committee cannot obtain a solution that is acceptable to all involved parties, the committee will provide an opportunity for a hearing on the grievance. Two weeks' notice will be provided to all parties in the grievance. Either party to the grievance may petition for a hearing on the grievance.
8. The hearing on the grievance will be informal and closed to the public. The chairperson of the committee shall take whatever action is necessary to ensure an equitable, orderly and expeditious hearing. Minutes of the meeting will be taken, and all parties to the grievance will be given an opportunity to be heard. Each party is responsible for having present at the hearing all witnesses that will speak on his or her behalf. In addition, the chairperson may request the presence at the hearing of any other person who has pertinent information on the grievance.

Witnesses shall not be present during the hearing proceedings except when called upon to speak before the committee. The parties will be permitted to question all individuals present at the hearing and heard by the committee. If any witness is unable to be present at the hearing, the chairperson may, at his or her discretion, accept a written statement from that witness to be presented at the hearing. The parties shall be accorded the right to assistance of counsel of their own choice; however, the role of counsel shall be solely to assist the party, and counsel shall not be permitted to participate actively in the proceedings.

9. Upon conclusion of the hearing, the committee, meeting in executive session, shall reach, by a majority vote of those committee members present, a solution to the grievance. If the chairperson can persuade all parties to the grievance to accept the committee's solution, the matter of the grievance will be considered closed when the solution is effected.
10. If, after the conclusion of the hearing, the chairperson cannot obtain approval of the committee's recommended solution from all involved parties, the grievance will be referred to the president of the University via the provost, with the committee's solution as the recommended solution to the grievance. When grievances are referred in this manner, the president shall make the final decision on behalf of the University.
11. The Graduate School shall keep in confidence all records pertinent to each grievance and pass these records to the Office of the Provost for filing. Records shall be available to succeeding chairpersons of the Graduate Student Academic Grievance Committee.
12. A majority of committee members shall constitute a quorum for transaction of committee business; at least one appointed faculty member and one appointed graduate student must be present.
13. The Graduate Student Academic Grievance Committee shall meet as often as necessary to dispense expeditiously with grievances brought before the committee.

14. These rules and procedures can be amended by the Commission on Graduate Studies. Such rule changes will not affect any case under consideration at the time of the change. Notification of any amendments to these rules and procedures should be given to the president of the University via the Academic Council.

Policy on Academic Dishonesty

I. General

- A. Academic dishonesty includes giving, receiving or using unauthorized aid on any academic work.
- B. Plagiarism, a form of academic dishonesty, includes the copying of language, structure or ideas of another and attributing the work to one's own efforts.
- C. All academic work submitted for grading contains an implicit pledge and may contain, at the request of the instructor, an explicit pledge by the student that no unauthorized aid has been received.
- D. Academic dishonesty includes attempts to copy, edit or delete computer files that belong to another person or use Computer Center account numbers that belong to another person without the permission of the file owner, account number owner or file number.

II. Penalties

- A. A student guilty of the first offense of academic dishonesty will receive as a maximum penalty a grade of F for the course.
- B. A student guilty of the second offense of academic dishonesty will receive a grade of F for the course, will be suspended for one or more semesters and may be permanently dismissed. Suspension and dismissal require approval of the president of the University.

III. Procedure

- A. Academic honesty is the individual responsibility of each student. Students should report violations of this policy either to the instructor of the affected course or to any member of the administration.
- B. When, in the opinion of an instructor, a student has committed an act of academic dishonesty, the following procedure must be followed:
 1. The instructor will inform the student in private of the nature of the alleged charge of academic dishonesty and will simultaneously request in writing that the department head verify from the registrar the incident's being a first offense.
 2. When this information has been received, the instructor will notify the student in writing of the charge of academic dishonesty and the penalty recommended by the instructor and approved by the head of the department in which the course is taught. The notification will further state that if the student regards the charge as unfair, the student has seven days from the date of receipt of notice to file a grievance with the Graduate Student Academic Grievance Committee.

3. If no grievance is filed by the student, the instructor will forward copies of the written notification to the dean of the college and to the registrar.
4. Should the act of dishonesty not be in the college of the student's major, the registrar will notify the major department head.

Grade Protests

A student wishing to protest a course grade must first attempt to resolve any disagreement with the instructor. In failing to reach a satisfactory resolution, the student may follow the procedure under "Appeals and Grievances" (page 45). All grade changes and grievances must be filed within 120 calendar days from the date on the grade report.

Policy on Sexual Harassment

Title VII of the Civil Rights Act of 1964, as amended, provides that it shall be unlawful discriminatory practice for any employer, because of the sex of any person, to discharge without just cause, to refuse to hire, or otherwise discriminate against any person with respect to any matter directly or indirectly related to employment. Harassment of any employee on the basis of sex violates this federal law. The Equal Employment Opportunity Commission has issued guidelines as to what constitutes sexual harassment of an employee under Title VII.

Unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature constitute sexual harassment when the following occurs:

1. submission to such conduct is made explicitly or implicitly a term or condition of an individual's employment or academic standing;
2. submission to or rejection of such conduct by an individual is used as a basis for employment or for arriving at academic decisions affecting an individual;
3. such conduct unreasonably interferes with an individual's work or academic performance, or creates an intimidating, hostile, or offensive working or academic environment.

Sexual harassment of University faculty, staff or students is prohibited and shall subject the offender to dismissal or other sanctions after compliance with procedural due process requirements. In the event a claim of sexual harassment arises, the claimant may use University grievance procedures that have been established for faculty, staff and students as appropriate. Employees or students who feel they are victims of this form of discrimination are encouraged to consult the Office of Human Resources, E-103 Martin Hall, for advice and assistance in resolving complaints.

ACADEMIC RESEARCH

Theses and Dissertations

Candidates for advanced degrees receive academic credit for conducting research and preparing a thesis (master's candidates) or a dissertation (doctoral candidates) under the direction of the research advisor. In those Master of Arts or Master of Science degree curricula requiring a thesis, six credits of research (891) are required. The thesis option curricula in the Master of Architecture, Master of City and Regional Planning, and Master of Fine Arts degree programs require 15, 6-9 and 15 credits of research, respectively. A dissertation, mandatory for all candidates for the Ph.D. or Ed.D. degrees, requires 18 credits of doctoral research (991) exclusive of any research credits earned at the master's level.

The accumulation of grades of pass in thesis or dissertation research does not imply completion of the research, but only indicates satisfactory progress.

1. Student Responsibility. The student, in consultation with his or her major advisor, shall provide each remaining advisory committee member with a copy of the manuscript for initial review. This action should take place well in advance of, and not less than three weeks prior to, the final examination and defense of the thesis or dissertation. Students must prepare the manuscript in a style acceptable to the Graduate School; a guide for the preparation of theses and dissertations at Clemson University may be obtained from the Union Copy Center at a cost of \$4.25* per copy. Following approval of the manuscript by the advisory committee and any ex-officio members, the thesis or dissertation is presented to the Graduate School for review and approval prior to duplication.

Three copies of the thesis or dissertation, required for hard binding, must be submitted to the Graduate School by the deadline date appropriate for the anticipated graduation date (see pages 2 and 3). A binding fee of \$20.55* must be paid to the bursar and the completed forms returned to the Graduate School at the time the duplicated theses or dissertations are submitted. If the student desires, additional copies may be bound at a cost of \$6.85* per copy.

For doctoral candidates, a fourth copy of the dissertation is required for microfilming and is placed by the Graduate School with University Microfilms International of Ann Arbor, Michigan. An additional copy of the approval page, title page and abstract must also be submitted, with the latter not exceeding 350 words. Occasionally, this will necessitate revision of the longer original abstract, which is retained in all copies. The abstract should be written and edited in a form suitable for publication and data base retrieval. The total microfilming fee is \$45* and must be paid to the bursar simultaneously with the binding fees. A fee of \$35* is necessary if copyright is desired.

2. Faculty Responsibility. The research advisor will determine when the manuscript is suitable for initial review by the remaining committee members. Guidelines for the review process and a thesis/dissertation review form are available in the departments and the Graduate School. These guidelines are designed to produce a timely review by each committee member and to provide a measure of protection for all affected parties against problems resulting from lack of communication and/or attention. If the student requests, the research advisor is obligated to initiate the thesis/dissertation review form and forward it to the remaining committee members along with the manuscript. The research advisor must be cognizant also of departmental practices regarding the quality of the manuscript at the various review stages and of the wishes of the department head, as an ex-officio committee member, to exercise the option of approving the thesis or dissertation in its final form.

Committee members should normally complete the initial review in three weeks or less. Provisions of the guidelines, however, allow for additional time if necessary. Failure of a committee member to complete the initial review within six weeks may result in his or her replacement, provided the student has requested use of the thesis/dissertation review form. A second review after revisions should be completed in one week, with provisions being available for additional time.

It should be understood that a vote to pass a student on his or her performance at the final examination (Form GS7) does not imply final approval of the thesis or dissertation. Approval of the thesis or dissertation is given by signing the approval page.

* Subject to change.

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.

Publication Policy

A university's primary function is the accumulation and dissemination of knowledge. It is therefore expected that the results of research performed using University facilities be published in the open literature (i.e., theses, dissertations, journals, magazines or books) and that any information obtained may be freely disclosed by the faculty in the teaching programs of the University.

Exceptional cases may arise, however, and the guidelines below shall apply to any sponsored projects requiring that results be kept confidential.

1. The University shall not accept awards that require research results to be kept confidential forever. A definite term of confidentiality shall be stated in a written nondisclosure agreement and shall not exceed one year beyond the date of notification to the sponsor that a manuscript suitable for publication has been prepared. Exceptions may be granted by the University administration only under unusual circumstances; e.g., national security, national emergency, classified activities or certain confidential agreements.
2. Students associated with confidential projects must have prior approval for the use of results in preparing reports, theses or dissertations in fulfillment of degree requirements. The Graduate School will normally not accept a thesis or dissertation that must be held in confidence for more than one year. Documents submitted in partial fulfillment of degree requirements will be retained by the Graduate School (or the department in the case of project reports for nonthesis programs) in accordance with the nondisclosure agreement. The student's thesis or dissertation defense shall not be open to those not bound by the nondisclosure agreement.

Patents and Copyrights

All students enrolling in the Graduate School at Clemson University do so with full understanding that:

1. The University has full ownership rights in any inventions, discoveries, developments and/or improvements, whether or not patentable (inventions), which are conceived, developed or reduced to practice, or caused to be conceived, developed or reduced to practice, by graduate students during the course of their research activities conducted as part of any Graduate School curriculum. Any such invention will be handled by the University in the same manner as set forth in *The Faculty Manual of Clemson University*, the pertinent provision for which appears as Part VI E entitled "Patent Policy."
2. Copyright ownership of any research work will be determined by University policy and by policies of organizations responsible for publishing or distributing copyrighted materials.

Copies of the policies on patents and copyrights are available in the individual departments and colleges and in the Graduate School. Any graduate student who plans to accept a research assistantship or public service assistantship is encouraged to read the policies prior to accepting the assistantship.

Scientific Research

Graduate students conducting scientific research in a student role at Clemson University do so with the full understanding of the following:

1. At the discretion of their employment supervisor, students may be required, at the initiation of the research efforts, to maintain and preserve all primary data and materials associated with the research, and deliver these materials to their supervisor in complete, cataloged and identified form before the students will have been deemed to have completed the requirements for their program of study. Once delivered, these materials may be disposed of at the discretion of the department.
2. At the discretion of their employment supervisor, students may be required to keep a clear, concise and complete research notebook(s) as an accurate record of their research activities and deliver these notebooks to their supervisor before they will have been deemed to have completed the requirements for their program of study. Once delivered, the notebook(s) may be disposed of at the discretion of the department.

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 Agricultural Education, Master of Agriculture, Master of Architecture, Master of Business Administration, Master of City and Regional Planning, Master of Construction Science and Management, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forest Resources, Master of Industrial Education, Master of Parks, Recreation and Tourism Management, and Master of Professional Accountancy.

MASTER'S DEGREE

Residence Requirements

There are no University-wide residence requirements for a master's degree. However, individual degree programs may establish such requirements, which will be described and publicized for all prospective master's degree candidates in the particular program.

Time Limit

All course work 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. For example, a person graduating in the spring semester must have started and completed all course work within the 72-month period beginning with the summer term six years earlier. 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.

Course Work Required

The total number of graduate credits required for the degree shall be determined by the student's advisory committee, consistent with the specific program guidelines and Graduate School policy. These credits constitute the core of the student's Graduate Degree Curriculum (Form GS2) and will appear on the form at the location entitled REQUIRED COURSES (GRADUATE LEVEL ONLY). Undergraduate deficiencies will be listed at the designated location. Supplemental courses, carrying undergraduate or graduate credit and chosen to broaden the student's academic experience, are not required on Form GS2. However, if a listing is desirable, such courses will be listed as departmental requirements at the designated location.

The Graduate School requires each degree program to consist of a minimum of 30 semester hours of graduate credit with at least 12 semester hours, exclusive of thesis research credits, in the student's major discipline. A minor, if chosen, shall consist of at least six semester hours in that area. The following conditions, appropriate for the types of degrees, must also be observed:

1. Master of Arts or Master of Science (Thesis Option). Each program will include a minimum of 24 semester hours of graduate credit exclusive of thesis research and six semester hours of thesis research (891). At least one-half of the total graduate credit hours required by the advisory committee must be selected from courses numbered at the 800 level or above, exclusive of thesis research.

2. Master of Arts or Master of Science (Nonthesis Option). Each program will include a minimum of 30 semester hours of graduate credit, none of which may be thesis research. At least one-half of the total graduate credit hours required by the advisory committee must be selected from courses numbered at the 800 level or above.

3. Professional Master's Degrees. Each program will include a minimum of 30 semester hours of graduate credit. Except for professional programs in the College of Architecture which require a thesis, research credits (891 or 991) may not be included in the program requirements. At least one-half of the total graduate credit hours required by the advisory committee must be selected from courses numbered at the 700 level or above. Any additional requirements for these degrees are described under the colleges which offer the degrees.

Foreign 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 doctoral degree as listed on page 56.

Study and Research 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 that 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 for the doctoral degree under "Off-campus Research" on page 55, 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 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, as well as members of the Graduate Curriculum Committee and the dean of the Graduate School, are invited to attend the examination. Within three days after the examination, the examining committee, through Form GS7, will notify the graduate dean of the results of the examination. A student who fails a final examination may be allowed a second opportunity only with the recommendation of the advisory committee. Failure of the second examination will result in dismissal from the Graduate School.

SPECIALIST IN EDUCATION DEGREE

The foregoing degree requirements pertaining to residence, time limits and final examinations 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 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 of 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 that 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.

Residence Requirements

Residence is a necessary concept in graduate education, particularly in the preparation of the dissertation. The purpose of residence 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; and
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 15 semester hours of graduate credit including research credit hours (991) on the Clemson University campus in a continuous 12-month period.

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 departure from campus, the student must submit a written plan for his or her research effort to the advisory committee for approval. The plan should include a discussion of the problem and 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: (a) the student's plan to complete dissertation research using the organization's equipment and facilities; (b) the apportioning of at least 25 percent or other appropriate amount of the student's employment hours to dissertation research; and (c) the organization's release of patent rights or copyrights arising from discoveries or concepts that 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 that involves the review of the completed dissertation and/or the final examination.

5. Supervision and Reports. When doctoral research is conducted away from the Clemson campus and under the immediate direction of a dissertation supervisor who is employed by an organization other than Clemson University, in order to accommodate the student, as well as to exercise proper and necessary control over this important phase of doctoral study, the following requirements must be met:

- (a) An employee, having earned a Ph.D. and being 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.
- (b) The employee must be recommended to the provost by the appropriate college dean for appointment as an adjunct professor of Clemson University.
- (c) A resumé of the research supervisor must be submitted to the student's full advisory committee for its review and recommendation to the graduate dean.
- (d) The research supervisor must submit a final statement regarding the dissertation research, as well as interim reports if the committee deems such as necessary.
- (e) The off-campus research supervisor cannot serve as the student's major advisor.

Time Limit

Because no minimum course work requirements exist for the Doctor of Philosophy degree, the time limitation for completion is determined by the dates by which essential ingredients of the degree are completed. The following must be passed in the five-year period prior to graduation:

1. comprehensive examination (see page 57),
2. foreign language examination, if required by program (see below),
3. defense of dissertation (see page 58), and
4. approval of dissertation by the Graduate School (see page 50).

Foreign Language Requirement

Certain doctoral programs include a foreign language requirement. Languages accepted by all departments are French and German. Under certain conditions Spanish, Russian or the classical languages may be accepted. 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 for such testing must be paid by the student.

The language level expected is a basic reading knowledge equivalent to that provided by two years of study at the college level. The requirement may be satisfied

by passing a translation test administered by the Department of Languages or by passing a test similar to that given as the final examination of a language course designed for graduate students.

On the recommendation of the head of the Department of Languages, a student may satisfy the requirement by having completed at least 12 semester credit hours in an approved foreign language with an average grade of B or better. These credit hours must be earned from an accredited baccalaureate institution and must have been completed in total within six years prior to the student's finishing the graduate degree. The head of the Department of Languages may recommend a waiver of the minimum grade and six-year limitation for any student who can substantiate extensive additional training in a foreign language.

The Department of Languages will administer the foreign language translation test four times annually — on the first Thursday of November and March and once during the final examination period of each summer session. The student will be assessed no fee for the first test administration. A fee of \$20 will be assessed for the second and any subsequent administration. Applications, available in the Department of Languages, must be filed with the Department of Languages at least three weeks before the test date.

The foreign language requirement must be satisfied in a five-year period prior to the awarding of the doctoral degree and prior to admission to candidacy for the degree.

Comprehensive Examinations Before Admission to Candidacy

Prior to undertaking the comprehensive examination before admission to candidacy, the doctoral student must have selected an advisory committee and filed an approved graduate degree curriculum (Form GS2) with the Graduate School.

Satisfactory completion of the comprehensive examination must occur no less than six months and no more than five years prior to the date of graduation. It is attempted only at the recommendation of the student's advisory committee after completion of most of the required course work. The function of the examination, which will be written or a combination of written and oral, is to obtain objective evidence of an adequate intellectual mastery of the areas of the major and minor specializations. This examination must be administered by the Clemson University program faculty offering the degree. The examining committee may be the student's advisory committee or a standing committee appointed in accordance with published program policies.

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 (dissertation defense) 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.

A student who fails a final oral examination may be allowed a second opportunity only with the recommendation of the advisory committee. Failure of the second examination will result in dismissal from the Graduate School.

DOCTOR OF EDUCATION DEGREE

Degree requirements pertaining to residence, time limit, and 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.

GRADUATE PROGRAMS AND COURSE OFFERINGS

EXPLANATION OF COURSE LISTINGS

Programs 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 and 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 and 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- and 400-series undergraduate courses. These are described in the general catalog, *Clemson University Undergraduate Announcements 1991-92*, 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 will be graded according to graduate standards. Courses numbered 700 or above are restricted to graduate students and certain qualified Clemson University seniors as described on page 38.

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 departments other than the one under which they are listed. In these cases, a note will indicate where the descriptions are located.

A secondary listing of a course in parentheses implies that this course is cross-listed with another course. The course description appears with the parent course only.

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

SPECIAL COURSES OF NONACADEMIC CONTENT

These courses of nonacademic content serve special needs for graduate students. They do not count toward a graduate degree, and no letter grades are given.

- GS 799 **COMPREHENSIVE STUDIES**
1-15 cr. (1-15 and 0)
Independent studies in preparation for comprehensive examinations; credit hours to be determined by the department head or program chair. A letter grade is not given, but satisfactory completion is indicated by a grade of "Credit."
- GS 800 **RESEARCH PROPOSAL DEVELOPMENT SEMINAR**
1 cr. (1 and 0)
Principles and techniques for the preparation of research proposals. Graded on a credit/no credit basis. Will not count toward a graduate degree. **Prerequisite:** Second year of higher graduate standing in current major.

COLLEGE OF AGRICULTURAL SCIENCES

AGRICULTURAL AND APPLIED ECONOMICS
AGRICULTURAL EDUCATION
AGRICULTURAL MECHANIZATION
AGRICULTURE
AGRONOMY
ANIMAL AND FOOD INDUSTRIES
ANIMAL PHYSIOLOGY
ANIMAL AND DAIRY SCIENCES
APPLIED ECONOMICS
AQUACULTURE, FISHERIES AND WILDLIFE BIOLOGY
ENTOMOLOGY
ENVIRONMENTAL SCIENCE
EXPERIMENTAL STATISTICS
FOOD SCIENCE
FOOD TECHNOLOGY
GENETICS
HORTICULTURE
NUTRITION
PLANT PATHOLOGY
PLANT PHYSIOLOGY
POULTRY SCIENCE

COLLEGE OF AGRICULTURAL SCIENCES

T. Ross Wilkinson, Dean, Academic Affairs

The College of Agricultural Sciences offers advanced degrees in the following areas of study. Concentrations within a major area are listed under the degree-granting program.

Agricultural and Applied Economics	Animal Physiology
Agricultural Education	Applied Economics **
Agricultural Engineering *	Aquaculture, Fisheries and
Agricultural Mechanization	Wildlife Biology
Agriculture	Entomology
Agricultural Economics	Food Technology
Agricultural Mechanization	Horticulture
and Business	Nutrition
Animal Industries	Plant Pathology
Plant Health	Plant Physiology
Agronomy	
Animal and Food Industries	
Animal and Dairy Sciences	
Food Science	
Poultry Science	

In addition to the M.S. and Ph.D. degrees, the College of Agricultural Sciences offers two professional degrees: the Master of Agricultural Education and the Master of Agriculture. These postbaccalaureate degree programs are designed primarily to provide continuing education for 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 or her advisory committee.

All candidates for the degree of Master of Agricultural Education are required to take a course in applied statistics if such a course has not been a part of the 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 AND APPLIED ECONOMICS

Garnett Bradford, Head, Department of Agricultural and Applied Economics

Major	Degrees
Agricultural and Applied Economics	M.S.
Applied Economics	Ph.D.

Graduate work in agricultural and applied economics enables the student to attain a higher degree of specialized professional competence and to secure a

* 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.

** This program is a cooperative effort between the Department of Agricultural and Applied Economics (College of Agricultural Sciences) and the Department of Economics (College of Commerce and Industry). The Department of Agricultural and Applied Economics is administratively responsible for the Ph.D. program, and the degree is awarded by the College of Agricultural Sciences.

greater mastery of techniques for applying quantitative economic analysis to agricultural and natural resource problems. Industry, government and universities offer challenging opportunities in research, development, education, management and other related areas for persons with advanced training.

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 and institutional problems. Flexibility is achieved through choice of elective courses and selection of an M.S. thesis or Ph.D. dissertation topic. There is no language requirement for the M.S. or Ph.D. degree.

The College of Agricultural Sciences offers a nonthesis degree program leading to a Master of Agriculture degree. The Department of Agricultural and Applied Economics offers courses in support of this program. For more details, see the Agriculture degree program on page 71.

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.

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	COMMODITY FUTURES MARKETS 3 cr. (3 and 0) F
AG EC 611 (CRD 611)	REGIONAL IMPACT ANALYSIS 2 cr. (2 and 0) F
AG EC 612 (CRD 612)	SPATIAL COMPETITION AND RURAL DEVELOPMENT 3 cr. (3 and 0) S
AG EC 613	ADVANCED REAL ESTATE APPRAISAL 3 cr. (3 and 0) S
AG EC 620	WORLD AGRICULTURAL TRADE 3 cr. (3 and 0) S
AG EC 625	AQUACULTURE ECONOMICS 3 cr. (3 and 0) F (offered in alternate years)
AG EC 626 (AGRON 626)	CROPPING SYSTEMS ANALYSIS 3 cr. (2 and 2)
AG EC 633	AGRICULTURAL LAW AND RELATED ENVIRONMENTAL ISSUES 3 cr. (3 and 0)
AG EC 652	AGRICULTURAL POLICY 3 cr. (3 and 0) F
AG EC 656	PRICES 3 cr. (3 and 0) S
AG EC 660	AGRICULTURAL FINANCE 3 cr. (3 and 0) F

- 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) F, S
 Students working toward a professional degree study selected topics under guidance of major professor. Course may be repeated for a maximum of six credits.
- AG EC 802 ADVANCED PRODUCTION ECONOMICS
 3 cr. (3 and 0) S
 Production economics theory in a quantitative framework; technical and economic factor-product, factor-factor and product-product relationships in single- and multiproduct firms under conditions of perfect and imperfect competition in both factor and product markets. **Prerequisite:** AG EC 808 or permission of instructor.
- AG EC 806 COMMUNITY AND REGIONAL ECONOMICS
 3 cr. (3 and 0) F
 Economic theory and research methods needed to understand happenings in the regional and community economy and how local and nonlocal decisions influence local economic change. **Prerequisite:** CRD 612 or permission of instructor.
- 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.
- 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) S
 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) F
 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 812 INTERREGIONAL COMPETITION ANALYSIS
 2 cr. (2 and 0) S
 Basic spatial dimensions of pricing and allocation examined within context of competitive equilibrium, emphasizing resource and commodity markets of the U.S. economy. **Prerequisite:** CRD 412 or permission of instructor.
- AG EC 814 CONTEMPORARY PUBLIC POLICY
 3 cr. (3 and 0) S
 Contemporary public policy, including price and resource policy, affecting rural areas; public participation, 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) F
 Individual and aggregate consumption decisions concerning agricultural products, emphasizing agricultural marketing applications; market interdependencies; policy applications of empirical work. **Prerequisite:** EX ST 803 or equivalent.
- AG EC 851 SEMINAR IN RESEARCH METHODOLOGY
 1 cr. (1 and 0) F
 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; group discussions of proposed thesis topics of individual students. Required of all graduate students who have not already had a comparable course.
- AG EC 852 RESEARCH METHODS FOR AGRICULTURAL ECONOMISTS I
 2 cr. (2 and 0) F
 Linear models and their application to problems related to the economics of agriculture. Topics include the simplex method, developing farm planning LP models, solving LP problems using the MPSX computer program, parametric analysis techniques and other LP applications related to rural problems.
- AG EC 853 RESEARCH METHODS FOR AGRICULTURAL ECONOMISTS II
 3 cr. (3 and 0) F
 Application of econometric techniques and stochastic models to problems related to the economics of agriculture. Topics include distribution theory, simple and multiple regression modeling, hypothesis testing and other issues in regression analysis.
- AG EC 871 WORKSHOP IN QUANTITATIVE METHODS IN AGRICULTURAL ECONOMICS
 1 cr. (1 and 0) S
 Application of quantitative methods in agricultural economics research; linear and nonlinear techniques. **Prerequisites:** AG EC 808, 852 and 853.
- AG EC 872 TECHNIQUES OF SURVEY ANALYSIS IN SOCIAL SCIENCES
 1 cr. (1 and 0) S
 Techniques and procedures used by social scientists to collect primary data with survey techniques. Topics include sample selection, questionnaire construction and personal interview techniques. **Prerequisite:** Permission of instructor.

- AG EC 881 INTERNSHIP IN COMMUNITY AND RESOURCE DEVELOPMENT
1-6 cr.
Supervised employment in an agency dealing with socioeconomic aspects, community development and/or natural resource management; monthly reports covering student's experience required.
Prerequisite: 18 semester hours of graduate credit.
- AG EC 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- AG EC 901
(ECON 901) PRICE THEORY
3 cr. (3 and 0)
See ECON 901 for description.
- AG EC 902
(ECON 902) PRODUCTION ECONOMICS PROBLEMS
2 cr. (2 and 0) F
Application of production economic theory and quantitative techniques to current problems; extensions of theory and new techniques may be introduced when examining problem areas. **Prerequisite:** AG EC 802.
- AG EC 903
(ECON 903) GENERAL EQUILIBRIUM AND WELFARE THEORY
3 cr. (3 and 0) S
The second of a two-course sequence of advanced price theory. The first part of this course is the development of the theory of general equilibrium and the economics of welfare; the second is the capital theory and the determination of the rate of interest. **Prerequisite:** AG EC 901.
- AG EC 904
(ECON 904) SEMINAR IN RESOURCE ECONOMICS
3 cr. (3 and 0) S
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 905
(ECON 905) ADVANCED MACROECONOMIC ISSUES
3 cr. (3 and 0)
See ECON 905 for description.
- AG EC 906
(ECON 906) SEMINAR IN AREA ECONOMIC DEVELOPMENT
3 cr. (3 and 0) F
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
(ECON 907) AGRICULTURAL MARKETING PROBLEMS
2 cr. (2 and 0) F
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 917 (ECON 917)	ADVANCED SEMINAR IN LABOR ECONOMICS 3 cr. (3 and 0) See ECON 917 for description.
AG EC 991 (ECON 991)	DOCTORAL DISSERTATION RESEARCH Credit to be arranged.
CRD 611 (AG EC 611)	REGIONAL IMPACT ANALYSIS 2 cr. (2 and 0) F
CRD 612 (AG EC 612)	SPATIAL COMPETITION AND RURAL DEVELOPMENT 3 cr. (3 and 0) S
RS 601 (SOC 601)	HUMAN ECOLOGY 3 cr. (3 and 0) S
RS 603 (SOC 603)	METHODS OF SOCIAL RESEARCH II 3 cr. (3 and 0)
RS 659 (SOC 659)	THE COMMUNITY 3 cr. (3 and 0) F
RS 671 (SOC 671)	DEMOGRAPHY 3 cr. (3 and 0) S
RS 881	SPECIAL PROBLEMS IN RURAL SOCIAL RESEARCH 1-3 cr. (0 and 2-6) Recent research problems and literature emphasizing research design, analysis, theoretical generalizations and application programs. May be repeated for a maximum of six credits. Prerequisite: Six semester hours of 600-level sociology or rural sociology courses or permission of instructor.

AGRICULTURAL EDUCATION

Glen C. Shinn, 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 agricultural extension and vocational education. The flexible program permits specialization in interest areas. Degree recipients often hold 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 major field;
2. at least three semester hours in statistics, three semester hours in adult education, and three semester hours in research methods; and

AGRICULTURAL EDUCATION

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

AG ED 601	METHODS IN AGRICULTURAL EDUCATION 3 cr. (2 and 3) F
AG ED 623	CURRICULUM 2 cr. (2 and 0) S
AG ED 625	TEACHING AGRICULTURAL MECHANICS 2 cr. (1 and 3) S
AG ED 628	SPECIAL STUDIES IN AGRICULTURAL EDUCATION 1-3 cr. (1-3 and 0)
AG ED 630	FUNDAMENTALS OF EXTENSION EDUCATION 2 cr. (2 and 0) F
AG ED 631	METHODS IN ENVIRONMENTAL EDUCATION 3 cr. (3 and 0) SS
AG ED 632	VISUAL MEDIA FOR AGRIBUSINESS 3 cr. (2 and 3) S
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)
AG ED 680 (IN ED 680) (ED 680) (COL ED 680)	EDUCATIONAL APPLICATIONS OF MICROCOMPUTERS 3 cr. (3 and 0)
AG ED 682 (IN ED 682) (ED 682) (COL ED 682)	ADVANCED EDUCATIONAL APPLICATIONS OF MICROCOMPUTERS 3 cr. (2 and 2)
AG ED 726	AGRICULTURAL MECHANIZATION FOR IN-SERVICE 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) SS
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 750 SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN AGRICULTURAL EDUCATION
1-3 cr. (1-3 and 0)
Subject areas organized according to institute needs. Topics vary from course to course. May be repeated for a maximum of nine credits. **Prerequisite:** Permission of instructor.
- 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)
Planning, conducting and reporting a special problem in agricultural and vocational 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, and developing off-farm experience programs.
- AG ED 821 THEORIES AND PRACTICES OF ADULT EDUCATION
3 cr. (3 and 0) S
Recent research on adult learnings; a comparison of the assumptions supporting pedagogy and andragogy; emphasis on teaching adults through formal classes and community organizations. **Prerequisite:** PSYCH 201 or ED 302 or equivalent.

AGRICULTURAL EDUCATION

- AG ED 825 SUPERVISION OF STUDENT TEACHING
3 cr. (3 and 0) F
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. **Prerequisites:** 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 RESEARCH IN EDUCATION
(ED 889) 3 cr. (3 and 0)
(IN ED 889) Problem selection; types of educational research and techniques employed; use of ERIC system and computer program packages; interpretation of research findings.

AGRICULTURAL MECHANIZATION

Richard O. Hegg, Head, Department of Agricultural and Biological Engineering

Advanced degrees are not awarded in agricultural mechanization. Courses are offered as a minor for students majoring in other areas. The faculty participate in the agricultural mechanization and business option of the interdisciplinary Master of Agriculture degree.

- AG M 602 DRAINAGE, IRRIGATION AND WASTE MANAGEMENT
3 cr. (2 and 3)
- AG M 604 FARM STRUCTURES
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 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 a 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 are used to teach working techniques, and each student builds a model of a system; computer background not required. **Prerequisite:** MTH SC 106 or permission of instructor.

AGRICULTURE

Jere A. Brittain, Program Coordinator, IPM Program

Major
Agriculture

Degree
M.Ag.

The Master of Agriculture degree program provides graduate-level, professional, nonresearch-oriented training in agriculture. It is designed to serve the graduate educational needs of working professionals in agribusiness, extension service personnel and other agricultural professionals. Four options are offered: agricultural economics, agricultural mechanization and business, animal industries and plant health. The departments of Agricultural and Applied Economics; Agricultural Engineering; Horticulture; Plant Pathology and Physiology; Entomology; Agronomy and Soils; Animal, Dairy and Veterinary Sciences; and Poultry Science participate in the program.

Applicants to the program are reviewed by a faculty coordinating committee and recommended for admission. Applicants with postbaccalaureate professional experience are required to submit letters of reference, written and oral expressions of professional goals, and have a minimum GPR of 2.5 overall or 2.7 for the last 60 undergraduate hours. Applicants without postbaccalaureate professional experience are required to satisfy the admission criteria for the M.S. degree program.

Agricultural Economics. Candidates are required to complete a minimum of 36 hours of course work: 12 hours in an area of special concentration, 12 hours of electives, with at least 12 hours in agricultural economics; and prepare and present an acceptable professional report in the form of a carefully researched, well-written paper.

Agricultural Mechanization and Business. This option is designed to provide a strong background in both technology and business management. Students are required to complete 30 semester hours of course work.

Animal Industries. Students may enter the program through the departments of Animal, Dairy and Veterinary Sciences or Poultry Science. Thirty hours of course work are required and are specifically selected to meet the career goals of each

student. In addition to the core courses, 12 credit hours of advanced courses relating to animal production and/or processing must be taken.

Plant Health. The curriculum in this option includes courses in crop science, entomology, plant pathology, weed science and integrated pest management. Experience is provided in plant problem diagnosis and treatment in field and clinical settings. Students may enter the program through the departments of Agronomy and Soils, Entomology, Horticulture, and Plant Pathology and Physiology. A minimum of 36 semester hours is required, and the student must satisfactorily complete an internship and oral and written examinations.

The core courses listed below are required of all candidates for the Master of Agriculture degree. Descriptions for the 700- and 800-level courses can be found under the respective departmental headings.

- AG EC 719 PROFESSIONAL PROBLEMS IN AGRIBUSINESS MANAGEMENT
3 cr. (3 and 0) F
- AG ED 632 VISUAL MEDIA FOR AGRIBUSINESS
3 cr. (2 and 3) S
 or
- ENGL 832 TOPICS IN SCIENTIFIC, TECHNICAL AND BUSINESS WRITING
3 cr. (3 and 0)
- EX ST 801 STATISTICAL METHODS
4 cr. (3 and 3)

In addition to these required courses, the following course is an elective. Core courses for each option as well as electives are available in the participating departments.

- AGRIC 640 MICROCLIMATOLOGY
3 cr. (3 or 0)

The following courses are required in the plant health option.

- IPM 601 PRINCIPLES OF INTEGRATED PEST MANAGEMENT
3 cr. (2 and 3)
- IPM 700 INTERNSHIP IN PLANT HEALTH
1-5 cr. (0 and 8-40)
Professional employment under competent supervision in an approved agency or organization dealing with the vocational or occupational aspects of plant health. During the internship, the student will submit weekly reports covering his or her experiences. A terminal report is required also. Graded on a pass/fail basis. **Prerequisites:** Graduate student standing for at least one semester, IPM 401/601 and permission of the Plant Health Curriculum Committee and instructor.
- IPM 704 SEMINAR
1 cr. (1 and 0)
Students and faculty review current research and development topics in integrated pest management. One or more presentations required. May be repeated for a maximum of two credits. **Prerequisite:** Permission of instructor.

- IPM 800 SPECIAL PROBLEMS IN PLANT HEALTH
1-3 cr. (0 and 3-9)
Directed individual study of a special problem in plant health; emphasis is on organizing, conducting and reporting on independent investigation. **Prerequisite:** Permission of instructor.

AGRONOMY

Ralph E. Franklin, Head, Department of Agronomy and Soils

Major
Agronomy

Degrees
M.S., Ph.D.

The Ph.D. and M.S. (thesis option) are research degrees that require a dissertation and thesis, respectively. The M.S. (nonthesis option) is a terminal degree for students who do not plan research careers or do not plan to pursue a Ph.D. degree. It may be suited for students who will pursue a career in business, educational or administrative areas that will not require research experience. The department participates in the plant health option of the interdisciplinary Master of Agriculture degree.

Areas of specialization normally are allied with those of the major professor. In the crop sciences this includes plant breeding and genetics; forage systems; physiology; ecology, production and management; cellular biology and molecular genetics; and weed science. The soil sciences include chemistry; physics; microbiology and biochemistry; fertility and plant nutrition; and genesis, morphology and classification.

- AGRON 603 SOIL GENESIS AND CLASSIFICATION
2 cr. (1 and 3) F
- AGRON 604 SOILS AND LAND USE
2 cr. (1 and 3) F
- AGRON 605 PLANT BREEDING
3 cr. (2 and 2) S
- AGRON 607 PRINCIPLES OF WEED CONTROL
3 cr. (2 and 2) F
- AGRON 608 LAND TREATMENT OF WASTEWATER AND SLUDGES
(ESE 608)
(AG E 608)
3 cr. (3 and 0)
- 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 625 SEED SCIENCE AND TECHNOLOGY
3 cr. (2 and 2) S (odd numbered years)

AGRONOMY

- AGRON 626
(AG EC 626) CROPPING SYSTEMS ANALYSIS
3 cr. (2 and 2)
- AGRON 633
(HORT 633) INTEGRATED WEED MANAGEMENT FOR AGRONOMIC AND
HORTICULTURAL CROPS
3 cr. (2 and 2) S
- AGRON 646 SOIL MANAGEMENT
3 cr. (3 and 0) F
- AGRON 652 SOIL FERTILITY AND MANAGEMENT
3 cr. (3 and 0) S
- AGRON 653 SOIL FERTILITY LABORATORY
1 cr. (0 and 3) S
- AGRON 655 SEMINAR
1 cr. (1 and 0) F
- AGRON 656 SEMINAR
1 cr. (1 and 0) S
- AGRON 675 SOIL PHYSICS AND CHEMISTRY
3 cr. (2 and 3) S
- AGRON 690 SOIL ORGANISMS IN CROP PRODUCTION
3 cr. (2 and 3) F (odd numbered years)
- AGRON 701 SOILS AND MAN
3 cr. (3 and 0)
Different kinds of soils, their properties, uses, management, conservation and their relationship with the environment and other human endeavors. Not open to agronomy majors pursuing the M.S. or Ph.D. degrees.
- AGRON 710 SELECTED TOPICS IN PLANT BIOTECHNOLOGY
3 cr. (2 and 2)
Update of the science teacher's knowledge and skills in biotechnology, including molecular biology of DNA, gene regulation, genetic engineering and practical applications of these techniques. Targeted to elementary and secondary school teachers. **Prerequisite:** Introductory biology.
- 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. **Prerequisite:** BOT 421/621 or equivalent.
- AGRON 802 PEDOLOGY
3 cr. (3 and 0) F (odd numbered years)
Current concepts and theories in soil genesis and morphology; advanced study of soil taxonomy. **Prerequisite:** AGRON 403/603.

- 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. **Prerequisites:** AGRON 405/605 and EX ST 801 or permission of instructor.
- AGRON 805 SOIL FERTILITY
3 cr. (3 and 0) S (even numbered years)
Soil properties affecting nutrient availability and plant growth; inventory of major soil groups with reference to plant stress features; behavior of essential elements in soils in relation to plant availability; current soil fertility research. **Prerequisite:** AGRON 452 or 403 or permission of instructor.
- 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, ion exchange and surface phenomena, chemical equilibria, soil acidity and oxidation-reduction reactions.
- AGRON 810 SOIL MICROBIOLOGY
3 cr. (3 and 0) F (even numbered years)
Biological nitrogen fixation, mycorrhizal fungi and pesticide interactions in soils with emphasis on microbial-plant-soil relationships. **Prerequisites:** AGRON 690 or MICRO 610 and permission of instructor.
- 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 the 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.

AGRONOMY

- 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. Graded on a pass/fail basis.
- AGRON 890 SPECIAL TOPICS IN AGRONOMY
1-3 cr. (1-3 and 0)
Group discussion of recent developments in agronomic research. May be repeated for a maximum of six credit hours. **Prerequisite:** Permission of instructor.
- AGRON 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- AGRON 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

ANIMAL AND DAIRY SCIENCES

Charles W. Foley, Head, Department of Animal, Dairy and Veterinary Sciences

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

A degree is not offered in this department. Degrees in the above areas with concentrations in animal science and dairy science are offered. Candidates must complete a research project and submit a thesis or dissertation. The department participates in the animal industries option of the interdisciplinary Master of Agriculture degree.

- AN SC 601 BEEF PRODUCTION
4 cr. (3 and 2)
- AN SC 608 PORK PRODUCTION
4 cr. (3 and 2)
- 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 253 and 255.

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

Excellent facilities are available for graduate student research in dairy science at either the J. P. LaMaster Dairy Center or the Ben E. Goodale Dairy Plant. Studies in dairy production, nutrition, reproduction, dairy products and processing, and dairy microbiology are offered.

- 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
2 cr. (2 and 0)
- DY SC 608 SPECIAL TOPICS IN DAIRY SCIENCE
1-4 cr. (1-4 and 0)
- DY SC 652 DAIRY CATTLE FEEDING AND MANAGEMENT
4 cr. (3 and 3)
- DY SC 653 ANIMAL REPRODUCTION
3 cr. (3 and 0)
- DY SC 655 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 and 461 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. **Prerequisite:** Graduate standing.
- DY SC 891 **MASTER'S THESIS RESEARCH**
Credit to be arranged.

ANIMAL AND FOOD INDUSTRIES

Charles W. Foley, Head, Department of Animal, Dairy and Veterinary Sciences

Major	Degree
Animal and Food Industries	M.S.

Students may concentrate in animal science, dairy science, food science or poultry science. See these departmental listings for course descriptions. Candidates for the M.S. degree are required to complete a thesis.

ANIMAL PHYSIOLOGY

Glenn P. Birrenkott, Program Coordinator, Department of Animal, Dairy and Veterinary Sciences

Major	Degrees
Animal Physiology	M.S., Ph.D.

Animal physiology is an interdepartmental graduate program developed and offered by faculty in the departments of Animal, Dairy and Veterinary Sciences; Poultry Science; Food Science; Biological Sciences; and Aquaculture, Fisheries and Wildlife. Applicants should have a strong background in the biological and physical sciences. Students with deficiencies in these sciences may be admitted provided they correct these deficiencies during the first year of their program of study.

A student's program will include a core of basic courses in physiology, biochemistry and statistics. Additional course work may be taken in areas of the student's

interest as approved by the graduate advisory committee. The student's program and research will emphasize a study of physiological processes, particularly those relating to reproduction, endocrinology, digestion and environmental factors. A thesis is required.

- AN PH 660 SYSTEMS PHYSIOLOGY
1 cr. (1 and 0) F
- AN PH 801 ELECTRON MICROSCOPY OF BIOLOGICAL SPECIMENS
(BIO SC 801) 3 cr. (1 and 6) F, S
Concepts and practice in preparing biological specimens for electron microscopy: fixing, embedding, thin-sectioning, staining, operating microscopes and photographing, developing, printing and interpreting micrographs. Each student must achieve proficiency with a selected specimen, including writing a brief research proposal, preparing specimen, studying specimen with electron microscope and interpreting micrographs. **Prerequisite:** Permission of instructor.
- AN PH 802 SPECIAL TOPICS IN ANIMAL PHYSIOLOGY
1 cr. (1 and 0) F, S
Current topics of special interest in animal physiology not covered in other courses. May be repeated for credit. **Prerequisite:** Permission of instructor.
- AN PH 806 CARE AND USE OF RESEARCH ANIMALS
3 cr. (1 and 6) F
Demonstration and practice of humane use and care of animals in research; study of pain, analgesia and anesthesia; regulatory aspects of the use of animals in teaching and research; surgical techniques and sample collection. **Prerequisites:** ZOOL 459/659 and AN PH 460/660 or permission of instructor.
- AN PH 807 SPECIAL PROBLEMS IN ANIMAL PHYSIOLOGY
1-3 cr. (1-3 and 0)
Research not related to a thesis. May include a comprehensive review of related literature.
- AN PH 808 CURRENT CONCEPTS IN ENDOCRINOLOGY
3 cr. (3 and 0) S
Advanced concepts relevant to interrelationships between the nervous and endocrine systems as they influence growth and development, body metabolism and regulatory mechanisms, reproduction and lactation. **Prerequisites:** AN PH 660 and ZOOL 675, or BIO CH 817, or permission of 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 (anatomy, filtration, secretion, reabsorption) and respiratory systems (transport, exchange and utilization of gases; the action of the nervous system, hormones and pharmacologic agents on these organ systems. **Prerequisites:** ZOOL 659 and AN PH 660 or permission of course coordinator.

ANIMAL PHYSIOLOGY

- AN PH 814 MEMBRANE, CARDIOVASCULAR AND NEUROMUSCULAR PHYSIOLOGY
5 cr. (4 and 3) S (even numbered years)
Development of advanced concepts in membrane physiology (permeability, action potentials, specialized functions), cardiovascular physiology (functions of the heart, blood-vascular system in maintaining acid-base balance, clotting mechanisms, homeostasis, circulation), neuromuscular physiology (anatomy and function of the nervous system, special senses, reflexes, control of muscular activity); the action of several pharmacologic agents on muscle and nerve functions. **Prerequisites:** ZOOL 659 and AN PH 660 or permission of course coordinator.
- AN PH 851 ANIMAL PHYSIOLOGY SEMINAR
1 cr. (1 and 0) F, S
Current research and development in animal physiology through related literature and student and faculty participation. May be repeated for a maximum of two credit hours.
- 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 departmental 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 633 GENERAL BIOCHEMISTRY LABORATORY I
2 cr. (0 and 4)
- BIOCH 634 GENERAL BIOCHEMISTRY LABORATORY II
2 cr. (0 and 4)
- 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)
- BIO SC 661 CELL BIOLOGY
4 cr. (3 and 3)

DY SC 653	ANIMAL REPRODUCTION 3 cr. (3 and 0)
DY SC 655	ANIMAL 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 640	INSECT BEHAVIOR 3 cr. (2 and 3)
ENT 670	INSECT PHYSIOLOGY 3 cr. (2 and 3)
EX ST 801	STATISTICAL METHODS 4 cr. (3 and 3)
EX ST 803	REGRESSION AND LEAST SQUARES ANALYSIS 3 cr. (3 and 0) F
EX ST 805	DESIGN AND ANALYSIS OF EXPERIMENTS 3 cr. (3 and 0) F, S
MICRO 614	BASIC IMMUNOLOGY 3 cr. (2 and 3) F
MICRO 811	BACTERIAL CYTOLOGY AND PHYSIOLOGY 4 cr. (4 and 0) S (odd numbered years)
PS 600	AVIAN PHYSIOLOGY 3 cr. (3 and 0) S (even numbered years)
PS 825	IMMUNOBIOLOGY 3 cr. (3 and 0) S
ZOOL 605	ANIMAL HISTOLOGY 4 cr. (3 and 3)
ZOOL 657	COMPARATIVE PHYSIOLOGY 4 cr. (3 and 3)
ZOOL 659	SYSTEMS PHYSIOLOGY 4 cr. (3 and 3)
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)

ANIMAL PHYSIOLOGY

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

APPLIED ECONOMICS

Garnett Bradford, Head, Department of Agricultural and Applied Economics

Major	Degree
Applied Economics	Ph.D.

The graduate program in applied economics utilizes the facilities and faculty of the Department of Agricultural and Applied Economics in the College of Agricultural Sciences and the Department of Economics in the College of Commerce and Industry. Students may carry out their dissertation research under the direction of a faculty member from either department.

AQUACULTURE, FISHERIES AND WILDLIFE BIOLOGY

D. Lamar Robinette, Head, Department of Aquaculture, Fisheries and Wildlife

Major	Degree
Aquaculture, Fisheries and Wildlife Biology	M.S.

Students desiring to pursue graduate work in aquaculture, fisheries and wildlife biology should have sound undergraduate training in the biological or related sciences. Programs of study are designed to emphasize relationships between wild animals and their changing environments and production of aquatic organisms.

Twenty-four semester hours of course work approved by the student's advisory committee, six credit hours of research (WFB 891), an acceptable thesis based upon original research and satisfactory performance in a final oral examination are required. Additional course work usually is taken in experimental statistics, biological sciences, forestry and other related areas. The following areas of concentration are offered: conservation biology, uplands and wetlands wildlife biology, aquaculture, freshwater fisheries science, marine fisheries science, wildlife toxicology and aquatic toxicology.

Research opportunities for graduate students are enhanced by cooperative programs with the S. C. Wildlife and Marine Resources Department, the U.S. Fish and Wildlife Service's Cooperative Research Unit at Clemson, Delta Waterfowl Research Station, Savannah River Ecology Laboratory, Webb Wildlife Research Center and the Waddell Mariculture Center. The department also is associated with the Institute of Wildlife and Environmental Toxicology and the Archbold Tropical Research Center. The graduate program in wildlife biology is accredited by the Southeastern Section of The Wildlife Society.

WFB 612 WILDLIFE MANAGEMENT
3 cr. (2 and 3)

WFB 614 WILDLIFE NUTRITIONAL ECOLOGY
3 cr. (3 and 0)

WFB 616 FISHERY BIOLOGY
3 cr. (2 and 3)

- WFB 650 AQUACULTURE
3 cr. (3 and 0)
- WFB 652 FISH PHYSIOLOGY
4 cr. (3 and 3)
- WFB 660 WARMWATER FISH DISEASES
2 cr. (2 and 0)
- WFB 662 WETLAND WILDLIFE BIOLOGY
3 cr. (3 and 0)
- WFB 669 AQUATIC INSECTS
(ENT 669) 3 cr. (1 and 6)
- WFB 809 SEMINAR IN WILDLIFE AND FISHERIES SCIENCE
1 cr. (1 and 0)
Current literature and research in fisheries and wildlife sciences; one or more presentations required. May be repeated for a maximum of four credits.
- WFB 812 CONSERVATION AND ECOLOGY OF ENDANGERED SPECIES
3 cr. (3 and 0)
Exploration of the processes by which species become endangered or extinct; state, federal and international strategies for species recovery. Students write a species recovery plan. **Prerequisite:** Graduate standing in a life science major or permission of instructor.
- WFB 815 PRINCIPLES OF WILDLIFE BIOLOGY
3 cr. (2 and 3)
Theories and principles applicable to wildlife biology emphasizing upland game species.
- WFB 816 APPLIED WILDLIFE BIOLOGY
3 cr. (2 and 3)
Techniques and practices involved in management of wildlife species emphasizing upland game.
- WFB 818 WATERFOWL ECOLOGY AND MANAGEMENT
3 cr. (2 and 3)
Identification, ecology and management of waterfowl; laboratory work includes demonstration and application of relevant waterfowl management techniques, current literature topics and field trips. **Prerequisite:** BIO SC 441/641 or WFB 412/612 or permission of instructor.
- WFB 819 SPECIAL TOPICS IN WILDLIFE MANAGEMENT
1-4 cr. (1-4 and 0)
Current areas of wildlife research and management. May be repeated for credit. **Prerequisite:** Permission of instructor.

- WFB 830 ESTIMATING ANIMAL NUMBERS
3 cr. (2 and 3)
Sampling fish and wildlife populations; estimation of population size and survival, emigration and immigration rates; underlying principles, correct application, and interpretation of contemporary wildlife and fisheries population enumeration models. **Prerequisite:** EX ST 801
- WFB 840 FISH AND SHELLFISH MANAGEMENT
3 cr. (2 and 3)
Principles and techniques of managing aquatic systems for recreational and/or commercial fishing, emphasizing streams, rivers, estuaries and impoundments; laboratory work includes demonstration and application of management techniques and field trips to observe management practices. **Prerequisite:** WFB 416/616 or ZOOL 463/663 or permission of instructor.
- WFB 854 AQUATIC TOXICOLOGY
3 cr. (3 and 0)
Concepts and practices in aquatic toxicology, including physiological responses to toxic substances, bioconcentration, biomagnification, toxicity testing (algal, invertebrate and fish) and criterion development; acquaints students interested in the environmental sciences and environmental policy with basic concepts of toxicology as applied to aquatic environments. **Prerequisites:** One year of general biology, one year of general chemistry and introductory biochemistry.
- WFB 860 DIAGNOSTIC PROCEDURES OF WARMWATER FISH DISEASES
2 cr. (1 and 2)
Study of warmwater fish disease diagnostic procedures employing proper protocol and procedures to be followed by a fish disease diagnostician. **Corequisite:** WFB 460/660 or permission of instructor.
- WFB 861 SPECIAL TOPICS IN FISHERY BIOLOGY
1-4 cr. (1-4 and 0)
Current areas of active fisheries research and management presented in lecture/seminar format. May be repeated for credit. **Prerequisite:** Permission of instructor.
- WFB 863 SPECIAL PROBLEMS IN WILDLIFE AND FISHERIES BIOLOGY
1-3 cr. (0 and 3-9)
Research not related to a thesis. Credit varies with problems selected. **Prerequisite:** Permission of instructor.
- WFB 891 MASTER'S THESIS RESEARCH
Credit to be arranged.

ENTOMOLOGY

Sidney B. Hays, Head, Department of Entomology

Major
Entomology**Degrees**
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 for study and research in economic entomology, insect ecology, insect pathology, insect behavior, insect physiology, insect toxicology, medical and veterinary entomology, urban entomology, molecular entomology, aquatic entomology, pest management, and the traditional fields of taxonomy and morphology.

Candidates for the M.S. degree are required to complete a thesis. The department participates in the plant health option of the interdisciplinary Master of Agriculture degree.

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 2)
ENT 603	FIELD CROP ENTOMOLOGY 3 cr. (2 and 3)
ENT 604	URBAN ENTOMOLOGY 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 630	TOXICOLOGY 3 cr. (3 and 0)
ENT 640	INSECT BEHAVIOR 3 cr. (2 and 3)
ENT 655	MEDICAL AND VETERINARY ENTOMOLOGY 3 cr. (2 and 3)
ENT 668	RESEARCH TECHNIQUES 2 cr. (2 and 0)
ENT 669 (WFB 669)	AQUATIC INSECTS 3 cr. (1 and 6)

ENTOMOLOGY

- ENT 670 INSECT PHYSIOLOGY
3 cr. (2 and 3)
- ENT 680 INSECT PATHOLOGY
3 cr. (2 and 3)
- ENT 700 ENTOMOLOGY FOR TEACHERS
3 cr. (2 and 2)
General entomology course for secondary school science teachers, with emphasis on collecting and identifying the more common insects; additional topics include insect morphology, physiology, metamorphosis and methods available for control of destructive species. Not open to entomology majors pursuing the M.S., M.Ag. or Ph.D. degrees. **Prerequisite:** Permission of instructor.
- ENT 808 TAXONOMY OF IMMATURE INSECTS
3 cr. (1 and 6)
Identification of immature insects, emphasizing the Holometabola; identified collection required.
- ENT 809 SEMINAR IN ENTOMOLOGY
1 cr. (1 and 0)
Current literature and research in entomology; one or more presentations required.
- ENT 810 SPECIAL TOPICS IN ENTOMOLOGY
1-4 cr. (1-4 and 0)
Current areas of entomological research and pest management. Course may be repeated for credit. **Prerequisite:** Permission of instructor.
- ENT 812 ENTOMOLOGY 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**
1-3 cr. (0 and 3-9)
Entomological research not related to thesis. **Prerequisite:** Permission of instructor.
- ENT 891 **MASTER'S THESIS RESEARCH**
Credit to be arranged.
- ENT 991 **DOCTORAL DISSERTATION RESEARCH**
Credit to be arranged.
- EN TOX 600 **WILDLIFE TOXICOLOGY**
3 cr. (3 and 0)

ENVIRONMENTAL SCIENCE

Alan W. Elzerman, Program Director, Department of Environmental Systems Engineering

Advanced degrees are not awarded in environmental science, but courses are offered to provide a minor, a concentration or electives for students in other areas. Course selection for a minor or concentration should be approved in advance. Scientific and engineering courses are offered as well as relevant courses in economics, history, ethics, public health, political science and other related areas.

- EN SC 631 **PUBLIC HEALTH ADMINISTRATION**
3 cr. (3 and 0) F
- EN SC 671 **MAN AND HIS ENVIRONMENT**
2 cr. (2 and 0) F
- EN SC 672 **ENVIRONMENTAL PLANNING AND CONTROL**
2 cr. (2 and 0) S

EXPERIMENTAL STATISTICS

Wilbert P. Byrd, Head, Department of Experimental Statistics

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 611 STATISTICAL METHODS FOR PROCESS DEVELOPMENT AND CONTROL
3 cr. (3 and 0) S
- EX ST 662 STATISTICS APPLIED TO ECONOMICS
3 cr. (3 and 0) S
- EX ST 801 STATISTICAL METHODS
4 cr. (3 and 3)
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 nonparametric 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) F, S
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.
- EX ST 811 SPECIAL PROBLEMS IN EXPERIMENTAL STATISTICS
1-3 cr. (0 and 2-6)
Statistical aspects of an individualized research problem; emphasis on determining an appropriate experimental design, performing proper analyses and generating effective reports.
- EX ST 812 SPECIAL TOPICS IN EXPERIMENTAL STATISTICS
1-3 cr. (1-3 and 0) S
Selected topics in applied statistics not covered in other courses.

FOOD SCIENCE

Ronald D. Galyean, Head, Department of Food Science

Major	Degrees
Animal and Food Industries	M.S.
Plant Physiology	Ph.D.
Food Technology	Ph.D.
Nutrition	M.S., Ph.D.

A degree is not offered in this department. Degrees in the above areas with a concentration in food science are offered. Candidates for the M.S. and Ph.D. degrees must complete a research project and submit a thesis or dissertation.

FD SC 601	FOOD CHEMISTRY I 4 cr. (3 and 3) F (even numbered years)
FD SC 602	FOOD CHEMISTRY II 4 cr. (3 and 3) S (odd numbered years)
FD SC 603	FOOD PRESERVATION AND PROCESSING I 3 cr. (3 and 0) F (odd numbered years)
FD SC 604	FOOD PRESERVATION AND PROCESSING II 3 cr. (3 and 0) S (even numbered years)
FD SC 605	FOOD PRESERVATION AND PROCESSING LABORATORY I 1 cr. (0 and 3) F (odd numbered years)
FD SC 606	FOOD PRESERVATION AND PROCESSING LABORATORY II 1 cr. (0 and 3) S (even numbered years)
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 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 601 or permission of instructor.

FOOD SCIENCE

- 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 810 CHEMICAL AND BIOCHEMICAL ASPECTS OF FOODS
4 cr. (4 and 0)
Chemical, biochemical and functional properties of food components and their interactions in food emulsions, foams, colloids, and gel and solution states; the influences of processing on isolation, utilization and production of the constituents using techniques based on constituent properties. **Prerequisites:** BLOCH 623 and FD SC 401/601 or permission of instructor.
- FD SC 811 PHYSICAL AND THERMOPHYSICAL PROPERTIES OF FOODS
3 cr. (3 and 0)
Principles involved in relating physical and thermophysical properties to food quality, including standard methods and instruments to determine texture and the relationship of physical properties to sensory evaluation; emphasis on interrelationships of chemical structure and physical properties in food processing operations. **Prerequisite:** FD SC 810 or permission of instructor.
- FD SC 812 MICROBIOLOGICAL ASPECTS OF FOOD SYSTEMS
3 cr. (3 and 0)
Function and characteristics of microorganisms in the utilization and manufacture of food products; food fermentations, microbially induced chemical and physical changes, environmental aspects and production of food ingredients and resources. **Prerequisite:** MICRO 407/607 or equivalent or permission of instructor.
- FD SC 820 SPECIAL TOPICS IN FOOD SCIENCE
1-3 cr. (1-3 and 0)
Special topics in food science not covered in other courses. Cumulative credits are not to exceed four.
- FD SC 821 SPECIAL PROBLEMS IN FOOD SCIENCE
1-3 cr. (0 and 3-9)
Independent research investigation in food science areas not conducted in other courses. Cumulative maximum of three credits. **Prerequisite:** Permission of instructor.
- FD SC 851 FOOD SCIENCE SEMINAR
1 cr. (1 and 0)
Current research and related developments in food science reviewed 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.

FOOD TECHNOLOGY

Ronald L. Thomas, Program Chairman, Department of Food Science

Major	Degree
Food Technology	Ph.D.

The interdepartmental food technology doctoral program is offered by selected faculty from the departments of Agricultural Engineering; Animal, Dairy and Veterinary Sciences; Food Science; Horticulture; and Poultry Science. Applicants must have a strong background in food science and technology and related areas. Required courses include FD TECH 851, Food Technology Seminar, and FD TECH 991, Doctoral Dissertation Research. Additional courses may be selected from those offered in agricultural economics, agricultural engineering, animal and dairy sciences, experimental statistics, food science, horticulture, poultry science and microbiology, as required by the student's graduate advisory committee.

- FD TECH 851 FOOD TECHNOLOGY SEMINAR
1 cr. (1 and 0) F, S
Current and ongoing research, as well as developments in food technology reviewed by faculty, students and invited lecturers.
Prerequisite: Enrollment in the Food Technology Ph.D. program or permission of instructor.
- FD TECH 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

GENETICS

Ralph E. Franklin, 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 616 MOLECULAR GENETICS
(BIO SC 616) 3 cr. (3 and 0)
- GEN 618 BIOTECHNOLOGY I: NUCLEIC ACIDS TECHNIQUES
(MICRO 618) 4 cr. (2 and 4)
(BIO SC 618)
- GEN 651 ADVANCED GENETICS
3 cr. (3 and 0) F
- 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 theory and in the laboratory. **Prerequisite:** A genetics course or equivalent in biology courses.

GENETICS

- GEN 801 **CYTOGENETICS**
3 cr. (2 and 3) S (odd 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 803 **BIOMETRICAL GENETICS**
3 cr. (3 and 0) S
Statistical methodology in the study of population genetics; probability as applied to genetic systems, gene and zygotic frequencies, derivation of genetic expectations, forces that change gene frequency, inbreeding, estimation and testing of genetic parameters, partitioning of variance, responses to selection and other statistical aspects of continuous variation. **Prerequisite:** GEN 451/651, EX ST 801 or equivalent.
- GEN 806 **SPECIAL PROBLEMS IN GENETICS**
1-3 cr. (0 and 3-9)
Research not related to a thesis.
- GEN 890 **SPECIAL TOPICS IN GENETICS**
1-3 cr. (1-3 and 0)
Group discussion of recent developments in genetic research. May be repeated for a maximum of six credit hours. **Prerequisites:** GEN 302 and permission of instructor.

HORTICULTURE

Jere A. Brittain, Acting Head, Department of Horticulture

Major	Degrees
Horticulture	M.S.
Plant Physiology	Ph.D.

The Master of Science degree is offered in floriculture, woody ornamentals, olericulture, pomology and turfgrass management. Master's degree candidates are required to conduct original research leading to a thesis.

The department participates in the plant health option of the interdisciplinary Master of Agriculture degree. The department participates in interdepartmental programs awarding the Doctor of Philosophy degree with a major in plant physiology and in food technology. The Ph.D. program requires the performance of original research leading to a dissertation.

Research concentrations are offered in molecular biology, plant breeding and genetics, tissue culture, weed science, photomorphogenesis, postharvest physiology, stress physiology, crop production physiology, landscape design and plant nutrition. Each student's degree program is tailored to his or her professional goals with the guidance of an advisor and graduate committee. All graduate students in horticulture must select an advisor before admission.

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

- HORT 607 LANDSCAPE DESIGN
3 cr. (2 and 3) F
- HORT 612 TURF MANAGEMENT
3 cr. (2 and 3) F
- HORT 615 FOLIAGE PLANTS FOR INTERIOR UTILIZATION
3 cr. (2 and 3) F (odd numbered years)
- HORT 633 (AGRON 633) INTEGRATED WEED MANAGEMENT FOR AGRONOMIC AND HORTICULTURAL CROPS
3 cr. (2 and 2) S
- HORT 652 TREE FRUIT CULTURE AND PHYSIOLOGY
3 cr. (2 and 3) F (even numbered years)
- HORT 655 SMALL FRUIT CROPS
3 cr. (2 and 3) F (even numbered years)
- HORT 656 VEGETABLE CROPS
4 cr. (3 and 3) F
- HORT 661 PROBLEMS IN LANDSCAPE DESIGN
4 cr. (3 and 3) S
- HORT 662 LANDSCAPE DESIGN IMPLEMENTATION
3 cr. (2 and 3) F
- HORT 664 POSTHARVEST HORTICULTURE
3 cr. (2 and 2) F
- HORT 670 HORTITHERAPY
3 cr. (3 and 0) S
- HORT 671 INTERNSHIP
1-6 cr. (0 and 2-12)
- HORT 701 HORTICULTURE: PLANT AND ENVIRONMENTAL SCIENCE
3 cr. (2 and 3) SS
Scope of South Carolina horticulture and how it affects the quality of life economically and aesthetically; exploration of environmental responsibilities; demonstration of methods of teaching plant principles; includes a three-day statewide field trip to horticultural industries. Not to be taken for credit by graduate students in horticulture.
- HORT 800 TOPICS IN HORTICULTURAL SCIENCE
1 cr. (1 and 0)
Timely topics in horticultural science. May be repeated for a total of four credits, as topics and instructors vary. **Prerequisite:** Permission of instructor.
- HORT 802 RESEARCH SYSTEMS IN HORTICULTURE
3 cr. (2 and 3) F (even numbered years)
Current trends, developments and techniques in horticultural research. **Prerequisites:** CH 223 and 227, or CH 201 and PHYS 207, or BIOCH 210.

HORTICULTURE

- 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 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 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 812 SPECIAL PROBLEMS IN HORTICULTURE
 1-4 cr. (1-4 and 0)
 Research not related to a thesis. Course may be repeated for credit, but total credit may not exceed four hours. **Prerequisite:** Permission of instructor.
- HORT 813 PHOTOMORPHOGENESIS
 3 cr. (2 and 2)
 Regulatory role of light quality in plant development (photomorphogenesis) and its consequences in and applications for crop production. **Prerequisite:** BOT 421/621 or permission of instructor; BOT 823 preferred.
- HORT 814 ENVIRONMENTAL PLANT STRESS PHYSIOLOGY
 3 cr. (2 and 2)
 Environmental stresses associated with water (drought, waterlogging), temperature, light and air pollution with quantitative treatment of stress effects on plants; mechanisms by which plants may avoid, tolerate or modify stress effects on plant growth and function at the molecular, cellular and whole-plant levels. **Prerequisite:** BOT 421/621 or permission of instructor.
- HORT 891 MASTER'S THESIS RESEARCH
 Credit to be arranged.
- HORT 921 PLANT PHYSIOLOGY COLLOQUIUM
 (BOT 921) 1 cr. (1 and 0)
 See BOT 921 for description.
- HORT 991 DOCTORAL DISSERTATION RESEARCH
 Credit to be arranged.

NUTRITION

Denzil V. Maurice, Program Coordinator, Department of Poultry Science

Major
Nutrition**Degrees**
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 nutrition faculty domiciled in the departments of Animal, Dairy and Veterinary Sciences; 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 undergraduate 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 thesis or nonthesis option is available.

- NUTR 601 FUNDAMENTALS OF NUTRITION
3 cr. (3 and 0) F
- NUTR 625 NUTRITION AND DIETETICS
3 cr. (3 and 0) F
- NUTR 651 HUMAN NUTRITION
3 cr. (3 and 0) F, S
- NUTR 655 NUTRITION AND METABOLISM
3 cr. (3 and 0) S
- NUTR 701 THERAPEUTIC NUTRITION
3 cr. (3 and 0) S
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) SS
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) SS
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) F
Volume feeding systems and their relationship to food quality, food acceptance, sanitation and materials selection; physical plant layout; management structure; food flow dynamics; computer-assisted diet formulation and accounting in various feeding systems.

NUTRITION

- NUTR 705 NUTRITION PRACTICUM
1-6 cr. (0 and 3-18)
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) SS
Principles of nutrition applied to nutrition education. **Prerequisite:** Permission of instructor.
- NUTR 721 METHODS IN HUMAN NUTRITION I
2 cr. (2 and 0)
Methods in human nutrition and constraints in the use of human subjects for experimental research. **Prerequisite:** NUTR 451/651, EX ST 801 or permission of instructor.
- NUTR 722 METHODS IN HUMAN NUTRITION II
2 cr. (2 and 0)
Continuation of NUTR 721; emphasis is on the interpretation of human nutrition literature and the role of nutrition intervention programs in nutrient intake of selected population groups. **Prerequisite:** NUTR 721 or 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 802 SPECIAL TOPICS IN NUTRITION
1-3 cr. (1-3 and 0) (Offered as needed)
Topics of special interest or contemporary subjects not examined in other courses.
- 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. **Prerequisite:** NUTR 401/601, 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 nonfibrous feed ingredients; properties and functions of nutrients, nonprotein nitrogen compounds and growth-promoting substances for dairy cattle, beef cattle and sheep. **Prerequisite:** NUTR 401/601 or permission of instructor.
- NUTR 811 CARBOHYDRATE NUTRITION
2 cr. (2 and 0)
The dietary sources, chemistry, absorption/excretion and functions of carbohydrates; the aberrations of metabolism and possible role in the etiology of degenerative diseases. **Prerequisites:** BIOCH 623 or equivalent; NUTR 601, 651 or equivalent; or permission of instructor.

- 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. **Prerequisite:** Permission of instructor.
- NUTR 814 NUTRITION TECHNIQUES WITH LABORATORY ANIMALS
2 cr. (1 and 3) F
Techniques of husbandry, handling and using laboratory animals for nutritional research. **Prerequisite:** Permission of instructor.
- NUTR 815 LIPID NUTRITION
2 cr. (2 and 0)
Nutrition of lipids in higher animals emphasizing their source, digestion and absorption, metabolism, function, dietary needs and interrelationships. **Prerequisites:** BIOCH 623 or equivalent; NUTR 601, 651 or equivalent; or permission of instructor.
- NUTR 816 AMINO ACIDS AND PROTEIN NUTRITION
2 cr. (2 and 0) F (odd numbered years)
Nutrition of amino acids, nonprotein nitrogen and proteins related to humans and domestic animals; essentiality, interrelationships and metabolism of amino acids.
- NUTR 817 MINERAL NUTRITION
2 cr. (2 and 0)
The occurrence, chemistry, absorption/excretion, and general and specific physiological functions of minerals. **Prerequisites:** BIOCH 623 or equivalent; NUTR 601, 651 or equivalent; or permission of instructor.
- NUTR 819 VITAMIN NUTRITION
2 cr. (2 and 0)
Overview of the chemistry, metabolism, physiology, digestion, absorption and excretion of the vitamins as applied to the nutrition of higher animals. **Prerequisites:** BIOCH 623 or equivalent; NUTR 601, 651 or equivalent; or permission of instructor.
- NUTR 820 NUTRITIONAL BIOENERGETICS
2 cr. (2 and 0)
Quantitative approach to the losses of dietary energy during digestion and metabolism, and the factors governing the energetic efficiency of different biological functions in animals and man; regulation of energy balance, body temperature regulation and techniques of calorimetry. **Prerequisites:** BIOCH 623 or equivalent; NUTR 601 or 651 or equivalent; or permission of instructor.
- 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.

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- 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 departmental headings.

- AN SC 805 NUTRITION OF MEAT ANIMALS
3 cr. (3 and 0)
- BIOCH 606 PHYSIOLOGICAL CHEMISTRY
3 cr. (3 and 0)
- 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) F (odd numbered years)

PLANT PATHOLOGY

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

Major
Plant Pathology

Degrees
M.S., Ph.D.

Graduate training in plant pathology is designed to aid students in understanding the principles and techniques used to diagnose plant problems, to develop integrated pest management programs, to engage in research involving causal agents and host-pathogen interactions, and to teach plant pathology. Facilities are available on campus and at four research and education centers in South Carolina. Current research interests include virology; nematology; microbial ecology and molecular genetics; fruit, field crops and vegetables; epidemiology; and chemical control of causal agents. Candidates for the M.S. degree are required to complete a thesis. The department participates in the plant health option of the interdisciplinary Master of Agriculture degree.

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

- PL PA 602 DISEASES OF ORNAMENTAL PLANTS AND TURFGRASSES
3 cr. (2 and 2)
- PL PA 611 PLANT DISEASE DIAGNOSIS I
2 cr. (1 and 2) SS (odd numbered years)
- PL PA 612 PLANT DISEASE DIAGNOSIS II
2 cr. (1 and 2) SS (even numbered years)
- PL PA 651 BACTERIAL PLANT PATHOGENS
3 cr. (2 and 3) S (odd numbered years)
- PL PA 656 PLANT VIROLOGY
3 cr. (2 and 3) S (even numbered years)
- PL PA 658 PLANT PARASITIC NEMATODES
3 cr. (2 and 3) F (odd numbered years)
- PL PA 800 ADVANCED PLANT PATHOLOGY
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 301.
- PL PA 801 EPIDEMIOLOGY AND CONTROL OF PLANT DISEASES
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 301 and organic chemistry.
- PL PA 802 SPECIAL TOPICS IN PLANT PATHOLOGY
1 cr. (1 and 0)
Students and faculty discuss research papers, recent advances in phytopathological technology, diseases of specific crops or topics of special interest; assigned readings and reports are required. Graded on a pass/fail basis. No more than two credits of this course can be applied to any one degree. **Prerequisites:** PL PA 301 and permission of instructor.
- PL PA 803 FUNGAL PLANT PATHOGENS
3 cr. (1 and 6) S (odd numbered years)
Plant pathogenic fungi, including recognition of fungus disease symptoms, isolation of fungi that cause diseases, cultural features of fungi, morphological characteristics, physiological reactions to environment, disease cycles, and management of pathogens and diseases. **Prerequisites:** BIOL 104 or equivalent, PL PA 301 and BOT 411/611.

PLANT PATHOLOGY

- 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 301 and organic chemistry.
- PL PA 805 SPECIAL PROBLEMS IN PLANT PATHOLOGY
Credit to be arranged.
Research not related to a thesis. **Prerequisites:** PL PA 411/611, 412/612 or equivalent, and permission of instructor.
- PL PA 807 SEMINAR
1 cr. (1 and 0) F, S
Areas of plant pathology and plant physiology not covered by formal courses; relevant literature is reviewed, and material is organized and presented by students. Graded on a pass/fail basis.
- PL PA 808 TECHNIQUES AND METHODS IN PLANT PATHOLOGY
1 cr. (0 and 3) F
Research techniques and methods. **Prerequisite:** PL PA 301 or concurrent registration in PL PA 301.
- PL PA 809 PHYSIOLOGICAL TECHNIQUES IN PLANT PATHOLOGY
2 cr. (1 and 3) S (odd numbered years)
Techniques in separation science; qualitative and quantitative analysis of concern to students in plant pathology and plant physiology. **Prerequisite:** Organic chemistry 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. Dwight Camper, Program Coordinator, Department of Plant Pathology and Physiology

Major	Degree
Plant Physiology	Ph.D.

The graduate program in plant physiology is interdisciplinary. Students may select courses and a major area of research from the departments of Agronomy and Soils, Biological Sciences (College of Sciences), Forest Resources, Horticulture, and Plant Pathology and Physiology. Dissertation projects are available in the Food Science Department.

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 departmental headings.

- AGRON 690 SOIL ORGANISMS IN CROP PRODUCTION
3 cr. (2 and 3) F (odd numbered years)

AGRON 801	CROP PHYSIOLOGY AND NUTRITION 3 cr. (3 and 0) F (odd numbered years)
AGRON 812	CROP ECOLOGY AND LAND USE 3 cr. (3 and 0) F (even numbered years)
AGRON 820	PESTICIDE RESIDUES IN THE ENVIRONMENT 3 cr. (3 and 0) S (odd numbered years)
AGRON 991	DOCTORAL DISSERTATION RESEARCH Credit to be arranged.
BIOSCI 618 (MICRO 618) (GEN 618)	BIOTECHNOLOGY I: NUCLEIC ACIDS TECHNIQUES 4 cr. (2 and 4)
BOT 821	INORGANIC PLANT METABOLISM 4 cr. (3 and 3) F (odd numbered years)
BOT 822	ORGANIC PLANT METABOLISM 3 cr. (3 and 0) S (even numbered years)
BOT 823	PLANT GROWTH AND DEVELOPMENT 3 cr. (3 and 0) F (even numbered years)
BOT 824	MODE OF ACTION OF GROWTH SUBSTANCES 4 cr. (3 and 3) S (odd numbered years)
BOT 842	PHYSIOLOGICAL PLANT ECOLOGY 3 cr. (3 and 0) F (odd numbered years)
BOT 843	PHYSIOLOGICAL PLANT ECOLOGY LABORATORY 1 cr. (0 and 3) F (odd numbered years)
BOT 850	PLANT TISSUE AND CELL CULTURE 3 cr. (2 and 3) F (odd numbered years)
BOT 861	PLANT CELL BIOLOGY 3 cr. (3 and 0) F (odd numbered years)
BOT 921 (HORT 921)	PLANT PHYSIOLOGY COLLOQUIUM 1 cr. (1 and 0)
FOR 806	ADVANCED SILVICULTURE — FOREST TREE GROWTH AND DEVELOPMENT 3 cr. (3 and 0) F (odd numbered years)
FOR 825	WOOD CHEMISTRY 3 cr. (2 and 1) F (even numbered years)
FOR 991	DOCTORAL DISSERTATION RESEARCH Credit to be arranged.
HORT 800	TOPICS IN HORTICULTURAL SCIENCE 1 cr. (1 and 0)

PLANT PHYSIOLOGY

- HORT 802 RESEARCH SYSTEMS IN HORTICULTURE
3 cr. (2 and 3) F (even numbered years)
- HORT 806 POSTHARVEST PHYSIOLOGY AND HANDLING OF
HORTICULTURAL CROPS
3 cr. (3 and 0) S (even numbered years)
- HORT 813 PHOTOMORPHOGENESIS
3 cr. (2 and 2)
- HORT 814 ENVIRONMENTAL PLANT STRESS PHYSIOLOGY
3 cr. (2 and 2)
- HORT 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.
- PL PA 804 PHYSIOLOGICAL PLANT PATHOLOGY
3 cr. (3 and 0) F (even numbered years)
- PL PA 809 PHYSIOLOGICAL TECHNIQUES IN PLANT PATHOLOGY
2 cr. (1 and 3) S (odd numbered years)
- PL PA 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.
- PL PH 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

POULTRY SCIENCE

Bruce Glick, Head, Department of Poultry Science

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

The M.S. programs in poultry science may emphasize immunology, physiology, nutrition, management, products and processing, or diseases. A thesis is required in this degree program. At the Ph.D., level interdisciplinary study is available in nutrition and physiology. Applicants with backgrounds in the basic biological sciences and all areas of animal agriculture are welcome. The department participates in the animal industries option of the interdisciplinary Master of Agriculture degree.

- PS 600 AVIAN PHYSIOLOGY
3 cr. (3 and 0) S (even numbered years)
- PS 602 POULTRY MANAGEMENT
2 cr. (1 and 2) S (odd numbered years)
- PS 605 SPECIAL TOPICS
1-4 cr. (1-3 and 0-3)

- PS 606 SPECIAL PROBLEMS
1-3 cr. (0 and 3-9)
- PS 651 POULTRY NUTRITION
2 cr. (2 and 0) F (odd numbered years)
- PS 653 POULTRY NUTRITION LABORATORY
1 cr. (0 and 3) F (odd numbered years)
- PS 655 POULTRY PRODUCTS GRADING AND TECHNOLOGY
3 cr. (2 and 3) S (odd numbered years)
- PS 658 AVIAN MICROBIOLOGY AND PARASITOLOGY
4 cr. (3 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)
Report on special topics or original research by students, staff and visiting speakers.
- PS 825 IMMUNOBIOLOGY
3 cr. (3 and 0) S
Conceptual approach to immunobiology emphasizing the molecular and cellular aspects; classical and current literature is the major source for the discussion/lecture format. **Prerequisite:** Permission of instructor.
- PS 891 MASTER'S THESIS RESEARCH
Credit to be arranged.

COLLEGE OF ARCHITECTURE

ARCHITECTURE
CITY AND REGIONAL PLANNING
CONSTRUCTION SCIENCE AND MANAGEMENT
VISUAL ARTS

COLLEGE OF ARCHITECTURE

James F. Barker, Dean

The College of Architecture offers advanced degrees in the following areas of study:

- Architecture
- City and Regional Planning
- Construction Science and Management
- Visual Arts

The college is comprised of the departments of Architectural Studies, Construction Science and Management, Planning Studies, and Visual Arts and History. All contribute to the preprofessional undergraduate design program, and all departments administer professional graduate programs leading to these degrees: Master of Science in Architecture, Master of Architecture, Master of City and Regional Planning, Master of Construction Science and Management, and Master of Fine Arts. Cross-disciplinary activities consist of a dual degree program in architecture and planning, and participation by graduate students from all departments in the Genoa study program.

A vital component of graduate work in the College of Architecture is the Charles E. Daniel Center for Building Research and Urban Studies in Genoa, Italy. The Center, which is jointly sponsored by the college and the Clemson Architectural Foundation, is available to all qualified graduate students. Emphasis is placed on studies related to this historic port city and the art and architectural heritage of the Italian setting. Studio and classroom work is enriched by visiting scholars and critics and complemented by scheduled field trips, both in Italy and continental Europe.

Courses of study in the Daniel Center, while under the jurisdiction of the related departments of the College of Architecture, are administered and taught by the professors-in-residence. Studio work is the core of the Genoa program, whether in architecture, city and regional planning, construction science and management, or visual arts. All students undertake a history research project, conduct field studies and participate in a design seminar.

ARCHITECTURE

John D. Jacques, Head, Department of Architectural Studies

Major
Architecture

Degrees
M.Arch., M.S.

The Master of Architecture is a first professional degree program which develops proficiency in responding to contemporary architectural issues through a range of both practical and theoretical knowledge, while providing opportunities for creatively challenging the limits of the profession. Major emphasis is on design, accompanied in turn by complementary course work of a professional focus, as well as elective subjects. Complex studio design projects stress social awareness and contextual fit and are responsive to all aspects of the architectural process. Practical experience is a requisite part of the overall program, which is concluded with a thesis combining literary search with design synthesis.

Admission to the Master of Architecture program is based on the student's ability to respond effectively to the intellectual rigor and creative challenge integral to graduate architecture study. This potential is measured by demonstrated proficiency in prior academic work and GRE general test scores, as well as creativeness of mind, motivation of spirit and maturity of purpose. A personal interview is normally required

of candidates whose application material has been favorably reviewed by the Admissions Committee. A postbaccalaureate program of preparatory study is available to qualified applicants with backgrounds in areas other than design. More detailed information concerning application procedures and requirements may be obtained by writing or calling the Department of Architectural Studies.

The duration of study required for the Master of Architecture degree is normally two academic years, and degree candidates may elect a concentration of study in either architecture, or architecture and health care. The specific study plan of each student is determined in consultation with the major advisor, and is intended to reflect individual educational objectives and career goals, while assuring a comprehensive development of professional competency. Requirements for the Master of Architecture degree include 45 credits of approved course work with a minimum grade point average of 3.00, along with acceptance of a thesis of 15 hours. All candidates for graduation are required to have 1,000 hours of practical experience in an architect's office.

The Master of Science in Architecture is a postprofessional degree program which offers the opportunity to achieve advanced learning within the discipline of architecture, and to undertake research responsive to increasingly complex challenges attendant to the built environment. This is accomplished through a foundation of course work, accompanied by directed studies within a selected area of inquiry, and followed by the critical examination of a singular aspect of architecture in a research thesis.

Admission to the Master of Science in Architecture program is available to students who have achieved a first professional degree in architecture, and who possess the intellectual mettle and dedication of purpose necessary to respond successfully to the rigor of advanced study and independent research. This is measured by academic proficiency in prior work and evidence of a well reasoned plan of advanced study, as well as GRE general test scores. A personal interview is required of all applicants whose application material has been favorably reviewed by the Admissions Committee. More information concerning application procedures and requirements may be obtained by contacting the Department of Architectural Studies.

The course work and directed studies required of the Master of Science program may be completed in one academic year, after which a variable period of time is dedicated to the research thesis. Degree candidates will elect to work within one of the following areas: architecture and health care facilities, environmental issues in architecture, architecture and human perception, and theory and philosophy of architecture. A study plan is determined in consultation with the major advisor who, along with the advisory committee, will periodically review the student's work and evaluate the research thesis. Credit requirements for the Master of Science in Architecture degree consist of 24 hours of combined course work and directed studies with a minimum grade point average of 3.00, and the acceptance of a 6-hour research thesis.

Architecture Concentration

This inclusive course of study leading to the Master of Architecture degree affords the student an opportunity to pursue individual academic and career objectives within the context of a rigorous professionally directed architecture program. The focus of learning is the design studio, where the student is involved in a wide range of theoretical and real-world explorations. Advanced studies in technology, theory and professional practice complement design work and are accompanied by additional subjects determined in concert with the major advisor.

Although designated subjects in design and other professional studies constitute a major portion of work in this concentration, sufficient elective hours are available to establish a study plan responsive to individual interests. The choice of thesis subject provides a further opportunity for personal development.

Architecture and Health Care Concentration

Master of Architecture students in this specialized area of study examine issues of programming, planning and design associated with a comprehensive approach to physical and mental health care delivery systems. Studio work emphasizes the integration of physical design systems with patient care techniques. Theoretical design projects, as well as those that lead to built projects, employ both investigative research and architectural synthesis. These design studies are complemented by lectures and seminars that deal with various aspects of health care, hospital administration and the environment.

The architecture and health care concentration is demanding in the scope of its professional studies, with most of the course work designated for specific areas of learning. The thesis, which normally deals with a particular area of health care, may be project or research oriented.

CA AR 603	THE MODERN ARCHITECTURE MOVEMENT 3 cr. (3 and 0)
CA AR 604	CURRENT DIRECTIONS IN ARCHITECTURE 3 cr. (3 and 0)
CA AR 612	HISTORY RESEARCH 3 cr. (3 and 0)
CA AR 614	DESIGN SEMINAR* 3 cr. (3 and 0)
CA AR 616	FIELD STUDIES* 3 cr. (0 and 9)
CA AR 624	PRODUCT DESIGN 3 cr. (0 and 9)
CA AR 625	ENERGY IN ARCHITECTURE 3 cr. (3 and 0)
CA AR 626	ARCHITECTURAL COLOR GRAPHICS 3 cr. (2 and 3)
CA AR 627	ADVANCED COLOR GRAPHICS 3 cr. (2 and 3)
CA AR 628	COMPUTER-AIDED DESIGN 3 cr. (2 and 3)
CA AR 685	HEALTH CARE FACILITIES 3 cr. (3 and 0)
CA AR 688	HEALTH CARE PROGRAMMING 3 cr. (3 and 0)

* Offered only at the Daniel Center in Genoa, Italy.

- CA AR 801 ARCHITECTURE SEMINAR
3 cr. (3 and 0)
Contemporary issues in the architectural profession.
- CA AR 802 PHENOMENOLOGY OF ARCHITECTURE
3 cr. (3 and 0)
Basic principles of phenomenological methods as they apply to the theoretical understanding of modern architecture; emphasis is on selected writings of Heidegger, Harries and Norberg-Schulz.
Prerequisite: CA AR 803.
- CA AR 803 THEORIES OF ARCHITECTURE
3 cr. (3 and 0)
Evolution of architectural theories from Vitruvius to the present; special emphasis on the writings of leading architects and theorists and the impact of these theories on architectural solutions.
Prerequisite: Graduate status.
- CA AR 804 SEMINAR IN MODERN MASTERS
3 cr. (3 and 0)
In-depth examination of one or more related groups of architects of the 20th century. Content varies from semester to semester (Kahn, Scarpa, Barrigan, Wright, Corbusier, etc.). **Prerequisite:** Graduate status.
- CA AR 805 ARCHITECTURE AND THE CITY
3 cr. (3 and 0)
Seminar examining contemporary theories of urban design and the design of urban buildings; real and ideal visions of cities; their representation, archaeology and iconography (Rossi, Kries, Ungers, Venturi, Duane, etc.).
- CA AR 821 RESEARCH METHODS
3 cr. (3 and 0)
The foundations and procedures of architectural research; alternate research methodologies, and their philosophical and epistemological limits. **Prerequisite:** Graduate status.
- CA AR 850 ARCHITECTURE STUDIO*
6 cr. (0 and 18)
Architectural design studies in the context of the Genoa urban setting. May be substituted for CA AR 853 or 854 and for CA AR 857 with permission of advisor.
- CA AR 853 ARCHITECTURE STUDIO
6 cr. (0 and 18)
Architectural design studies with emphasis on selected problem issues.
- CA AR 854 ARCHITECTURE STUDIO
6 cr. (0 and 18)
Architectural design studies involving structured and situational problems. **Prerequisite:** CA AR 853.

* Offered only at the Daniel Center in Genoa, Italy.

ARCHITECTURE

- CA AR 857 ARCHITECTURE STUDIO
6 cr. (0 and 18)
Architectural design studies dealing with comprehensive problem-solving situations. **Prerequisite:** CA AR 854.
- CA AR 858 THESIS RESEARCH
3 cr. (0 and 9)
Architectural predesign inventory and analysis for the thesis project. **Prerequisite:** CA AR 854.
- CA AR 859 THESIS MANUSCRIPT
1-3 cr. (0 and 3-9)
Architectural predesign synthesis of research for the thesis project. **Prerequisite:** CA AR 858.
- CA AR 881 DELIVERY OF ARCHITECTURE
3 cr. (3 and 0)
Ethical, legal and business issues in the architectural profession. **Prerequisite:** Professional degree program status.
- CA AR 886 HEALTH CARE COMPONENTS
3 cr. (3 and 0)
Components and service functions of physical and mental health care delivery systems and facilities.
- CA AR 890 DIRECTED STUDIES
1-5 cr. (1-5 and 0)
Special topics in architecture undertaken on an individual basis with faculty guidance. **Prerequisite:** Permission of advisor.
- CA AR 891 THESIS PROJECT
3-9 cr. (0 and 9-27)
Complex architectural project emphasizing design exploration and independent work. Graded on a pass/fail basis. **Prerequisites:** CA AR 857 and 858.

CITY AND REGIONAL PLANNING

Jose R. Caban, Head, Department of Planning Studies

Major	Degree
City and Regional Planning	M.C.R.P.

The two-year Master of City and Regional Planning program emphasizes land development and financial planning. The standard core curriculum is followed by concentrated studies in one of several areas: urban design and land development, planning administration, health and social services planning, environmental planning, land use planning and geographic information systems (GIS). Specialty concentrations can be tailored to doctoral programs elsewhere. Students normally choose a concentration for which their undergraduate background is best suited. No specific undergraduate area of study is required; options are available for students with or without a design background. The result is a rich cross section of students with a variety of interests. The relatively small enrollment leads to intensive faculty-student

interaction. Ongoing public service and research projects provide a real-world dimension to the program. Graduates are well equipped for careers in private-sector planning and development, as well as public-sector planning and administration.

The Overseas Center for Urban Studies in Genoa, Italy, is a unique support element in the planning studies program. It provides the option of a one-semester overseas study experience in an interdisciplinary program of planning studies, design and fine arts.

Admission Requirements

1. A bachelor's degree from an accredited college or university.
2. A satisfactory academic record in the last two years of undergraduate work.
3. An on-campus interview is highly recommended.
4. Three letters of recommendation from undergraduate teachers, employers or personal acquaintances.
5. Completion of the Graduate Record Examination.
6. One three-credit course in statistics, economics and computer applications is highly recommended.

Deficiencies in any of these areas may be remedied after enrollment in the graduate program. Postbaccalaureate status may be recommended in some cases.

Requirements for Degree Candidacy

The two-year Master of City and Regional Planning degree requires a minimum of 54 semester hours. Nine courses, eight of three semester hours of credit and one a six-credit studio, make up the core curriculum. Four approved courses of three semester hours of electives are required to complete an optional concentration. In addition, each student is required to complete an internship (or equivalent) and a terminal project/paper or thesis.

Requirements for Awarding of a Degree

1. Thesis Option *
 - (a) A minimum of 45 hours of course work with a B average in the student's prescribed professional curriculum, including the thesis.
 - (b) Satisfactory completion of a six- to nine-semester-hour planning thesis. Only those students who have been approved by the planning faculty and have performed satisfactorily on the 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. Nonthesis Option *
 - (a) A minimum of 45 hours of course work with a B average in the student's prescribed professional curriculum.

* 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.

- (b) Satisfactory completion of an approved six-semester-hour terminal paper sequence. Students must perform satisfactorily on a 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.

CRP 605	URBAN GENESIS AND FORM 3 cr. (3 and 0)
CRP 611	INTRODUCTION TO CITY AND REGIONAL PLANNING 3 cr. (3 and 0)
CRP 615	SMALL CITY AND RURAL PLANNING 3 cr. (3 and 0)
CRP 672	PLANNING PROCESS AND ADMINISTRATION 3 cr. (3 and 0)
CRP 673	GOVERNMENT AND PLANNING LAW 3 cr. (3 and 0)
CRP 683	SEMINAR ON PLANNING COMMUNICATION 3 cr. (3 and 0)
CRP 812	CITY AND REGIONAL PLANNING THEORY 3 cr. (3 and 0) Development of the planning practice and theories of planning process; major topics include historical evolution of planning practice in the U.S., social issues in planning, theories of planning and critiques of those theories, and ethical issues in planning practice. Prerequisite: Permission of instructor or department head.
CRP 821	INTERGOVERNMENTAL RELATIONS IN THE PLANNING PROCESS 1-3 cr. (1-3 and 0) Operations, structure and review procedures between local, state, and multistate agencies and the federal government; techniques of regional delineation and areal problems in governmental planning operations. Prerequisites: Permission of instructor and department head.
CRP 822	URBAN SYSTEMS AND DESIGN 3 cr. (3 and 0) Analysis of the evolution of the physical patterns of cities through research in the historical development of urban form in Europe and America within the context of prevailing social, economic and political influences; approaches to the analysis of contemporary cities through the study of 20th century planning theorists. Prerequisite: Permission of instructor or department head.
CRP 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.

- CRP 831 PHYSICAL PLANNING STUDIO
3 cr. (3 and 0)
Working knowledge of natural systems, infrastructure systems, land use activity, social concerns, visual/spatial topics and implementation practice.
- CRP 832 PROBLEMS IN SITE PLANNING
3 cr. (1 and 2)
Advanced site planning and design concept studies developed through site projects; concentration on industrial, residential and recreational facilities; emphasis on use-specific site analysis and generation of development alternatives. **Prerequisite:** CRP 831.
- CRP 834 GEOGRAPHIC INFORMATION SYSTEMS FOR CITY AND REGIONAL PLANNING
3 cr. (3 and 0)
Introduction to geographic information systems for planning and related resource management disciplines. Topics include data development and management, spatial analysis techniques, critical review of GIS applications, needs analysis and institutional context, overview of GIS hardware and software, completion of hands-on application project.
- CRP 835 ADVANCED TOPICS IN GEOGRAPHIC INFORMATION SYSTEMS
3 cr. (3 and 0)
Seminar/laboratory devoted to development and analysis of leading edge GIS capabilities and applications; seminar focus varies from year to year, based upon developments in the GIS field and student interests. **Prerequisite:** CRP 834 or permission of instructor.
- CRP 840 SEMINAR IN COASTAL PLANNING
3 cr. (3 and 0)
Issues relating to development and conservation of coastal environments, focusing on inherent tradeoffs between growth and environmental quality; ecology and carrying capacity of coastal areas; appropriate management approaches to balance coastal resource demand. **Prerequisite:** Graduate standing.
- CRP 841 SEMINAR IN ENVIRONMENTAL PLANNING
3 cr. (3 and 0)
Current and emerging environmental issues and appropriate planning options, including population dynamics and limits to growth, entropy law, waste management and global climate change; students pursue individual research on an environmental issue of particular concern and report findings. **Prerequisite:** Graduate standing.
- CRP 853 PLANNING METHODS I: THEORY AND TECHNIQUE
3 cr. (0 and 9)
Introduction to analytic planning methods; material is drawn principally from the fields of economics, geography, regional science, and city and regional planning. **Prerequisite:** An undergraduate class in microeconomics.

- CRP 854 PLANNING METHODS II: TECHNIQUES AND APPLICATIONS
3 cr. (0 and 9)
Techniques for planning analysis, including social/economic profiles and projections, impact assessment, land use planning analysis and feasibility studies; computer modelling and simulation; students apply these techniques in studio projects. **Prerequisite:** CRP 853.
- CRP 858 RESEARCH METHODS AND THESIS PLANNING PROPOSAL
3 cr. (0 and 9)
Preliminary analysis of data to determine most advisable form of terminal presentation within thesis or nonthesis options for Master of City and Regional Planning degree. **Prerequisite:** Permission of faculty.
- CRP 859 PLANNING TERMINAL PROJECT
3 cr. (0 and 9)
Student selects, with approval of advisor, and conducts research on an individual planning problem of suitable scope. Oral, written and, where appropriate, visual presentation of solution required. Student must enroll during final semester. **Prerequisite:** CRP 858.
- CRP 860 PLANNING STUDIO
3-6 cr. (0 and 9-18)
Planning studies related to the city of Genoa and its environs. May be substituted for CRP 854, 863 or 865 with approval of credit hours by major advisor.
- CRP 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.
- CRP 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.
- CRP 865 ADVANCED LAND USE AND BUILT FORM STUDIES: STUDIO
3-9 cr. (0 and 9-27)
Continuation of CRP 863; may include terminal paper on one or more items listed in CRP 863.
- CRP 866 COMPREHENSIVE PLANNING STUDIO
6 cr. (3 and 9)
Serves as a vehicle for synthesis and application of skills developed in other courses and includes participation in one or more real-world planning projects in addition to seminars and readings devoted to development of professional practice skills. **Prerequisite:** Second year CRP student or permission of instructor.

- CRP 871 GROWTH MANAGEMENT AND LEGAL ISSUES
3 cr. (3 and 0)
Basic laws and court cases relating to the comprehensive plan, implementing tools and other aspects of the planning process in the growth management context. **Prerequisites:** CRP 672 and permission of instructor or department head.
- CRP 872 HOUSING ISSUES IN THE UNITED STATES
3 cr. (3 and 0)
Regulation, stimulation, salvage and replacement of housing through public policy administrative procedures; specific housing programs analyzed in detail.
- CRP 881 QUANTITATIVE METHODS FOR URBAN PLANNING AND POLICY
3 cr. (3 and 0)
Use of quantitative information for policy analysis in planning and related fields; topics covered include measurement construction, using descriptive and inferential statistics for policy development, and computer use in planning and related professions. **Prerequisite:** Permission of instructor or department head.
- CRP 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; evaluation; theoretical knowledge applied to development of operational empirical models.
- CRP 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:** CRP 881, 865 and permission of instructor.
- CRP 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.
- CRP 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.
- CRP 889 SELECTED TOPICS IN PLANNING
3 cr. (3 and 0)
Topics emphasizing current literature and results of current research. May be repeated for credit. **Prerequisite:** Permission of instructor.

- CRP 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.
- CRP 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.
- CRP 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 a pass/fail basis. **Prerequisite:** Two semesters of city and regional planning or equivalent.

CONSTRUCTION SCIENCE AND MANAGEMENT

Roger W. Liska, Head, Department of Construction Science and Management

Major	Degree
Construction Science and Management	M.C.S.M.

The Master of Construction Science and Management degree program is designed to provide students with a high level of skill and understanding in the technical areas of construction project administration and control. Substantial emphasis is placed on advanced study in the field of business, in new and emerging techniques for construction project delivery systems, and in the administration of the construction firm.

Requirements for the M.C.S.M. degree include a minimum of 36 semester hours of graduate credit, 12 of which must be from the core courses (BLD SC 860, 861, 862, 863, 864, 865 and 891). The program offers a thesis or nonthesis option. The balance of hours is selected from a list of elective courses related to the major field of study. Those students with a B.S. degree in construction science or its equivalent will normally have completed all prerequisite courses and will be eligible to enroll in advanced courses, provided they have met all other admission requirements. Those with undergraduate degrees in design, architecture, engineering or other disciplines must complete certain prerequisite courses as approved by their advisory committee.

Admission Requirements

In addition to the completed graduate application form, three letters of recommendation, as well as test scores on the Graduate Record Examination (GRE) must be submitted. To be admitted, students must be accepted by the Graduate School and the Department of Construction Science and Management. Graduate School acceptance is based on performance in previous undergraduate studies and a satisfactory score on the GRE. Acceptance by the department is based on performance in undergraduate studies and the letters of recommendation.

- BLD SC 655 REDUCING ADVERSARIAL RELATIONS IN CONSTRUCTION
3 cr. (3 and 0)
- BLD SC 661 CONSTRUCTION ECONOMIC SEMINAR
3 cr. (3 and 0)
- BLD SC 850 INTERNATIONAL CONSTRUCTION
6 cr. (0 and 18)
Building industries in foreign countries and the methods of managing the construction process within them. This course will be taken by M.B.S.M. students at the Genoa Center in Italy.
- BLD SC 852 CONSTRUCTION MANAGEMENT RESEARCH
3 cr. (0 and 9)
Research methodology applied to the construction industry. **Prerequisite:** Permission of instructor.
- BLD SC 854 BUILDING SYSTEMS RESEARCH
3 cr. (0 and 9)
Detailed evaluation of construction systems with in-depth analysis of their qualities and performance under varying conditions of use and location. **Prerequisite:** Permission of instructor.
- BLD SC 855 BUILDING ENVIRONMENTAL SYSTEMS SEMINAR
3 cr. (3 and 0)
Advanced study of building environmental control systems. **Prerequisite:** Permission of instructor.
- BLD SC 860 FINANCIAL PLANNING AND ANALYSIS
3 cr. (3 and 0)
Theory of financial management as it relates to the financial problems faced by the building construction firm.
- BLD SC 861 CONSTRUCTION CONTROL SYSTEMS
3 cr. (3 and 0)
Design and administration of the quality assurance program for large and complex construction projects.
- BLD SC 862 PERSONNEL MANAGEMENT AND NEGOTIATIONS
3 cr. (3 and 0)
The role of management and unions in the construction industry. Topics include contract negotiation, collective bargaining, dispute resolution and management for productivity improvement.
- BLD SC 863 ADVANCED SCHEDULING
3 cr. (1 and 6)
Analysis and control of complex construction projects using advanced techniques for scheduling and resource leveling.
- BLD SC 864 COST ANALYSIS AND MARKETING
3 cr. (1 and 6)
Advanced techniques for cost analysis and their use in marketing construction management, design-build or single-contract project delivery services.

CONSTRUCTION SCIENCE AND MANAGEMENT

- BLD SC 865 PROJECT MANAGEMENT
3 cr. (3 and 0)
Theory of project administration and control with special emphasis on the role and responsibilities of the resident project representative and the project manager.
- BLD SC 871 ARCHITECTURAL STRUCTURES I
3 cr. (3 and 0)
Examination and evaluation of structural systems with emphasis on the compatibility and constraints exerted on architectural design goals. **Prerequisite:** BLD SC 302.
- BLD SC 872 ARCHITECTURAL STRUCTURES II
3 cr. (3 and 0)
Continuation of BLD SC 871. **Prerequisite:** BLD SC 871.
- BLD SC 875 BUILDING EQUIPMENT AND SYSTEMS
3 cr. (3 and 0)
Selection and integration of building support systems with other systems: heating, ventilation, air conditioning, electrical and plumbing. **Prerequisite:** BLD SC 403 or equivalent as approved by instructor.
- BLD SC 876 DESIGN FOR NATURAL HAZARDS
3 cr. (3 and 0)
Basic principles of design for natural hazards to the built environment: wind (hurricane, tornado, cyclone), water (flood, seiche, tsunami), seismic (shaking, faulting, landslide, liquefaction), and fire (vegetation, exposing structures, lightning); weather characteristics and geological conditions; site and land-use planning; hazard forces and hazard-resistant design fundamentals. **Prerequisite:** Permission of instructor.
- BLD SC 877 ADVANCED ARCHITECTURAL ACOUSTICS
3 cr. (3 and 0)
Advanced study of acoustics with emphasis on individual research into design for good hearing and sound control in and around buildings, and applications to design studio work and thesis project; ray tracing for ITDGs, analog models using lasers, evaluations of completed buildings, and rigorous analysis of case studies. **Prerequisite:** BLD SC 403 or equivalent.
- BLD SC 878 LIGHTING FOR ARCHITECTURE
3 cr. (3 and 0)
Interrelationships among the many fields that constitute lighting and its impact on building form, materials and spatial use; the potential contribution of daylight and electric light to human response and performance. **Prerequisite:** Graduate status.
- BLD SC 881 PROFESSIONAL SEMINAR
3 cr. (3 and 0)
New and emerging methods for management of the construction or construction-related firm. **Prerequisite:** Permission of instructor.

BLD SC 890 DIRECTED STUDIES

3-6 cr.

Special topics not covered in other courses; emphasis is on field studies, research activities and current developments in building science. **Prerequisite:** Permission of instructor.

BLD SC 891 MASTER'S THESIS RESEARCH

Credit to be arranged.

With the approval of his or her advisory committee, the student will carry on independent research and analysis. The thesis will be presented orally and in writing and in strict compliance with the guidelines of the Graduate School.

VISUAL ARTS

John T. Acorn, Head, Department of Visual Arts and History

Major
Visual Arts

Degree
M.F.A.

The Master of Fine Arts degree is the terminal degree within the areas of visual arts. The program offers concentration in the studio areas of drawing, painting, printmaking, ceramics, photography and sculpture. 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 arts leading to the Master of Fine Arts degree admits a limited number of talented and creative 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, liberal arts, fine arts or architecture. Especially well qualified persons may be accepted from other degree backgrounds.
2. Attainment of satisfactory academic record in the last 60 major credit hours of undergraduate work.
3. A portfolio documentation of candidate's creative work. Portfolio should represent between 15-20 works, the majority of which should represent the chosen field of study. 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 Visual Arts and History. Upon acceptance of the past accomplishments of the candidate, a personal interview will be arranged.
4. Letters of recommendation are preferred from the following: former major professors, producing artists or professional acquaintances. Other letters of recommendation will be accepted.
5. A statement of intent regarding applicant's interest and direction in pursuing the graduate degree.

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 ART 600- and 800-level courses 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 exhibition" and an oral examination by the Graduate Committee.

ART 605	DRAWING 3 cr. (0 and 6)
ART 607	PAINTING 3 cr. (0 and 6)
ART 609	SCULPTURE 3 cr. (0 and 6)
ART 611	PRINTMAKING 3 cr. (0 and 6)
ART 613	PHOTOGRAPHY 3 cr. (0 and 6)
ART 615	GRAPHIC DESIGN 3 cr. (0 and 6)
ART 617	CERAMIC ARTS 3 cr. (0 and 6)
ART 690	DIRECTED STUDIES 1-5 cr. (0 and 2-10)
ART 805	VISUAL ARTS SEMINAR ON THEORIES AND PRACTICE I 3 cr. (3 and 0) Issues related to the practice of the artist, emphasizing theories and criticism of contemporary art.
ART 806	VISUAL ARTS SEMINAR ON THEORIES AND PRACTICE II 3 cr. (3 and 0) Continuation of ART 805.
ART 840	VISUAL ARTS STUDIO 3-6 cr. (0 and 9-18) Studio work in visual arts with adjunct lectures and gallery tours. May be substituted for ART 800-level visual arts studio.

- ART 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:** Permission of department head or instructor.
- ART 851 VISUAL ARTS STUDIO
3-6 cr. (0 and 9)
Continuation of ART 850. May be repeated for maximum of six credits. **Prerequisite:** Permission of department head or instructor.
- ART 870 VISUAL ARTS STUDIO
6 cr. (0 and 16)
Advanced theory; directed research in art criticism; applied work in ceramic arts, drawing, painting, sculpture, photography, graphic design or multimedia. **Prerequisite:** Permission of department head or instructor.
- ART 871 VISUAL ARTS STUDIO
3-6 cr. (0 and 8-16)
Continuation of ART 870. May be repeated for maximum of six credits. **Prerequisite:** Permission of department head or instructor.
- ART 880 VISUAL ARTS STUDIO
3-15 cr. (0 and 6-30)
Continuation of ART 871. May be repeated for maximum of 15 credits. **Prerequisite:** Permission of department head or instructor.
- ART 891 MASTER'S THESIS RESEARCH
3-15 cr. (0 and 6-30)
May be repeated for maximum of 15 credits. **Prerequisite:** Permission of department head or instructor.

No degrees are offered in art and architectural history. Courses are offered to provide electives for students in other areas.

- AAH 611 DIRECTED RESEARCH IN ART HISTORY I
3 cr. (3 and 0)
- AAH 612 DIRECTED RESEARCH IN ART HISTORY II
3 cr. (3 and 0)
- AAH 613 TWENTIETH CENTURY VISUAL ARTS
3 cr. (3 and 0)
- AAH 617 STUDIES IN THE ART AND ARCHITECTURE OF THE ANCIENT WORLD I
3 cr. (3 and 0)
- AAH 618 STUDIES IN THE ART AND ARCHITECTURE OF THE ANCIENT WORLD II
3 cr. (3 and 0)
- AAH 619 STUDIES IN THE ART AND ARCHITECTURE OF THE EARLY MIDDLE AGES
3 cr. (3 and 0)

VISUAL ARTS

- AAH 620 STUDIES IN THE ART AND ARCHITECTURE OF THE LATE
MIDDLE AGES
3 cr. (3 and 0)
- AAH 623 STUDIES IN THE ART AND ARCHITECTURE OF THE
RENAISSANCE I
3 cr. (3 and 0)
- AAH 624 STUDIES IN THE ART AND ARCHITECTURE OF THE
RENAISSANCE II
3 cr. (3 and 0)
- AAH 625 ARCHITECTURE OF THE TECHNOLOGICAL REVOLUTION:
1685-1865
3 cr. (3 and 0)
- AAH 627 EIGHTEENTH CENTURY VISUAL ARTS
3 cr. (3 and 0)
- AAH 628 NINETEENTH CENTURY VISUAL ARTS
3 cr. (3 and 0)
- AAH 629 STUDIES IN THE ART AND ARCHITECTURE OF INDIA AND THE
FAR EAST
3 cr. (3 and 0)
- AAH 815 ART AND ARCHITECTURAL HISTORY SEMINAR I
3 cr. (3 and 0)
Particular aspect of period of art/architectural history. **Prerequi-
site:** Permission of instructor.
- AAH 816 ART AND ARCHITECTURAL HISTORY SEMINAR II
3 cr. (3 and 0)
Continuation of AAH 815.

COLLEGE OF COMMERCE AND INDUSTRY

ACCOUNTING
BUSINESS ADMINISTRATION
ECONOMICS
FINANCE
INDUSTRIAL MANAGEMENT
MANAGEMENT SCIENCE
MARKETING
TEXTILE AND POLYMER SCIENCE
TEXTILE CHEMISTRY
TEXTILE SCIENCE

COLLEGE OF COMMERCE AND INDUSTRY

Ryan C. Amacher, Dean

The College of Commerce and Industry offers advanced degrees in the following areas of study:

Accounting	Management Science**
Applied Economics*	Textile and Polymer Science
Business Administration	Textile Chemistry***
Economics	Textile Science
Industrial Management	

Courses also are offered in finance and marketing to provide electives for students in other areas.

Graduate programs offered by the College of Commerce and Industry are designed to prepare students for professional careers in business, industry, government and education.

ACCOUNTING

Jerry E. Trapnell, Director, School of Accountancy

Major	Degree
Accounting	M.P.Acc.

The School of Accountancy's Master of Professional Accountancy degree program prepares students for positions in industrial, commercial, governmental, financial or public accounting. The program requires 31 semester hours and is open to students with appropriate backgrounds. The program accommodates both full- and part-time students. In addition to the on-campus program, the program is offered to part-time students at the Greenville Higher Education Center. Full-time students are able to complete the program in one calendar year. Part-time students on campus or in Greenville can complete the program in two to three years depending on individual course loads. The program recognizes the rapid pace of change in accounting resulting from technological advances in the managing of data, the theory and practice of management, and increases in the volume and scope of authoritative pronouncements from the FASB, SEC and IRS. The program is separately accredited by the American Assembly of Collegiate Schools of Business.

Applicants should hold at least a bachelor's degree from an institution whose scholastic rating is acceptable to the Graduate Admissions Committee of the School of Accountancy. Admission to the program is based on academic record and score on the Graduate Management Admission Test (GMAT). Letters of recommendation and relevant work experience may be considered also. Applicants should have

* This program is a cooperative effort between the Department of Agricultural and Applied Economics (College of Agricultural Sciences) and the Department of Economics (College of Commerce and Industry). The Department of Agricultural and Applied Economics is administratively responsible for the Ph.D. program, and the degree is awarded by the College of Agricultural Sciences.

** Jointly administered by the Department of Management and the Department of Mathematical Sciences. The Ph.D. degree is awarded by the College of Commerce and Industry.

*** The Ph.D. degree program is jointly administered by the School 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.

completed a basic business core of at least 30 semester hours, as well as the following accounting prerequisites: Intermediate Accounting (at least six semester hours), Cost Accounting (three semester hours), Tax (three semester hours) and Auditing (three semester hours). An undergraduate microcomputer applications course is strongly recommended.

- ACCT 604 INDIVIDUAL TAXATION
3 cr. (3 and 0)
- ACCT 610 BUDGETING AND EXECUTIVE CONTROL
3 cr. (3 and 0)
- ACCT 630 GOVERNMENTAL AND INSTITUTIONAL ACCOUNTING
3 cr. (3 and 0)
- ACCT 801 CONTEMPORARY FINANCIAL ACCOUNTING THEORY
3 cr. (3 and 0)
Development of accounting theory from its origin to the present; currently advocated pronouncements of professional accounting societies. **Prerequisite:** ACCT 302 or equivalent.
- ACCT 802 ADVANCED AUDITING I
3 cr. (3 and 0)
In-depth examination of basic auditing theory; evaluation of current publications and research in auditing; discussion of contemporary auditing problems and cases. **Prerequisite:** ACCT 415 or equivalent.
- ACCT 803 ACCOUNTING INFORMATION SYSTEMS
3 cr. (3 and 0)
Accounting systems including database concepts, systems design and evaluation, systems controls and systems implementation. **Prerequisites:** ACCT 302 and 303 or equivalent.
- ACCT 804 THE ENVIRONMENT OF ACCOUNTING
3 cr. (3 and 0)
Professional, legislative, judicial and social environments in which the accounting profession operates. **Prerequisite:** ACCT 801 or permission of instructor.
- ACCT 805 RESEARCH SEMINAR IN ACCOUNTING
1 cr. (1 and 0)
Latest developments in accounting; individual research in the student's professional area of interest. **Prerequisite:** Permission of instructor.
- ACCT 806 SEMINAR IN CURRENT ACCOUNTING PROBLEMS
3 cr. (3 and 0)
Specialized aspects of financial accounting including business combinations, accounting and reporting practices of regulated and nonregulated industries, emerging practices and developments in financial accounting, fund accounting, and corporate reorganizations and liquidations. **Prerequisite:** ACCT 302 or equivalent.
- ACCT 807 ADVANCED AUDITING II
3 cr. (3 and 0)
Application of auditing theory and standards to realistic problems faced by practicing auditors; focus is on the solution of selected auditing problems. **Prerequisite:** ACCT 802 or permission of instructor.

ACCOUNTING

- ACCT 815 FEDERAL AND STATE INCOME TAXATION OF CORPORATIONS
3 cr. (3 and 0)
Tax principles and concepts involved in corporate-shareholder transactions, tax planning of corporations, Subchapter C and related provisions of the Internal Revenue Code. **Prerequisite:** ACCT 404, 405 or equivalent.
- ACCT 816 TAXATION OF ESTATES, GIFTS AND FIDUCIARIES
3 cr. (3 and 0)
Federal estate and gift tax laws; federal income tax laws related to trusts and estates. **Prerequisite:** ACCT 404 or 405 or equivalent.
- ACCT 817 TAX PLANNING AND RESEARCH
3 cr. (3 and 0)
Tax research methodology as applied to the solution of routine and complex tax problems; emphasis is on methodology of solution rather than a specific tax area; tax planning to cover all phases of taxation—state, local, federal, income, gift, etc. **Prerequisite:** ACCT 404, 405 or equivalent.
- ACCT 818 TAXATION OF PARTNERSHIPS
3 cr. (3 and 0)
Tax principles and concepts involved in partnership transactions, tax planning and tax shelters. **Prerequisite:** ACCT 404, 405 or equivalent.
- ACCT 819 SPECIAL TOPICS IN TAXATION
3 cr. (3 and 0)
Specialized and contemporary topics in federal taxation and tax practice. **Prerequisite:** ACCT 404, 405 or equivalent.
- ACCT 821 CONTROLLERSHIP
3 cr. (3 and 0)
Advanced internal accounting emphasizing accounting implications for management decision making. **Prerequisite:** ACCT 303, 307 or equivalent, or permission of instructor.
- ACCT 822 MANAGEMENT ACCOUNTING IN TEXTILES AND
MANUFACTURING
3 cr. (3 and 0)
Techniques and problems related to accounting for products in manufacturing organizations with particular emphasis on textiles. **Prerequisite:** ACCT 821.
- ACCT 823 MANAGEMENT ACCOUNTING IN FINANCIAL INSTITUTIONS
3 cr. (3 and 0)
Elements necessary for an accounting system designed to measure and control costs in the setting of a depository financial institution. **Prerequisite:** ACCT 821.
- ACCT 840 INTERNAL AUDITING SEMINAR
3 cr. (3 and 0)
Advanced topics in internal auditing theory and practice, using case studies and readings. **Prerequisite:** ACCT 440 or 415 or equivalent.

BUSINESS ADMINISTRATION

Dudley W. Blair, Director*

Major	Degree
Business Administration	M.B.A.

The Master of Business Administration degree program is designed for the study of advanced concepts of business, industry and government operations. The program is intended for both the active manager or technical supervisor as well as the recent graduate interested in advanced business study.

Classes in the M.B.A. program are offered on both the Clemson University campus, as primarily a full-time, daytime program, and the campus of Furman University in Greenville, S.C., as a part-time, evening program. A limited number of classes are offered also on the campus of Lander College in Greenwood, S.C., as evening classes for part-time students. Separate fee structures apply to the Furman and Lander sites. (See page 26.)

Requirements for the M.B.A. degree include 30 semester hours of graduate credit beyond the bachelor's degree. Certain prerequisite courses are required of all students. In most instances, individuals with an undergraduate business degree will have completed the necessary prerequisite courses. Students who have completed the prerequisite courses may begin taking advanced courses during the fall, spring or summer sessions.

The prerequisite courses, or their equivalents listed below taken at another acceptable institution, are required of all students.

Principles of Accounting and Control Systems
 Statistics
 Principles of Economics
 Business Management and Organization
 Business or Corporate Finance
 Principles of Marketing
 Legal and Social Environment of Business
 Management Information Systems
 Calculus

The advanced courses MBA 802, 803, 804, 806, 807, 808, 809 and 810 form the core of the program and are required of all candidates for this degree. Six credit hours of electives also are required and should be chosen from the remaining courses or from certain other graduate courses in the business field chosen with approval of the MBA Director.

MBA 801 RESEARCH AND COMMUNICATIONS
 3 cr. (3 and 0)
 Concept of systems, as related to the flow of communications, examined as a means of improving the decision-making process; library and field research is stressed.

* Correspondence for the evening program on the Furman University campus should be addressed to Director, Clemson MBA Program, 119 Furman Hall, Furman University, Greenville, S.C. 29613; or call (803) 294-2090. Correspondence for the daytime program on the Clemson campus as well as for classes at Lander College should be addressed to Director, Clemson MBA Program, College of Commerce and Industry, 124 Sistine Hall, Clemson University, Clemson, S.C. 29634; or call (803) 656-3975. Information on the classes at Lander College can be obtained by calling (803) 229-8787.

- MBA 802 **MANAGERIAL ECONOMICS**
 3 cr. (3 and 0)
 Intensive study of the functioning of the market economy with emphasis on the role of prices in determining the allocation of resources, the functioning of the firm in the economy and forces governing the production of economic goods; emphasis is on using economic analysis in managerial decision making. **Prerequisites:** Economic principles and basic statistics.
- MBA 803 **STATISTICAL ANALYSIS OF BUSINESS OPERATIONS**
 3 cr. (3 and 0)
 The role of statistical inference in the decision making of business managers; emphasis is on techniques and proper applications of modern statistical methods in business and on univariate and multivariate analysis, including analysis of variance, regression and covariance; sample theory and design, basic experimental designs and time series analysis. **Prerequisite:** Basic statistics.
- MBA 804 **MANAGERIAL ACCOUNTING AND INFORMATION SYSTEMS**
 3 cr. (3 and 0)
 Preparation, analysis, interpretation and use of accounting information in the guidance and control of a business enterprise; case material and problems are used. **Prerequisites:** Principles of accounting and a demonstrated proficiency in basic finance.
- MBA 805 **LEGAL AND SOCIAL ENVIRONMENT OF BUSINESS**
 3 cr. (3 and 0)
 Interaction between business and the social, political and legal order; through analysis of particular situations, attention is focused on the broad effects of the total environment on the administration of business enterprise.
- MBA 806 **OPERATIONS MANAGEMENT**
 3 cr. (3 and 0)
 Analytical methods as applied to business and industrial problems; basic mathematical and statistical models useful to management decision making in the functions of production, marketing, finance and general management are developed; emphasis is on the development and application of deterministic and probabilistic models to problems in forecasting, production scheduling, inventory, maintenance, queuing, plant location, product lines, line balancing, critical path methods and simulation. **Prerequisites:** MBA 803 and a demonstrated proficiency in basic management.
- MBA 807
 (FIN 807) **FINANCIAL MANAGEMENT**
 3 cr. (3 and 0)
 Theory of financial management as it relates to the financial problems faced by business concerns; concepts developed are used to assess the validity of emerging formalized techniques for improving decision making in the financial area. Topics include financial planning, short- and long-term fund raising, capital budgeting, the administration of working capital, recapitalization, listing of securities and reorganization. Case material and problems are used. **Prerequisite:** Principles of accounting.

- MBA 808 **MANAGERIAL PROBLEMS IN MARKETING**
 3 cr. (3 and 0)
 Major decisions facing marketing executives and top management in their attempt to harmonize the objectives and resources of the organization with the opportunities found in the marketplace; emphasizes recent theoretical developments in marketing and related disciplines and their application in management. Readings, case analysis and discussions are used. **Prerequisite:** Principles of marketing.
- MBA 809
 (MGT 809) **ORGANIZATION THEORY AND BEHAVIOR**
 3 cr. (3 and 0)
 Advanced consideration of theories and models as they apply to managing individual and work group behavior in organizations. Topics include leadership, decision making, motivation, power, conflict, communication, job design and group processes. **Prerequisite:** Graduate standing.
- MBA 810 **MANAGERIAL POLICY**
 3 cr. (3 and 0)
 Decisions involved in the establishment of managerial policy; problems, resources and alternative courses of action are analyzed and discussed relative to the selection of company objectives and the most feasible means for achieving company goals; integrates material and treats the coordination of the affairs of the firm as a whole. Case studies are emphasized. This course should be completed as the final course in the program.
- MBA 811 **INTERNATIONAL BUSINESS MANAGEMENT**
 3 cr. (3 and 0)
 Survey and analysis of economic, managerial and financial aspects of U.S. firms operating abroad, including the impact of U.S. and foreign government policies on management. Case studies of specific companies operating abroad are discussed. **Prerequisite:** Advanced standing.
- MBA 812
 (FIN 812) **FINANCIAL MARKETS AND INSTITUTIONS**
 3 cr. (3 and 0)
 Financial institutions and markets with primary focus on financial markets and instruments; the goal is to familiarize students with the pricing of financial instruments and the manners by which market participants use these instruments. **Prerequisite:** MBA 807/ FIN 807 or permission of instructor.
- MBA 813 **INDUSTRIAL RELATIONS**
 3 cr. (3 and 0)
 Relationship between management and employees, as institutions and as individuals; the role of management and unions in society; issues in labor-management relations. Topics include the issues and processes of collective bargaining, contract negotiation and administration, and dispute resolution; government regulation of labor relations is also examined.
- MBA 814 **DIRECTED RESEARCH IN QUANTITATIVE ANALYSIS**
 3 cr. (3 and 0)

BUSINESS ADMINISTRATION

- MBA 815 DIRECTED RESEARCH IN QUALITATIVE ANALYSIS
3 cr. (3 and 0)
- MBA 816 ECONOMICS OF PROPERTY RIGHTS
3 cr. (3 and 0)
Evolution and impact of various property rights institutions on individual behavior and the subsequent use of resources; particular attention is paid to the importance of property rights structures in the organization of business and in managerial decision making. **Prerequisite:** MBA 802 or equivalent.
- MBA 817 BUSINESS FORECASTING TECHNIQUES AND APPLICATIONS
3 cr. (3 and 0)
Forecasting techniques and their application for developing and assessing forecasts. Topics include economic data sources, multiple regression and time series analysis, and the interpretation of forecasts for management and other clients. **Prerequisite:** MBA 802, 803 or equivalent.
- MBA 821 BUSINESS TAXATION
3 cr. (3 and 0)
Basic tax techniques and the conceptual foundation essential to management for implementing and making decisions affecting business policies, priorities and resources.
- MBA 822 CORPORATE FINANCIAL REPORTING
3 cr. (3 and 0)
Current state of financial reporting practices and requirements, the ways financial statements and data affect the economic system, and the significance of these practices to users of financial statements.
- MBA 823 INTERNATIONAL ACCOUNTING
3 cr. (3 and 0)
Technical and nontechnical issues in international accounting. Topics include the role of international bodies in developing standards, accounting issues dealing with exports and imports, and the role of accounting and MNCs in development.
- MBA 824 THE MANAGEMENT OF SALES OPERATIONS
3 cr. (3 and 0)
The sales function as an element of marketing strategy; the field of professional sales management; concepts and tools useful to managers at different levels of the sales organization. **Prerequisite:** MBA 808.
- MBA 826 BUSINESS MARKETING
3 cr. (3 and 0)
Strategic marketing as it applies to industrial, organizational and institutional markets; consumer marketing versus business to business marketing; current business marketing literature and practices. **Prerequisite:** MBA 808.
- MBA 828 SERVICES MARKETING
3 cr. (3 and 0)
The nature of services marketing and the special requisites that distinguish successful services marketing from goods marketing. Topics

include promoting and making the service tangible, designing optimal service operations, the ideal service worker, pricing of services and critical points of services delivery. **Prerequisite:** MBA 808.

MBA 831
(FIN 831)

COMPUTER APPLICATIONS IN FINANCIAL MANAGEMENT
3 cr. (3 and 0)

Students access and use financial data bases such as the Center for Research in Security Prices (CRSP), Compustat and SEC Registered Offerings of Securities (ROS) tapes; students become familiar with various statistical packages used in econometric analysis of financial data. **Prerequisite:** MBA 807/FIN 807 or permission of instructor.

MBA 832
(FIN 832)

INTERNATIONAL FINANCIAL MANAGEMENT
3 cr. (3 and 0)

Factors that influence the financial management of the firms in an international environment. Topics include the international parity conditions, political risk and international banking. **Prerequisite:** MBA 807/FIN 807 or permission of instructor.

MBA 834
(FIN 834)

ADVANCED FINANCIAL MANAGEMENT
3 cr. (3 and 0)

Students develop financial problem-solving skills through case analysis, class discussion, reading assignments and a project. **Prerequisite:** MBA 807/FIN 807 or permission of instructor.

MBA 835
(FIN 835)

INVESTMENT MANAGEMENT
3 cr. (3 and 0)

Current techniques and strategies in the analysis of various investment alternatives; portfolio management with an introduction to options and futures markets. **Prerequisite:** Principles of accounting and a demonstrated proficiency in basic finance.

MBA 889

ORGANIZATION DESIGN AND THEORY
3 cr. (3 and 0)

Topics include structuring of organizations, external environment, goals and effectiveness, organizational change, power and politics, organization culture and other topics focusing on the total organization, as opposed to individual behavior in organizations.

MBA 890

TOPICS IN STRATEGIC MANAGEMENT
3 cr. (3 and 0)

In-depth coverage of a variety of issues facing today's executive. Topics may vary with each offering. Current relevant literature is examined and discussed in a graduate seminar environment.

MBA 895

TOPICS IN MARKETING
3 cr. (3 and 0)

In-depth study of a current topic in marketing. **Prerequisite:** MBA 808.

ECONOMICS

Michael T. Maloney, Head, Department of Economics

Major	Degrees
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, also is required. When necessary, the economic theory, mathematics and statistics courses may be taken at Clemson.

The graduate program will include at least one course in econometrics or statistics and a minimum of two courses in economic theory. Program concentrations in financial economics, labor economics, monetary economics, environmental economics, industrial organization and public sector economics have been designed for students interested in these areas. There are both thesis and nonthesis options.

Applicants to the Ph.D. program should have a strong background in economic theory and statistics. The program has required fields in these areas. Students choose two additional fields of concentration from those listed above and others supported by departments across the University.

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 609 (MGT 609)	MANAGERIAL ECONOMICS 3 cr. (3 and 0)
ECON 610	ECONOMIC DEVELOPMENT 3 cr. (3 and 0)
ECON 611 (MA SC 611)	INTRODUCTION TO ECONOMETRICS 3 cr. (3 and 0)
ECON 612	INTERNATIONAL MICROECONOMICS 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)
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 Commerce and Industry.
- ECON 751 CURRENT ISSUES IN ECONOMICS FOR TEACHERS
3 cr. (3 and 0)
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 Commerce and Industry. **Prerequisite:** ECON 200, 211 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 807 (MA SC 807) ECONOMETRIC METHODS I
3 cr. (3 and 0)
Economic models expressed as systems of equations; problems of identification, parameter estimation, measurement errors and statistical inference; techniques of simulation, forecasting, model validation and interpretation.
- ECON 808 (MA SC 808) ECONOMETRIC METHODS II
3 cr. (3 and 0)
Continuation of ECON 807; current economic models and estimation procedures. **Prerequisite:** ECON 807.
- 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.

ECONOMICS

- ECON 816 LABOR ECONOMICS
3 cr. (3 and 0)
Wage and employment theory; labor markets; labor history; 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 processes.
- 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 824 ORGANIZATION OF INDUSTRY
3 cr. (3 and 0)
The structure of markets and firms; forces that determine the size of firms and the boundaries of markets; emphasis on the behavior of firms, both singly and in concert, to exploit market positions.
- 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 826 ECONOMIC THEORY OF GOVERNMENT REGULATION
3 cr. (3 and 0)
The scope of governmental regulation in the economy of the United States, its evolution and development; emphasis on the application of the tools of economic analysis to the issues of regulated enterprise. **Prerequisite:** ECON 314 or equivalent.
- ECON 827 ECONOMICS OF PROPERTY RIGHTS
3 cr. (3 and 0)
Evolution and impact of various property rights institutions on individual behavior and the subsequent use of resources; particular attention given to the importance of property rights structures in the organization of business and in managerial decision making. **Prerequisite:** ECON 801.
- ECON 831 SEMINAR IN URBAN DEVELOPMENT ECONOMICS
3 cr. (3 and 0)
Economic analysis of development of urban areas within the 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 the 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 and 802 or permission of instructor.
- ECON 841 INTERNATIONAL FINANCE
3 cr. (3 and 0)
Financial economics of decision making in a multinational environment featuring autonomous governments and multiple currencies. Typical topics include examination of the macroeconomic problems of unemployment and inflation in an international economy, management of exchange rate risk, credit risk, political risk and taxation. **Prerequisite:** ECON 407 or equivalent.
- 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 855 FINANCIAL ECONOMICS
3 cr. (3 and 0)
Modern theory of corporate finance; basic theories of efficient markets, portfolio selection, capital asset pricing, option pricing and agency costs. **Prerequisite:** ECON 801 or permission of instructor.
- 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.
- ECON 901 PRICE THEORY
(AG EC 901) 3 cr. (3 and 0)
Neoclassical paradigm of market price and quantity; rigorous consideration of consumer behavior, the theory of the firm and market equilibrium, production and resource demands, and the supply of resources. **Prerequisite:** ECON 801 or equivalent.
- ECON 902 PRODUCTION ECONOMICS PROBLEMS
(AG EC 902) 2 cr. (2 and 0) F
See AG EC 902 for description.
- ECON 903 GENERAL EQUILIBRIUM AND WELFARE THEORY
(AG EC 903) 3 cr. (3 and 0) S
See AG EC 903 for description.

ECONOMICS

- ECON 904
(AG EC 904) SEMINAR IN RESOURCE ECONOMICS
3 cr. (3 and 0) S
See AG EC 904 for description.
- ECON 905
(AG EC 905) ADVANCED MACROECONOMIC ISSUES
3 cr. (3 and 0)
Current unsettled issues in macroeconomic analysis. Topics include disequilibrium macro models, macro models of open economies, rational expectations and its critics, government stabilization policies and the controversy surrounding the concept of Ricardian equivalence. **Prerequisite:** ECON 805 or equivalent.
- ECON 906
(AG EC 906) SEMINAR IN AREA ECONOMIC DEVELOPMENT
3 cr. (3 and 0) F
See AG EC 906 for description.
- ECON 907
(AG EC 907) AGRICULTURAL MARKETING PROBLEMS
2 cr. (2 and 0) F
See AG EC 907 for description.
- ECON 917
(AG EC 917) ADVANCED SEMINAR IN LABOR ECONOMICS
3 cr. (3 and 0)
Follow-up to ECON 816, bridging the gap between theory and modern empirical research in labor economics; emphasis on reading recent empirical research papers to understand the techniques of modern research in labor economics. **Prerequisite:** ECON 816.
- ECON 991
(AG EC 991) DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

FINANCE

Rodney H. Mabry, Head, Department of Finance

Advanced degrees are not awarded in finance. Courses are offered to meet requirements and provide electives for students in other areas.

- FIN 605 PORTFOLIO MANAGEMENT AND THEORY
3 cr. (3 and 0)
- FIN 606 STOCK OPTIONS AND FUTURES MARKETS
3 cr. (3 and 0)
- FIN 610 RESEARCH IN FINANCE
1-3 cr. (1-3 and 0)
- FIN 615 REAL ESTATE INVESTMENT
3 cr. (3 and 0)
- FIN 617 REAL ESTATE FINANCE
3 cr. (3 and 0)
- FIN 807
(MBA 807) FINANCIAL MANAGEMENT
3 cr. (3 and 0)
See MBA 807 for description.
- FIN 812
(MBA 812) FINANCIAL MARKETS AND INSTITUTIONS
3 cr. (3 and 0)
See MBA 812 for description.

- FIN 831
(MBA 831) COMPUTER APPLICATIONS IN FINANCIAL MANAGEMENT
3 cr. (3 and 0)
See MBA 831 for description.
- FIN 832
(MBA 832) INTERNATIONAL FINANCIAL MANAGEMENT
3 cr. (3 and 0)
See MBA 832 for description.
- FIN 834
(MBA 834) ADVANCED FINANCIAL MANAGEMENT
3 cr. (3 and 0)
See MBA 834 for description.
- FIN 835
(MBA 835) INVESTMENT MANAGEMENT
3 cr. (3 and 0)
See MBA 835 for description.
- FIN 836 REAL ESTATE FINANCE AND INVESTMENTS
3 cr. (3 and 0)
Practices and analysis of real estate finance and investment. Topics include real estate financing techniques, mortgage loan underwriting, real estate ownership structure and syndications, real estate taxation, and real estate investment and risk analysis. **Prerequisite:** MBA 807/FIN 807 or equivalent or permission of instructor.

INDUSTRIAL MANAGEMENT

William H. Hendrix, Head, Department of Management

Major	Degrees
Industrial Management	M.S., Ph.D.

The objective of the M.S. program in industrial management is to prepare technically or quantitatively oriented college graduates for positions of major management responsibility in industry. The program is designed to broaden career opportunities in industrial, operations or engineering management for graduates of business, engineering, science and mathematics curricula.

Requirements for the M.S. degree include a minimum of 30 semester hours of graduate work beyond the bachelor's degree. All students take a core curriculum of 21 hours in the areas of management science, statistical analysis, finance, operations management, human resources management, management research methods and management policy. Electives must be selected from the disciplines of accounting, computer science, economics, engineering, finance, management, management science, marketing, mathematical science, science or statistics. A thesis or nonthesis option is allowed.

The Ph.D. program is designed to develop a high-level management scholar capable of applying the most advanced concepts and methods of analysis and research to industrial management problems. It also provides excellent preparation for a university teaching and research career.

The Ph.D. program is a balanced program of management theory, analytical technique and research methodology. Each student is expected to show competency in three areas of study: management, production/operations analysis, and statistical analysis/research methodology. Each student must also complete a minimum of 12 semester credit hours in a specified area of concentration. Choice of an area of concentration and selection of courses within the area will be made in consultation with the student's advisory committee.

INDUSTRIAL MANAGEMENT

- MGT 602 PRODUCTION AND OPERATIONS MANAGEMENT I
3 cr. (3 and 0)
- MGT 606 LOCATION ECONOMICS
3 cr. (3 and 0)
- MGT 608 PRODUCTION AND OPERATIONS MANAGEMENT II
3 cr. (3 and 0)
- MGT 609 (ECON 609) MANAGERIAL ECONOMICS
3 cr. (3 and 0)
- MGT 615 BUSINESS STRATEGY
3 cr. (3 and 0)
- MGT 616 MANAGEMENT OF HUMAN RESOURCES I
3 cr. (3 and 0)
- MGT 618 MANAGEMENT INFORMATION SYSTEMS
3 cr. (3 and 0)
- MGT 620 DEFENSE MANAGEMENT
3 cr. (3 and 0)
- MGT 623 INTERNATIONAL BUSINESS MANAGEMENT
3 cr. (3 and 0)
- MGT 624 INTERNATIONAL TRANSPORTATION AND LOGISTICS
3 cr. (3 and 0)
- MGT 625 COMPENSATION MANAGEMENT
3 cr. (3 and 0)
- 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 PRODUCTION AND PRICING ANALYSIS
3 cr. (3 and 0)
Mathematical formulation of production and pricing theory as it applies to management decision making; analytical techniques of production and pricing analysis. **Prerequisite:** MGT 409/609 or permission of instructor.
- MGT 803 OPERATIONS MANAGEMENT
3 cr. (3 and 0)
Concepts and techniques of operations management. Topics include forecasting, aggregate planning, inventory management, scheduling and production control, project management and quality control. **Prerequisite:** MA SC 810 or equivalent.

- MGT 804** **MANAGERIAL POLICY**
3 cr. (3 and 0)
Management policy making, emphasizing determining objectives and developing sound policies for achieving them; builds upon and integrates the other graduate courses; case method is used extensively; written and oral presentation required. **Prerequisite:** MGT 803, MBA 807/FIN 807 or permission of instructor.
- 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. **Prerequisites:** MTH SC 301 and MGT 404 or equivalent.
- MGT 807** **COMPARATIVE MANAGEMENT THEORY**
3 cr. (3 and 0)
Evolution of management theory, up to and including contemporary theories; comprehensive review of the major schools of management thought, with emphasis on the area of organization theory and design. **Prerequisite:** Graduate standing.
- MGT 808** **MANUFACTURING PLANNING AND CONTROL SYSTEMS**
3 cr. (3 and 0)
Important components of a manufacturing planning and control system, emphasizing the integration of planning and control functions in a dynamic manufacturing environment; extensive hands-on work with integrated manufacturing software. **Prerequisite:** MGT 803 or permission of instructor.
- MGT 809**
(MBA 809) **ORGANIZATION THEORY AND BEHAVIOR**
3 cr. (3 and 0)
Advanced consideration of theories and models as they apply to managing individual and work group behavior in organizations. Topics include leadership, decision making, motivation, power, conflict, communication, job design and group processes. **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:** LAW 322 or equivalent 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 systems; future transportation systems and attendant problems and policies. **Prerequisite:** MGT 405/605 or permission of instructor.

- MGT 813 BUSINESS RESEARCH
3 cr. (3 and 0)
Business research to support management decision making. Topics include information collection and analysis and report preparation and presentation. Requires the use of integrated microcomputer software for the preparation of student reports. **Prerequisite:** MA SC 814 and MGT 399 or equivalent.
- MGT 815 PERSONNEL MANAGEMENT
3 cr. (3 and 0)
Personnel management activities, including recruitment, selection, training and development, performance appraisal, discipline, grievance handling, wage and salary administration, and employee benefit programs. **Prerequisite:** Graduate standing.
- MGT 817 INFORMATION SYSTEMS DESIGN AND IMPLEMENTATION
3 cr. (3 and 0)
Issues in design and implementation of computer-based information systems from the management perspective. **Prerequisite:** Permission of instructor.
- MGT 818 MANAGEMENT SUPPORT SYSTEMS
3 cr. (3 and 0)
Computer-based management support systems.
- MGT 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- MGT 903 RESEARCH ISSUES IN MATERIAL REQUIREMENTS PLANNING
3 cr. (3 and 0)
Current research issues and developments in material requirements planning (MRP); emphasis is placed on empirical research dealing with the management of production activities in an MRP environment. **Prerequisite:** MGT 803 or permission of instructor.
- MGT 904 SEMINAR IN CURRENT MANAGEMENT TOPICS
3 cr. (3 and 0)
Topics from current management literature; emphasis is on research from scholarly journals. Topics vary in keeping with developments in the literature. May be repeated with different faculty for a maximum of six credit hours. **Prerequisite:** Permission of instructor.
- MGT 905 RESEARCH METHODS
3 cr. (3 and 0)
Research methods supporting scholarly research and publication in management. Topics include theory building, hypothesis specification and testing, experimental design, measurement, sampling, research ethics and related issues. Enrollment restricted to doctoral students. **Prerequisite:** MA SC 814 or equivalent.
- 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 into practice while considering behavioral and economic aspects of the problem. **Prerequisite:** Permission of instructor.

- 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.
- 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 is on effect of model results on managerial policy decisions. **Prerequisite:** CP SC 150 or equivalent.
- MGT 915 SEMINAR IN BUSINESS-LEVEL STRATEGY FORMULATION AND IMPLEMENTATION
3 cr. (3 and 0)
Theoretical and empirical foundations of business-level strategy research, focusing on how firms compete in a particular business, including strategic typologies, the strategic management process, strategy-environment fit, organization performance, business-unit culture, and functional strategies and structure. **Prerequisite:** MGT 804.
- MGT 916 DIRECTED READINGS IN MANAGEMENT
1-3 cr. (1-3 and 0)
Directed reading and research in the student's area of interest. May be repeated for a maximum of three credit hours. **Prerequisite:** Permission of instructor.
- MGT 918 SEMINAR IN MANAGEMENT SUPPORT SYSTEMS
3 cr. (3 and 0)
Contemporary topics in decision-oriented information systems research; structure of the field, research methodologies and research opportunities. **Prerequisite:** MGT 818 or permission of instructor.
- MGT 921 SEMINAR IN THE SCIENCE AND PRACTICE OF BUSINESS AND ECONOMIC MODELING
3 cr. (3 and 0)
Current literature used as a resource for studying and analyzing selected topics important in the design and development of simulation models. Students will both lead and participate in group discussions. **Prerequisite:** MGT 913 or equivalent.
- MGT 950 SEMINAR IN CORPORATE-LEVEL STRATEGY FORMULATION AND IMPLEMENTATION
3 cr. (3 and 0)
Theoretical and empirical foundations of corporate-level strategy research, emphasizing both formulation and implementation issues, including boards of directors, decision making, diversification, strategic fit, mergers and acquisitions, divestitures, joint ventures and corporate structure. **Prerequisite:** MGT 804.

INDUSTRIAL MANAGEMENT

- MGT 952 SEMINAR IN MANUFACTURING AND OPERATIONS STRATEGY
3 cr. (3 and 0)
Emerging theoretical and empirical research showing the linkages among competitive business priorities, patterns of operations decisions and firm performance. Topics include development of operations objectives and strategies that reflect competitive priorities, and strategic operations decisions in the areas of process, capacity, facility, and planning and control systems. **Prerequisite:** MGT 804.
- MGT 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.
- H ADM 608 HOSPITAL AND HEALTH SERVICES ADMINISTRATION
3 cr. (3 and 0)
- H ADM 610 HOSPITAL INTERNSHIP
3 cr. (0 and 9)

MANAGEMENT SCIENCE

Mark A. McKnew, Program Coordinator, Department of Management

Major	Degree
Management Science	Ph.D.

The departments of 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 decision-making techniques used 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 and economics to provide a balanced offering of advanced work in each field contributing to the degree.

- MA SC 611 INTRODUCTION TO ECONOMETRICS
(ECON 611) 3 cr. (3 and 0)
- MA SC 806 REGIONAL SCIENCE METHODS
3 cr. (3 and 0)
Regional growth theory, 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.
- MA SC 807 ECONOMETRIC METHODS I
(ECON 807) 3 cr. (3 and 0)
See ECON 807 for description.
- MA SC 808 ECONOMETRIC METHODS II
(ECON 808) 3 cr. (3 and 0)
See ECON 808 for description.

- MA SC 810 FOUNDATIONS OF MANAGEMENT SCIENCE
3 cr. (3 and 0)
Management science techniques and their application to management; concepts include queuing models, problem formulation, simplex solution of linear programming problems, post-optimality analysis, transportation problems, and branch and bound integer solution techniques. Models are applied to a wide range of managerial decisions.
- MA SC 812 MANAGEMENT SCIENCE II
3 cr. (3 and 0)
Continuation of MA SC 810; dynamic, integer and nonlinear programming emphasizing applications of different types of mathematical programming to business and industrial problems. **Prerequisite:** MA SC 810 or permission of instructor.
- MA SC 814 DESIGN OF EXPERIMENTS IN BUSINESS AND MANAGEMENT
3 cr. (3 and 0)
Design and analysis of experiments with a focus on business and industrial applications. Topics range from the analysis of single-factor experimental designs through factorial experiments, multiple comparisons and confounding. Problems arising in the actual industrial environments are used to illustrate the application of the techniques and to introduce the student to major statistical software packages for the analysis of experimental data.

Management science students are required to take some of the following courses offered by various departments. Descriptions for all 800-level courses are listed under the respective departmental headings.

- MGT 801 PRODUCTION AND PRICING ANALYSIS
3 cr. (3 and 0)
- MGT 803 OPERATIONS MANAGEMENT
3 cr. (3 and 0)
- MGT 804 MANAGERIAL POLICY
3 cr. (3 and 0)
- MGT 807 COMPARATIVE MANAGEMENT THEORY
3 cr. (3 and 0)
- MGT 809
(MBA 809) ORGANIZATION THEORY AND BEHAVIOR
3 cr. (3 and 0)
- MGT 910 SEMINAR IN OPERATIONS MANAGEMENT
1-3 cr. (1-3 and 0)
- MGT 911 SEMINAR IN DECISION THEORY
1-3 cr. (1-3 and 0)
- MGT 913 MANAGEMENT SYSTEMS ANALYSIS
3 cr. (3 and 0)
- MTH SC 603 INTRODUCTION TO STATISTICAL THEORY
3 cr. (3 and 0)

MANAGEMENT SCIENCE

- MTH SC 606 SAMPLING THEORY AND METHODS
3 cr. (3 and 0)
- MTH SC 641 INTRODUCTION TO STOCHASTIC MODELS
3 cr. (3 and 0)
- MTH SC 800 PROBABILITY
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 810 MATHEMATICAL PROGRAMMING
3 cr. (3 and 0)
- MTH SC 811 NONLINEAR PROGRAMMING
3 cr. (3 and 0)
- MTH SC 813 ADVANCED LINEAR PROGRAMMING
3 cr. (3 and 0)
- MTH SC 814 NETWORK FLOWS
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 SCIENTIFIC COMPUTING
3 cr. (3 and 0)
- MTH SC 907 MULTIVARIATE ANALYSIS
3 cr. (3 and 0)

MARKETING

J. Norman Kangun, Head, Department of Marketing

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

MKT 620	PROFESSIONAL SELLING 3 cr. (3 and 0)
MKT 622	MARKETING FOR SMALL BUSINESS 3 cr. (3 and 0)
MKT 623	MARKETING COMMUNICATIONS 3 cr. (3 and 0)
MKT 624	SALES MANAGEMENT 3 cr. (3 and 0)
MKT 625	RETAIL MANAGEMENT 3 cr. (3 and 0)
MKT 626	BUSINESS MARKETING 3 cr. (3 and 0)
MKT 627	INTERNATIONAL MARKETING 3 cr. (3 and 0)
MKT 628	SERVICES MARKETING 3 cr. (3 and 0)
MKT 629	PUBLIC AND NONPROFIT MARKETING 3 cr. (3 and 0)
MKT 630	MARKETING PRODUCT MANAGEMENT 3 cr. (3 and 0)
MKT 631	MARKETING RESEARCH 3 cr. (3 and 0)
MKT 632	QUANTITATIVE MARKETING ANALYSIS 3 cr. (3 and 0)
MKT 637	GLOBAL MARKETING STRATEGIES 3 cr. (3 and 0)
MKT 638	TECHNICAL MARKETING 3 cr. (3 and 0)
MKT 650	MARKETING MANAGEMENT 3 cr. (3 and 0)
MKT 695	SEMINAR IN MARKETING 3 cr. (3 and 0)

TEXTILE AND POLYMER SCIENCE

Douglas V. Rippy, Director, School of Textiles

Major
Textile and
Polymer Science

Degree
Ph.D.

Qualification to pursue the degree is accomplished by obtaining a grade of A or B in at least three courses 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 I; TEXT 835, Textile Structures I; TEXT 866, Fiber Formation; TC 811, Polymer Science I; or TC 812, Polymer Science II.

Other courses, tailored to the individual's objectives, will be selected by the student and his or 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 also is required.

Admission to candidacy for the Ph.D. degree requires completion of written and oral comprehensive examinations. Each candidate must carry out an independent, original scientific investigation and formally report and defend the methodology, results and conclusions.

TEXTILE CHEMISTRY

Douglas V. Rippy, Director, School of Textiles

Major
Textile Chemistry

Degree
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 is normally 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 is usually chemistry, physics, engineering, life sciences or mathematics. Each candidate must complete an independent, scientific or technical investigation and formally report and defend the methodology, 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)
Fundamentals of polymer chemistry; chemistry and synthesis of monomers and polymers discussed in relation to the thermodynamics, kinetics and mechanisms of polymerization reactions emphasizing fiber-forming polymers, plastics and composite matrix materials.
- TC 812 POLYMER SCIENCE II
3 cr. (3 and 0)
Chemical structure and properties of polymers; polymer solution properties, the viscoelastic state and the crystalline morphology of polymeric materials; the current theories for describing polymer thermal transitions, molecular weight and molecular weight distributions and transport phenomena in polymeric systems, as well as interfacial phenomena.
- TC 820
(CH E 820) COMPOSITE POLYMERIC MATERIALS
3 cr. (3 and 0)
See CH E 820 for description.
- 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 840 ANALYTICAL METHODS IN TEXTILE AND POLYMER SCIENCE
3 cr. (3 and 0)
Use of chemical and physical instrumental methods to characterize polymeric materials in textile and polymer science; basic principles are discussed and the unique problems encountered when techniques such as IR, NMR, GC, LC, MS, GC/MS and thermal analysis, microscopy and tensile testing are applied to polymeric materials emphasized. **Prerequisite:** Permission of instructor.
- TC 891 MASTER'S THESIS RESEARCH
Credit to be arranged.

TEXTILE SCIENCE

Douglas V. Rippey, Director, School of Textiles

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.

The student's major area of study is usually fiber science, polymer science or textile technology. The minor area of study normally is the life or physical sciences, engineering, mathematics or management. The thesis option requires each student to complete an independent, scientific or technical investigation and formally report and defend the methodology, results and conclusions in a thesis.

The nonthesis option for the Master of Science in textile science requires a total of 36 hours of course work with a net grade point average of 3.0. The option consists of a core group of courses that totals 24 hours with 12 additional approved hours of the student's choice. Successful performance in a comprehensive oral examination also is required. This program is geared specifically to those with five years of industrial experience who are currently employed in the textile industry and who view the Master of Science as a terminal degree. Further information can be obtained from the director of the School of Textiles.

TEXT 611	FABRIC DEVELOPMENT III 3 cr. (2 and 2)
TEXT 616	NONWOVEN STRUCTURES 3 cr. (2 and 2)
TEXT 620	ADVANCED COMPUTER APPLICATIONS IN TEXTILES 3 cr. (3 and 0)
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. (2 and 3)
TEXT 660	TEXTILE PROCESSES 3 cr. (3 and 0)
TEXT 672	TEXTILE INTERNATIONAL TRADE 3 cr. (3 and 0)
TEXT 675	TEXTILE MARKETING 3 cr. (3 and 0)
TEXT 676	CARPET MANUFACTURING 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 the classroom will be translated into industrial applications by use of field trips, demonstrations and experimentation in the laboratory. Not open to students in the College of Commerce and Industry. **Prerequisite:** Permission of instructor.
- TEXT 821 FIBER PHYSICS I
3 cr. (3 and 0)
Fiber physical properties and their relationship to fiber structure; methods of investigating fiber structure and physical properties; theories of viscoelastic behavior and thermal properties, and models of fiber structure.
- TEXT 822 FIBER PHYSICS II
3 cr. (3 and 0)
Extension of TEXT 821, providing a more in-depth study of the mathematics of polymer fiber viscoelasticity and the solid state thermodynamics of polymeric systems. Topics include properties of copolymers, polymer optical and electrical properties, and radiation physics of polymers. **Prerequisites:** TEXT 821 and MTH SC 208 or permission of instructor.
- 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. **Prerequisite:** Graduate standing.
- 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, and 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 845 GEOTEXTILES AND GEOMEMBRANES IN ENGINEERING STRUCTURES
3 cr. (3 and 0)
Theory and practice of the application of textile materials used in civil engineering constructions, design methods and technological advances; fundamentals of soil mechanics and the manufacture of the textile material; testing and evaluation of the materials. **Prerequisite:** Permission of instructor.

TEXTILE SCIENCE

- TEXT 846 TEXTILE STRUCTURES II
3 cr. (3 and 0)
Recent advances in the theoretical and experimental studies on fabric structures, structural mechanics of woven, knitted and non-woven fabrics; relationship between yarn geometry and fabric structure; design of industrial fabrics and laminated structures.
Prerequisite: Permission of instructor.
- 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; interrelationships 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, nonwoven 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 EDUCATION

**ELEMENTARY AND SECONDARY EDUCATION
INDUSTRIAL EDUCATION
VOCATIONAL/TECHNICAL EDUCATION**

COLLEGE OF EDUCATION

Gordon W. Gray, Dean

The College of Education offers advanced degrees in the following areas of study:

Administration and Supervision	Secondary Education
Counseling and Guidance Services	Special Education
Elementary Education	Industrial Education
Reading	Vocational/Technical Education

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

The College of Agricultural Sciences and the College of Education cooperatively offer a Master of Agricultural Education program. However, the degree is awarded by the College of Agricultural Sciences (see page 67).

The programs in the College of Education 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 students 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 Industrial Education program requires a minimum of 30 semester hours. The Master of Education program in counseling and guidance services requires 42 hours; other Master of Education programs require at least 36 semester hours. At least half 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 or program.

The College of Education offers off-campus courses for school districts and other South Carolina agencies through the Office of Extension and Public Relations. Off-campus course schedules are published by the Office of Extension and Public Relations for fall, spring and summer offerings. In addition, courses are taught under contract with local school districts in the Clemson University service region.

ELEMENTARY AND SECONDARY EDUCATION

Richard L. Blackburn, Head, Department of Elementary and Secondary Education

Major	Degrees
Administration and Supervision	M.Ed., Ed.S.
Counseling and Guidance Services	M.Ed.
Elementary Education	M.Ed.
Reading	M.Ed.
Secondary Education	M.Ed.
Special Education	M.Ed.

Students seeking admission to the Master of Education degree programs with majors in administration and supervision, counseling and guidance services (in the areas of elementary counseling or secondary counseling), elementary education, reading, secondary education and special education should have a valid professional teacher's certificate on the appropriate level. Those seeking admission to the counseling and guidance services program in the area of higher education counseling must have at least 15 hours in education, and those interested in vocational counseling must have at least 15 hours in psychology and/or sociology. Courses in human development and learning theory, with a grade of C or better, also are required for admission.

A major in educational administration and supervision is offered to experienced teachers (at least one year) who wish to prepare as elementary school administrators, elementary school supervisors, secondary school administrators or secondary school supervisors. Appropriate scores on the Graduate Record Examination (GRE) or the Miller Analogies Test (MAT) are required. Courses are selected from four areas as prescribed by the Department of Elementary and Secondary Education.

A major in counseling and guidance services requires 42 hours and is offered to those desiring to specialize in guidance counseling in the public schools, postsecondary schools or the vocational counseling field. Degree candidates are required to complete the following:

1. a minimum of 24 hours in the area of specialization, including six hours of field experience in the area of specialization;
2. 3 to 6 hours in statistics and research; and
3. 12 to 15 hours in a field related to the area of specialization.

A major in elementary education is offered to teachers who hold professional early childhood or elementary certificates. Courses may be selected from six areas as prescribed by the Department of Elementary and Secondary Education.

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 15 and not more than 18 hours in education and a minimum of 18 hours in the area of specialization.

A major in special education is offered to those desiring specialization in the areas of mental retardation, emotional handicaps and learning disabilities. Appropriate certification is a prerequisite for admission. Courses are prescribed by the Department of Elementary and Secondary Education.

The Specialist in Education degree program in school administration consists of a minimum of 30 semester hours beyond the master's degree that must be selected from five areas as prescribed by the Department of Elementary and Secondary Education. Admission requirements include a master's degree, an administrator's certificate and appropriate GRE/MAT scores.

ED 606 PHILOSOPHY, SCHOOLING AND EDUCATIONAL POLICY
3 cr. (3 and 0)

ED 614 RECREATION AND LEISURE FOR SPECIAL POPULATIONS
(PRTM 614) 3 cr. (3 and 0)

ED 629 TEACHER AS MANAGER
3 cr. (3 and 0)

ELEMENTARY AND SECONDARY EDUCATION

- ED 631 SPECIAL INSTITUTE COURSE: EARLY CHILDHOOD EDUCATION
1-3 cr. (1-3 and 0)
- ED 632 SPECIAL INSTITUTE COURSE: ELEMENTARY SCHOOL
1-3 cr. (1-3 and 0)
- ED 633 SPECIAL INSTITUTE COURSE: SECONDARY SCHOOL
1-3 cr. (1-3 and 0)
- ED 634 SPECIAL INSTITUTE COURSE FOR COMPARATIVE STUDIES IN
EDUCATION
1-3 cr. (1-3 and 0)
- ED 635 SPECIAL INSTITUTE COURSE: CURRICULUM
1-3 cr. (1-3 and 0)
- ED 636 SPECIAL INSTITUTE COURSE: SUPERVISION AND
ADMINISTRATION
1-3 cr. (1-3 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 680 EDUCATIONAL APPLICATIONS OF MICROCOMPUTERS
(IN ED 680) 3 cr. (3 and 0)
(AG ED 680)
(COL ED 680)
- ED 682 ADVANCED EDUCATIONAL APPLICATIONS OF
(IN ED 682) MICROCOMPUTERS
(AG ED 682) 3 cr. (2 and 2)
(COL ED 682)
- ED 690 STUDENT MANAGEMENT AND DISCIPLINE
3 cr. (3 and 0)
- ED 697 AUDIOVISUAL AIDS IN EDUCATION
3 cr. (3 and 0)
- ED 700 SUPERVISING THE STUDENT TEACHER IN THE PUBLIC SCHOOL
(IN ED 700) 2-3 cr. (2-3 and 0)
Knowledge and skills desirable for supervisors of student teachers; use of observation instruments for recording objective data and evaluating teaching performance is explored. Graded on a pass/fail basis. **Prerequisite:** A professional teaching certificate, at least one year of teaching experience, a recommendation from the employing school district or consent of the instructor.
- ED 701 HUMAN GROWTH AND DEVELOPMENT
3 cr. (3 and 0)
Theory and research in human development and its impact on the teaching/learning process. **Prerequisites:** ED 334, 335, 336 or equivalent; classroom teaching experience.
- ED 702 ADVANCED EDUCATIONAL PSYCHOLOGY
3 cr. (3 and 0)
Educational applications of research and theory on objectives, motivation, class climate, class management and learning theory. **Prerequisites:** ED 302 or equivalent; classroom teaching experience recommended.
- ED 705 FOUNDATIONS OF COUNSELING AND GUIDANCE SERVICES
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
1-3 cr. (1-3 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.

ELEMENTARY AND SECONDARY 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 723 FIELD EXPERIENCE IN ELEMENTARY ADMINISTRATION AND SUPERVISION
3 cr. (1 and 6)
Practicum with an experienced elementary administrator or supervisor. **Prerequisite:** Presentation of score on NTE Test in Educational Leadership or permission of instructor.
- ED 724 FIELD EXPERIENCE IN SECONDARY ADMINISTRATION AND SUPERVISION
3 cr. (1 and 6)
Practicum with an experienced secondary administrator or supervisor. **Prerequisite:** Presentation of score on NTE Test in Educational Leadership or permission of instructor.
- ED 725 PRACTICUM IN SCHOOL SYSTEM ADMINISTRATION AND SUPERVISION
3 cr. (1 and 6)
Practicum with an experienced school-system-level administrator or supervisor. **Prerequisite:** Presentation of score on NTE Test in Educational Leadership or permission of instructor.
- 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; 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 THE PSYCHOLOGY OF POSTSECONDARY POPULATIONS
3 cr. (3 and 0)
Developmental aspects of the young adult age group and its relationship to postsecondary 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. **Prerequisite:** Graduate status.
- ED 770 **METHODS FOR SCIENCE LABORATORY INSTRUCTION**
3 cr. (3 and 0)
Methods of designing and conducting productive laboratory learning activities for the science teacher; products developed to have direct classroom application. **Prerequisite:** Undergraduate science teaching methods course or permission of instructor.
- ED 778 **EXPERIMENTAL AND NONEXPERIMENTAL RESEARCH
METHODS IN EDUCATION I**
3 cr. (3 and 0)
Types of educational research and uses; logical bases of quantitative and qualitative analysis techniques; basic research issues important in education; educational research design and procedures; introduction to measurement and evaluation; applications to special problems in classroom settings and program development; and evaluation in curriculum, administration and educational support services. **Prerequisite:** EX ST 301 or equivalent or permission of instructor; ED 808 recommended.
- 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 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 805 THE TWO-YEAR COLLEGE
3 cr. (3 and 0)
Historical developments, functions, organization and administration of the two-year college.
- ED 806 FOUNDATIONS OF COUNSELING IN THE ELEMENTARY SCHOOL
3 cr. (3 and 0)
Specialized information concerning theory and practice of elementary school counseling; opportunity to explore elementary school counseling techniques.
- ED 808 EDUCATIONAL TESTS AND MEASUREMENTS
3 cr. (3 and 0)
Construction, use and interpretation of subjective and standard tests; measurement applications.
- ED 809 ANALYSIS OF THE INDIVIDUAL
3 cr. (2 and 1)
Experience in gathering, interpreting and utilizing data as it relates to the individual. Especially significant to counselors. **Prerequisite:** ED 808 or permission of instructor.
- 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. (3 and 0)
Rationale, content and consultation process in school and non-school settings; study of and practice in various consulting activities. **Prerequisite:** ED 705 or permission of instructor.

- ED 813 EDUCATIONAL AND VOCATIONAL INFORMATION SERVICES 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 I
3 cr. (1 and 6)
Supervised field experience in counseling and other services in an elementary school. **Prerequisite:** ED 705, 810, 817 or permission of instructor.
- ED 815 FIELD EXPERIENCES IN SECONDARY SCHOOL GUIDANCE I
3 cr. (1 and 6)
Supervised field experience in counseling and other services in a secondary school setting. **Prerequisites:** ED 810 and 817.
- ED 816 FIELD EXPERIENCES IN COUNSELING IN POSTSECONDARY SETTINGS I
3 cr. (1 and 6)
Supervised field experience in counseling and other student services in a postsecondary school setting. **Prerequisite:** ED 705, 810, 817 or 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 videotaping, interviewing, lecture and discussion. **Prerequisite or Corequisite:** 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 ADVANCED COUNSELING TECHNIQUES AND STRATEGIES
3 cr. (3 and 0)
Development of in-depth counseling skills; techniques for working with a wide variety of populations and/or problems. **Prerequisites:** ED 810, 817, 871 and completion of 30 hours in a master's program in counseling or certification as a school counselor.
- 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 or ED 469/669 and 474/674 and 476/676; or ED 470/670 and 475/675.

- 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 824 SECONDARY CURRICULUM ADAPTATIONS FOR THE HANDICAPPED
 3 cr. (3 and 0)
 Designed for teachers of handicapped students in secondary schools; adaptation of curriculum and instruction to meet the needs of students with mild to moderate learning handicaps. Topics include text modification, study skills, curriculum design and mainstreaming. **Prerequisite:** ED 471/671 or permission of instructor.
- ED 825 CAREER/VOCATIONAL EDUCATION FOR THE HANDICAPPED
 3 cr. (3 and 0)
 Designed for special education teachers at the secondary level to attain the necessary competency to assist the handicapped adolescent in preparing for the world of work. **Prerequisite:** ED 471/671 or permission of instructor.
- ED 828 FIELD EXPERIENCES IN ELEMENTARY SCHOOL GUIDANCE II
 3 cr. (1 and 6)
 Additional field experiences in counseling, consulting and coordinating services for the elementary school child. **Prerequisite:** ED 705, 810, 814, 817 or permission of instructor.
- ED 829 FIELD EXPERIENCES IN SECONDARY SCHOOL GUIDANCE II
 3 cr. (1 and 6)
 Additional field experiences in counseling, consulting and coordinating services for the secondary school student. **Prerequisites:** ED 810, 815, 817 and 30 hours completed in the program.
- ED 830 TECHNIQUES OF SUPERVISION — THE PUBLIC SCHOOLS
 3 cr. (3 and 0)
 Improving, coordinating and evaluating instruction; modern trends of supervisory practices.
- ED 832 FIELD EXPERIENCES IN COUNSELING IN POSTSECONDARY SETTINGS II
 3 cr. (1 and 6)
 Additional supervised field experience in counseling and other student services in a postsecondary setting. **Prerequisite:** ED 705, 810, 816, 817 or permission of instructor.
- ED 834 EDUCATIONAL EVALUATION
 3 cr. (3 and 0)
 Evaluation theory and design applied to classroom instruction and to evaluation procedures applicable to school center and district programs and projects.

- ED 835 FIELD EXPERIENCES IN COUNSELING IN COMMUNITY AGENCY SETTINGS I
3 cr. (1 and 6)
Supervised field experiences in counseling and other services in a community agency setting. **Prerequisite:** ED 705, 810, 817 or permission of instructor.
- ED 836 FIELD EXPERIENCES IN COUNSELING IN COMMUNITY AGENCY SETTINGS II
3 cr. (1 and 6)
Additional field experiences in counseling and other agency activities. **Prerequisite:** ED 705, 810, 817, 835 or permission of instructor.
- ED 840 PROGRAM DEVELOPMENT AND IMPLEMENTATION IN EARLY CHILDHOOD EDUCATION
3 cr. (2 and 2)
Current issues in early childhood curriculum, their sources and the beliefs supporting them; design of a modified curriculum for a specific content area and level. For graduate students with teaching experience. **Prerequisites:** ED 701 and 740, relevant teaching experience, or permission of instructor.
- ED 841 ADVANCED STUDIES IN THE TEACHING OF SECONDARY SCHOOL ENGLISH
3 cr. (3 and 0)
Methods of teaching secondary school English, based on research and review of current literature.
- ED 842 ADVANCED STUDIES IN THE TEACHING OF SECONDARY SCHOOL MATHEMATICS
3 cr. (3 and 0)
Mathematics education history, research in mathematics education, knowledge of the learner, instructional strategies, materials management and evaluation. **Prerequisite:** ED 426 or permission of instructor.
- ED 843 ADVANCED STUDIES IN THE TEACHING OF SECONDARY SCHOOL SCIENCE
3 cr. (3 and 0)
Methods of science teaching theory and practice as shown by current research literature; emphasis on laboratory, inquiry and other student-centered teaching strategies; techniques in science curriculum development; issues in science teaching; science teaching leadership skills. **Prerequisite:** ED 427 or permission of instructor.
- ED 844 ADVANCED STUDIES IN THE TEACHING OF SECONDARY SCHOOL SOCIAL STUDIES
3 cr. (3 and 0)
Social studies teaching strategies derived from major theories of learning and contemporary research; curricular issues in social studies education. **Prerequisite:** ED 428 or permission of instructor.

- ED 846 THE CURRENT LITERATURE IN ENGLISH EDUCATION
3 cr. (3 and 0)
Research literature in English education; an examination of literature in research methods and curriculum in English teaching. **Prerequisite:** A methods course in English education.
- ED 847 THE CURRENT LITERATURE IN MATHEMATICS TEACHING
3 cr. (3 and 0)
Recent literature of mathematics education; examination of literature in both the research and curriculum in secondary mathematics teaching. **Prerequisite:** A graduate teaching methods course or permission of instructor.
- ED 848 THE CURRENT LITERATURE IN SCIENCE TEACHING
3 cr. (3 and 0)
Recent literature of science education; examination of literature in both the research and curriculum in secondary science teaching. **Prerequisite:** A graduate teaching methods course or permission of instructor.
- ED 849 THE CURRENT LITERATURE IN SOCIAL STUDIES TEACHING
3 cr. (3 and 0)
Recent literature in social studies education; literature in both curriculum and instruction is considered. **Prerequisite:** A graduate teaching methods course 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 851 THE PRINCIPALSHIP
3 cr. (3 and 0)
Roles and responsibilities of the principalship, including the organization and administration of schools.
- ED 852 ORGANIZATIONAL THEORY FOR SCHOOL ADMINISTRATION
3 cr. (3 and 0)
Theory of management, communication, human relations, social systems, motivation, contingency, decision-making and change. **Prerequisite:** ED 850 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 854 ADVANCED EDUCATIONAL LEADERSHIP: THEORY AND PRACTICE
3 cr. (3 and 0)
Accepted principles and theories of leadership as practiced in the institutional setting. **Prerequisites:** ED 794, 830 and 850, or permission of instructor.

- ED 855 BUSINESS MANAGEMENT IN EDUCATION
3 cr. (2 and 3)
Fiscal management of individual schools and districts, including budgeting, purchasing and accounting for funds. **Prerequisites:** ED 721, 811 and 850, 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 857 SELECTED TOPICS IN EDUCATIONAL ADMINISTRATION
1-3 cr. (1-3 and 0)
Current literature and results of current research. Topics vary from year to year. May be repeated for a maximum of six credits.
- 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 is 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 762, and/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. **Prerequisite:** ED 759, 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 868 TEACHING READING THROUGH A LITERATURE EMPHASIS
3 cr. (3 and 0)
Strategies for integrating literature into the traditional reading program. **Prerequisite:** An introductory reading class or equivalent.
- ED 869 THE READING-WRITING CONNECTION: AN INTEGRATED APPROACH
3 cr. (3 and 0)
Theoretical bases and practical techniques for teaching reading and writing in an integrated manner; reading and writing as processes; Basic Skills instruction in a coordinated program; multiple subject areas; use of student interest and ability. **Prerequisite:** Basic reading methods course.
- ED 871 INTERPERSONAL AND GROUP RELATIONSHIPS
3 cr. (3 and 0)
Experience as a member of a group to aid the student in understanding group dynamics and the role of a group member as a participant and facilitator; emphasis is on small group participation, communication skills and self-understanding.
- ED 875 SEMINAR IN HUMAN GROWTH AND DEVELOPMENT
3 cr. (3 and 0)
Selected topics in human development from any area of the life span; development topics examined for their impacts on the teaching/learning process, administrative processes and/or counseling approaches. **Prerequisites:** ED 701 or equivalent and teaching, counseling or administrative experience.
- ED 876 SEMINAR IN LEARNING THEORY AND ENVIRONMENTS
3 cr. (3 and 0)
Selected topics in learning theory and variables affecting learning environments. Topics vary with student interests and needs and for their impacts on the teaching/learning process, administrative processes and/or counseling approaches. **Prerequisites:** ED 702 or equivalent and classroom, counseling or administrative experience.
- ED 878 EXPERIMENTAL AND NONEXPERIMENTAL RESEARCH METHOD IN EDUCATION II
3 cr. (3 and 0)
Advanced concepts and skills necessary to analyze, conduct and evaluate educational research; nonexperimental, quasi-experimental and experimental design specific to problems in educational research; complementary educational research methods involving qualitative approaches; coding and computer analysis of sample data; summarization and interpretation of data; applications of measurement and evaluation in educational research. **Prerequisite:** ED 778, 808 and EX ST 801, or equivalent.
- ED 879 QUALITATIVE RESEARCH IN EDUCATION
3 cr. (3 and 0)
Application of qualitative studies to educational questions; examination of the nature of qualitative research; examination of rationale and applications of qualitative research methods; particular attention is given to integration of qualitative and quantitative research methods in educational research. **Prerequisite:** ED 778, 878 or equivalent.

- ED 881 **INDIVIDUAL TESTING I**
3 cr. (3 and 0)
Interpretation of Wechsler scales with supervised practice in their administration. **Prerequisites:** ED 701, 702, 808, 809 and permission of instructor.
- ED 882 **PSYCHOEDUCATIONAL EVALUATOR INTERNSHIP I**
3 cr. (0 and 6)
Supervised practical work in a school psychology setting for psychoeducational evaluators, school psychologists and counselors. Students complete 300 hours of practical work with a certified school psychologist. **Prerequisite:** Open only to those seeking certification as a school psychologist or counselor.
- ED 883 **PSYCHOEDUCATIONAL EVALUATOR INTERNSHIP II**
3 cr. (0 and 6)
Practical work in a school psychology setting for psychoeducational evaluators, school psychologists and counselors. Students complete 300 hours of practical work with a certified school counselor. **Prerequisite:** Open only to those seeking certification as a school psychologist or counselor.
- ED 884 **SCHOOL PSYCHOLOGY**
3 cr. (3 and 0)
Roles and function of the school psychologist, legal/ethical issues; planning and evaluating school psychology service delivery systems; specialized practice procedures to evaluate learning and behavior problems. **Prerequisites:** ED 701 or 702, and ED 808 or 809, and permission of instructor.
- ED 885 **INDIVIDUAL TESTING II**
3 cr. (3 and 0)
Training in administering and interpreting individual tests to assess exceptional children; tests studied extend beyond the basic historical battery of intelligence, achievement and learning modalities tests; tests of recent development also covered. **Prerequisite:** ED 881.
- ED 886 **INDIVIDUAL TESTING III — PROJECTIVE TECHNIQUES WITH STUDENTS**
3 cr. (3 and 0)
Training in administering and interpreting individually administered projective techniques to assess abnormal personality factors in students referred for possible placement in special education classes for the emotionally handicapped. **Prerequisites:** ED 881 and 885.
- ED 887 **PSYCHOEDUCATIONAL INTERNSHIP III — PROJECTIVE TECHNIQUES**
3 cr. (1 and 6)
Training and supervised field work in administering and interpreting projective techniques to assess personality and adjustment problems in referred emotionally handicapped students in schools; 400 hours of supervision required. **Prerequisites:** ED 881, 882, 883, 885 and 886.

ELEMENTARY AND SECONDARY EDUCATION

- ED 889 RESEARCH IN EDUCATION
IN ED 889) 3 cr. (3 and 0)
(AG ED 889) See AG ED 889 for description.
- ED 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
Student participates in a new or existing research project with a faculty member; develops basic skills in a selected research methodology. **Prerequisite:** Advanced methods course, ED 808, 889, or permission of instructor.
- ED 894 DIRECTED RESEARCH
1-4 cr. (1-4 and 0)
Research option for graduate students wishing to pursue a line of inquiry in education under the direction of faculty; specific educational question is investigated and reported using appropriate methodology. Graded on a pass/fail basis. May be repeated for a total of 4 hours. **Prerequisite:** Advanced methods course, ED 808 or 809 or 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 Commerce and Industry, the College of Liberal Arts and the College of Sciences.

English

C. Harold Woodell, Advisor

- ENGL 700 CHILDREN'S LITERATURE FOR TEACHERS
3 cr. (3 and 0)
- ENGL 701 LITERATURE FOR TEACHERS
3 cr. (3 and 0)

History and Government

Donald G. Nieman, Advisor

- HIST 700 UNITED STATES THROUGH THE CIVIL WAR
3 cr. (3 and 0)
- HIST 710 UNITED STATES SINCE 1865
3 cr. (3 and 0)
- HIST 720 SOUTHERN HISTORY
3 cr. (3 and 0)
- HIST 760 BRITISH HISTORY
3 cr. (3 and 0)
- HIST 770 EUROPE TO THE 18TH CENTURY
3 cr. (3 and 0)
- HIST 775 EUROPE SINCE THE 18TH CENTURY
3 cr. (3 and 0)

- HIST 790 HISTORICAL AREA STUDIES
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

William R. Hare, Advisor

- MTH SC 700 MATHEMATICAL COMPUTER APPLICATIONS FOR ELEMENTARY
TEACHERS
3 cr. (3 and 0)
- 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 707 MATHEMATICS FOR MIDDLE SCHOOL TEACHERS — ALGEBRA
3 cr. (3 and 0)
- MTH SC 709 MATHEMATICS FOR MIDDLE SCHOOL TEACHERS — GEOMETRY
3 cr. (3 and 0)
- MTH SC 710 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT I
3 cr. (3 and 0)
- MTH SC 711 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT II
3 cr. (3 and 0)
- MTH SC 712 MODERN ALGEBRAIC CONCEPTS
3 cr. (3 and 0)
- MTH SC 715 ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS
3 cr. (3 and 0)
- MTH SC 719 DISCRETE MATHEMATICS
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)

ELEMENTARY AND SECONDARY EDUCATION

- MTH SC 723 APPLICATIONS OF LINEAR AND MODERN ALGEBRA
3 cr. (3 and 0)
- MTH SC 725 COMBINATORIAL MATHEMATICS FOR TEACHERS
3 cr. (3 and 0)
- MTH SC 727 ANALYSIS CONCEPTS FOR TEACHERS I
3 cr. (3 and 0)
- MTH SC 728 ANALYSIS CONCEPTS FOR TEACHERS II
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 761 PROBABILITY AND STATISTICS FOR TEACHERS
3 cr. (3 and 0)
- MTH SC 771 NUMERICAL METHODS IN SECONDARY SCHOOL MATHEMATICS I
3 cr. (3 and 0)
- MTH SC 772 NUMERICAL METHODS IN SECONDARY SCHOOL 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

Thomas 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)
- ASTR 730 EARTH SCIENCE V: ASTRONOMY FOR SCIENCE TEACHERS
3 cr. (3 and 0)

- ASTR 731 EARTH SCIENCE VI: SPECIAL TOPICS IN ASTRONOMY
1 cr. (0 and 2)
- ASTR 732 ASTRONOMY FOR EARTH SCIENCE TEACHERS
3 cr. (3 and 0)
- BIOL 700 CLASSICAL GENETICS
1 cr.
- BIOL 701 THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM I
1 cr.
- BIOL 702 ECOLOGY
1 cr.
- BIOL 703 SURVEY OF THE KINGDOMS MONERA, PROTISTA AND FUNGI
1 cr. SS
- BIOL 704 ANALYTICAL THINKING IN BIOLOGY
1 cr.
- BIOL 705 PUBLIC HEALTH MICROBIOLOGY
1 cr.
- BIOL 706 BASIC METHODS OF PRESERVING VERTEBRATES FOR
TEACHING COLLECTIONS
1 cr. (1 and 0)
- BIOL 707 PREPARATION OF PLANTS FOR PERMANENT TEACHING
COLLECTIONS
1 cr. (1 and 0)
- BIOL 708 FOOD MICROBIOLOGY
1 cr. (1 and 0)
- BIOL 709 BIOLOGICAL MICROSCOPY AND MICROTECHNIQUES
1 cr.
- BIOL 710 SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN BIOLOGY
1-6 cr. (0-6 and 0-18)
- BIOL 711 CONCEPTUAL THEMES IN BIOLOGY
3 cr. (2 and 2)
- BIOL 731 THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM II
1 cr.
- BIOL 732 MICROECOSYSTEMS IN THE CLASSROOM
1 cr.
- BIOL 733 THE BRAIN, NERVOUS SYSTEM AND SENSE ORGANS
1 cr.
- BIOL 734 THE PHYSIOLOGY OF RESPIRATION
1 cr.

ELEMENTARY AND SECONDARY EDUCATION

BIOL 761	THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM III 1 cr.
BIOL 762	HUMAN GENETICS 1 cr.
BIOL 763	FUNDAMENTAL IMMUNOLOGY AND SEROLOGY IN PUBLIC HEALTH 1 cr.
BIOL 764	MODERN MOLECULAR GENETICS 1 cr.
BOT 701	EVOLUTIONARY BOTANY FOR TEACHERS 3 cr. (2 and 3) S, SS
BOT 702	MODERN BOTANICAL CONCEPTS FOR TEACHERS 3 cr. (3 and 0) F, SS
CH 700	PHYSICAL SCIENCE IN ELEMENTARY SCHOOL — CHEMISTRY 3 cr. (2 and 3)
CH 701	REVIEW OF GENERAL CHEMISTRY 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: GEOLOGY FOR SCIENCE TEACHERS 3 cr. (2 and 3)
GEOL 711	EARTH SCIENCE II: SPECIAL TOPICS IN GEOLOGY FOR SCIENCE TEACHERS 1 cr. (0 and 2)
GEOL 740	EARTH/SPACE SCIENCE FOR ELEMENTARY SCHOOL TEACHERS 3 cr. (2 and 3)
GEOL 790	SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN EARTH SCIENCES 1-6 cr. (0-6 and 0-18)
NUTR 706	NUTRITION FOR TEACHERS 3 cr. (3 and 0) SS
PHYS 703	MODERN PHYSICS FOR HIGH SCHOOL TEACHERS 3 cr. (3 and 0)
PHYS 710	SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN PHYSICS 1-6 cr. (0-6 and 0-18)

- PHYS 711 ORIGINS OF PHYSICAL SCIENCE
3 cr. (3 and 0)
- PHYS 716 EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS
4 cr. (2 and 4)
- PHYS 720 EARTH SCIENCE III: METEOROLOGY AND OCEANOGRAPHY FOR SCIENCE TEACHERS
3 cr. (3 and 0)
- PHYS 721 EARTH SCIENCE IV: SPECIAL TOPICS IN METEOROLOGY FOR SCIENCE TEACHERS
1 cr. (0 and 2)
- PHYS 723 WEATHER SCIENCE FOR SCIENCE TEACHERS
3 cr. (3 and 0)
- ZOOL 701 MAN'S IMPACT ON ECOLOGY
3 cr. (3 and 0) SS

These courses in coaching education are offered by the Department of Elementary and Secondary Education for recertification or as electives.

- C ED 711 MEASUREMENT AND EVALUATION IN SPORTS
3 cr. (3 and 0)
Administering, scoring and developing evaluation tools; prescriptions based on evaluative information as it relates to sports training.
- C ED 712 ORGANIZATION AND ADMINISTRATION OF PHYSICAL EDUCATION AND ATHLETIC PROGRAMS
3 cr. (3 and 0)
Policies and procedures of administration on the secondary and collegiate levels; special emphasis on construction and care of facilities, equipment and personnel.
- C ED 751 PHYSIOLOGY OF TRAINING THE ATHLETE
3 cr. (3 and 0)
Specific sport skill training; emphasis is on the design of exercise programs for the particular sport.
- C ED 752 ADVANCED SKILL ANALYSIS IN SPORTS
3 cr. (3 and 0)
Application of the basic laws of physics to human movement; student uses videotapes to break down sports skill and make recommendations for improvement.
- C ED 753 ATHLETIC INJURIES: PREVENTION, ASSESSMENT AND REHABILITATION
3 cr. (3 and 0)
Prevention, treatment and rehabilitation techniques of athletic injuries.
- C ED 762 PSYCHOLOGICAL BASIS OF COACHING
3 cr. (3 and 0)
Psychological theory and techniques that enhance the performance and personal growth of athletes from youth sports to the elite levels.

These courses are offered by the College of Education.

COL ED 680 EDUCATIONAL APPLICATIONS OF MICROCOMPUTERS
 (ED 680) 3 cr. (3 and 0)
 (AG ED 680)
 (IN ED 680)

COL ED 682 ADVANCED EDUCATIONAL APPLICATIONS OF
 (ED 682) MICROCOMPUTERS
 (AG ED 682) 3 cr. (2 and 2)
 (IN ED 682)

INDUSTRIAL EDUCATION

D. Henry Pate, Jr., Head, Department of Industrial Education

Major	Degree
Industrial Education	M.In.Ed.

The Master of Industrial Education degree allows for specialization in five areas: industrial technology education, vocational/technical education, administration and supervision for the two-year college, human resources development (HRD) and graphic communications.

Sufficient flexibility is permitted to structure each student's plan of study to meet the objectives for any of the five areas of specialization listed above. The industrial technology area is designed to enhance competencies in teaching industrial technology and prevocational and career education. Those who want to improve their competency in teaching and administering vocational or technical subjects in secondary or postsecondary institutions will specialize in the vocational/technical area. 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. The human resources development area is designed to prepare training directors, educational specialists, training coordinators and personnel for HRD occupations in industry. Graphic communications specialists pursue technical and professional study to enter careers in printing management, sales and technical teaching in postsecondary graphic communications programs.

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 technology education applicants must hold or meet the minimum requirements for an industrial arts (or technology) 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 HRD program requires a minimum of 24 hours of undergraduate courses or work experience appropriate to the occupation or industrial specialty the applicant desires to enter.

5. Graphic communications specialists must have a technical background in one or more phases of graphic communications or complete a specified sequence of prerequisite courses.

Candidates for the Master of Industrial Education degree are required to complete the following:

1. eighteen hours in subjects that contribute to the student's technical, administrative and/or supervisory competence;
2. six hours in research or six hours in special problems; and
3. six to twelve hours taken outside the major department.

IN ED 604	ORGANIZATION OF INDUSTRIAL TRAINING MATERIALS 3 cr. (3 and 0)
IN ED 605	COURSE ORGANIZATION AND EVALUATION 3 cr. (3 and 0)
IN ED 607	ARCHITECTURAL DRAFTING FOR INDUSTRIAL EDUCATION 3 cr. (1 and 6)
IN ED 608	TRAINING PROGRAMS IN INDUSTRY II 3 cr. (3 and 0)
IN ED 610	SPECIAL INSTITUTE COURSE: TOPICS IN INDUSTRIAL EDUCATION 1-3 cr. (1-3 and 0)
IN ED 612	COMMUNICATIONS TECHNOLOGY II: SYSTEMS 3 cr. (2 and 2)
IN ED 614	ELECTRONICS FOR TEACHERS 3 cr. (1 and 6)
IN ED 615	CONSTRUCTION TECHNOLOGY II: PRACTICES AND SYSTEMS 3 cr. (2 and 3)
IN ED 618	MANUFACTURING TECHNOLOGY II: MATERIALS AND PROCESSES 3 cr. (2 and 3)
IN ED 622	HISTORY AND PHILOSOPHY OF INDUSTRIAL AND VOCATIONAL EDUCATION 3 cr. (3 and 0)
IN ED 624	SCHOOL SAFETY 3 cr. (3 and 0)
IN ED 625	TEACHING INDUSTRIAL SUBJECTS 3 cr. (3 and 0)
IN ED 632	ADVANCED WOODWORKING 2 cr. (1 and 3)

INDUSTRIAL EDUCATION

- IN ED 635 ADVANCED INDUSTRIAL METALWORKING PRACTICES
3 cr. (2 and 3)
- IN ED 638 ADVANCED MACHINING
3 cr. (1 and 6)
- IN ED 642 COMPETENCY TESTING IN VOCATIONAL SUBJECTS
3 cr. (3 and 0)
- IN ED 643 VOCATIONAL SPECIAL NEEDS EDUCATION
3 cr. (3 and 0)
- IN ED 652 ADVANCED PROJECTS
1-6 cr.
- IN ED 660 INTRODUCTION TO CAREER EDUCATION
3 cr. (3 and 0)
- IN ED 664 STILL MEDIA PRODUCTION
3 cr. (1 and 4)
- IN ED 665 INSTRUCTIONAL VIDEO PRODUCTION
3 cr. (1 and 4)
- IN ED 668 POWER TECHNOLOGY II: TRANSMISSION AND CONTROL
SYSTEMS
3 cr. (2 and 2)
- IN ED 670 INTERNAL COMBUSTION ENGINES
3 cr. (2 and 3)
- IN ED 680 EDUCATIONAL APPLICATIONS OF MICROCOMPUTERS
(ED 680) 3 cr. (3 and 0)
(COL ED 680)
(AG ED 680)
- IN ED 682 ADVANCED EDUCATIONAL APPLICATIONS OF
(ED 682) MICROCOMPUTERS
(COL ED 682) 3 cr. (2 and 2)
(AG ED 682)
- IN ED 696 PUBLIC RELATIONS
3 cr. (3 and 0)
- IN ED 700 SUPERVISING THE STUDENT TEACHER IN THE PUBLIC SCHOOL
(ED 700) 2-3 cr. (2-3 and 0)
See ED 700 for description.
- IN ED 815 SEMINAR IN INDUSTRIAL EDUCATION
1 cr. (1 and 0)
Students and faculty discuss and study new technological and pro-
fessional advances. May be taken up to three times. Graded on a
pass/fail basis.

- IN ED 820 RECENT PROCESS DEVELOPMENTS
3 cr. (3 and 0)
Recent technological innovations, inventions, processes and products, and their impact on our industrial, labor, educational and social institutions.
- IN ED 830 CONCEPTS OF HUMAN RESOURCES DEVELOPMENT
3 cr. (3 and 0)
Theory and practice of contemporary applications of human resources development (HRD) programs; training and development functions; strategies for designing and developing programs; and application of methods, techniques and resources in the context of changing needs, technologies, demographics and economic circumstances that create the need for different skills and knowledge in the work force. **Prerequisite:** Permission of instructor.
- 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 NEEDS ASSESSMENT FOR EDUCATION AND INDUSTRY
3 cr. (3 and 0)
Theory and practice of needs assessment activities in human resource development (HRD) programs; importance of the process to the identification of content/curricula topics and the overall training environment; specific methodologies used in the needs assessment process; supportive components of various program planning systems.
- IN ED 846 APPLIED PUBLIC RELATIONS
3 cr. (3 and 0)
Practical and theoretical approaches to problem identification and the development of respective solutions in the public relations process; action and message generation, media development and evaluation of public relations techniques in existing organizations. **Prerequisites:** Employment or ready access to an employer and place of employment; IN ED 496 or 696 is desirable.
- IN ED 847 INSTRUCTIONAL SYSTEMS DESIGN
3 cr. (3 and 0)
Theory and practice of instructional systems development activities in human resource development (HRD) programs; identification, selection and organization of subject matter appropriate for competency-based training (CBT) programs; occupational analysis techniques; rationale statements, goals and objectives; related instructional materials; participant evaluation; and instructional scheduling. **Prerequisite:** Permission of instructor.
- IN ED 849 EVALUATION OF TRAINING AND DEVELOPMENT/HRD PROGRAMS
3 cr. (3 and 0)
Theory and practice of evaluation processes related to training and development in human resource development (HRD) programs; developing a results-oriented approach based on specific criteria or standards; designing instruments; determining program costs; and collecting, analyzing and interpreting data to ascertain return on investment. **Prerequisite:** Permission of instructor.

INDUSTRIAL EDUCATION

- IN ED 850 ISSUES IN INDUSTRIAL TECHNOLOGY
1-3 cr. (1-3 and 0)
Industrial technology for public school teachers and individuals employed in business and industry; emphasis is on emerging technologies and innovations in instructional strategies. **Prerequisite:** Graduate status.
- IN ED 851 CURRENT TOPICS IN COMMUNICATION TECHNOLOGY
1-3 cr. (1-3 and 0)
Recent technological processes in the communication industry, such as CAD, desktop publishing and interactive video, for teachers and industrial personnel. **Prerequisite:** Graduate status.
- IN ED 852 CURRENT TOPICS IN MANUFACTURING TECHNOLOGY
1-3 cr. (1-3 and 0)
Contemporary manufacturing practices for public school teachers and industry personnel.
- IN ED 853 CURRENT TOPICS IN CONSTRUCTION TECHNOLOGY
1-3 cr. (1-3 and 0)
Update for teachers in industrial technology education programs at the secondary level, instructors in construction-related programs at the postsecondary level and industrial trainers in the private sector; emphasis is on contemporary technological processes in construction industries.
- IN ED 854 CURRENT TOPICS IN POWER TECHNOLOGY
1-3 cr. (1-3 and 0)
Contemporary applications of power and energy for public school teachers and industry personnel.
- IN ED 860 INSTRUCTIONAL MATERIALS DEVELOPMENT
3 cr. (3 and 0)
Development and application of instructional materials and laboratory activities for training programs in education and industry; reinforcement of instructional training concepts and materials development procedures that are applied across human resource development (HRD) programs.
- 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; industrial plant visits supplement study of industrial organization, economics, management, production and products.
- IN ED 870 CONSULTING FOR EDUCATION AND INDUSTRY
3 cr. (3 and 0)
Theory and practice of external and internal consulting practices in human resources development (HRD) programs; dynamics of a

professional helping relationship; methods and techniques for initiating and terminating consulting relationships; diagnosing client situations; identification, selection and implementation of alternative problem solutions; evaluation of professional consulting relationships. **Prerequisite:** Permission of instructor.

- IN ED 889 RESEARCH IN EDUCATION
(ED 889) 3 cr. (3 and 0)
(AG ED 889) See AG ED 889 for description.
- 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.
- GC 606 PROBLEMS IN SPECIALTY PRINTING
4 cr. (2 and 6)
- GC 607 ADVANCED FLEXOGRAPHIC METHODS
4 cr. (2 and 6)
- GC 640 ADVANCED LITHOGRAPHIC METHODS
4 cr. (2 and 4)
- GC 644 CURRENT DEVELOPMENTS AND TRENDS IN GRAPHIC COMMUNICATIONS
4 cr. (2 and 6)
- GC 645 ADVANCED SCREEN PRINTING METHODS
3 cr. (2 and 3)
- GC 646 INK AND SUBSTRATES
3 cr. (2 and 3)
- GC 648 PLANNING AND CONTROLLING PRINTING FUNCTIONS
3 cr. (3 and 0)
- GC 801 PROCESS CONTROL IN COLOR REPRODUCTION
3 cr. (2 and 3)
Emphasis on techniques and rationale for procedures used in reproducing color originals for printed media. Topics include color systems, measurement, reproduction characteristics, proofing systems, process evaluation/analysis for offset, flexographic, gravure and screen printing processes. **Prerequisite:** GC 444 or equivalent.

VOCATIONAL/TECHNICAL EDUCATION

D. Henry Pate, Jr., Head, Department of Industrial Education

Major	Degree
Vocational/Technical Education	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, public schools, industry and vocationally related agencies.

Areas of specialization are available in the following fields:

1. Administration — technical colleges and public schools.
2. Curriculum and Instruction — technical colleges, industry and public schools. Emphasis is on curriculum development, materials and instructional technologies, and human resources development.
3. Guidance — technical colleges, public schools and vocational agencies.
4. 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 or 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 service, and a dissertation.

VT ED 810	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 812	VOCATIONAL AND TECHNICAL PROGRAM FINANCE 3 cr. (3 and 0) National, state and local legislation governing financial support of vocational/technical programs; development of budget, audit, and financial administrative plans and systems. Prerequisites: VT ED 810 and ED 811 or equivalent.
VT ED 833	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 835 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 850 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 861 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 810 or permission of instructor.
- VT ED 863 ADULT AND CONTINUING EDUCATION
3 cr. (3 and 0)
Theory and practice of the philosophical, sociological and psychological aspects of adult and continuing education in America; the role of secondary and postsecondary public education; the role of human resource development in industrial settings; practices, methodologies, techniques and strategies of adult education. **Prerequisite:** Permission of instructor.
- 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.
- VT ED 893 ADVANCED RESEARCH DESIGN AND ANALYSIS
3 cr. (3 and 0)
Emphasis on the dissertation from the proposal to the fully developed outline of all chapters. Required of all doctoral candidates in the vocational/technical education program. **Prerequisite:** AG ED 889 or equivalent.
- VT ED 980 INTERNSHIP IN VOCATIONAL/TECHNICAL EDUCATION
1-6 cr. (0 and 3-18)
Internship in which the student gains experience working in a chosen area of specialization in vocational/technical education; field experience activities must be planned to build competence in the student's field of specialization. Graded on a pass/fail basis. **Prerequisite:** Permission of the student's major advisor.
- VT ED 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

COLLEGE OF ENGINEERING

**AGRICULTURAL ENGINEERING
BIOENGINEERING
CERAMIC ENGINEERING
CHEMICAL ENGINEERING
CIVIL ENGINEERING
COMPUTER ENGINEERING
ELECTRICAL ENGINEERING
ENGINEERING GRAPHICS
ENGINEERING MECHANICS
ENVIRONMENTAL SYSTEMS ENGINEERING
INDUSTRIAL ENGINEERING
MECHANICAL ENGINEERING**

COLLEGE OF ENGINEERING

J. Charles Jennett, Dean

The College of Engineering offers advanced degrees in the following areas of study:

Agricultural Engineering*
Bioengineering
Ceramic Engineering
Chemical Engineering
Civil Engineering
Computer Engineering

Electrical Engineering
Engineering Mechanics
Environmental Systems
Engineering
Industrial Engineering
Mechanical 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 full-time graduate students. Industrial Residency Programs leading to the Master of Science degree also are available in certain departments. A Master of Science degree with specialization in automated manufacturing systems engineering also is available through the departments of Mechanical Engineering, Electrical and Computer Engineering, or Industrial Engineering. Financial aid, in the form of full and partial fellowships and teaching and research assistantships, is available. Other financial aid packages are available to outstanding applicants. A broad and vigorous research program provides excellent thesis and dissertation research opportunities. Details on current research projects and special facilities are available from the various department heads.

The Master of Engineering program is open to individuals who are interested in professionally oriented advanced study. Requirements for the program are a baccalaureate degree from an ABET-accredited engineering program or equivalent, academic and professional records which indicate motivation for and the ability to complete additional professional study, and the acceptance of the head of the department in which the individual plans to major and of the dean of the College of Engineering.

The college offers cooperative graduate programs in which semesters of on-campus study are alternated with work assignments in industry.

The Clemson University Master of Engineering Program at The Citadel was established to provide high quality graduate engineering education to practicing engineers in the South Carolina lowcountry. This is a design-oriented professional program of study that integrates theoretical knowledge with engineering application. Currently courses are offered in the three subject areas of structural, geotechnical and construction engineering within the field of civil engineering. Before graduation, students will complete an original engineering design project related to their program of study. Graduates from the program are granted the Master of Engineering degree in civil engineering.

Information about courses and registration can be obtained by writing to the program director, Master of Engineering Program at The Citadel, P.O. Box 57, Charleston, South Carolina 29409, or by calling (803) 792-2242.

* Jointly administered by the College of Engineering and the College of Agricultural Sciences. The degrees are awarded by the College of Engineering.

AGRICULTURAL ENGINEERING

Richard O. Hegg, Head, Department of Agricultural and Biological Engineering

Major
Agricultural
Engineering**Degrees**
M.Engr., M.S., Ph.D.

Graduate programs in agricultural engineering are designed to prepare the individual for leadership, creative accomplishment and continued 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, and biological and engineering sciences. Candidates for the M.S. degree must complete a thesis.

AG E 608 (ESE 608) (AGRON 608)	LAND TREATMENT OF WASTEWATER AND SLUDGES 3 cr. (3 and 0)
AG E 616	MECHANICAL DESIGN FOR AGRICULTURAL AND BIOLOGICAL SYSTEMS 3 cr. (2 and 3) S
AG E 628 (CH E 628)	BIOCHEMICAL ENGINEERING 3 cr. (3 and 0)
AG E 630 (BIO SC 630)	BIOENERGETICS FOR ENGINEERS 4 cr. (3 and 3)
AG E 631	AGRICULTURAL STRUCTURES AND ENVIRONMENTAL DESIGN 3 cr. (2 and 3) F
AG E 642	PROPERTIES AND PROCESSING OF BIOLOGICAL PRODUCTS 3 cr. (2 and 3) S
AG E 650	INSTRUMENTATION FOR AGRICULTURAL AND BIOLOGICAL SYSTEMS 3 cr. (2 and 3)
AG E 651 (ESE 651) (FOR 651)	NEWMAN SEMINAR AND LECTURE SERIES IN NATURAL RESOURCES ENGINEERING 1 cr. (0 and 2) S, F
AG E 658 (BIO SC 658)	CELL PHYSIOLOGY 3 cr. (3 and 0)
AG E 781	SPECIAL PROBLEMS 1-3 cr. (1-3 and 0) 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.

AGRICULTURAL ENGINEERING

- 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; off-the-road locomotion. **Prerequisite:** AG E 416/616 or equivalent.
- AG E 822 WATER MOVEMENT IN SOILS
3 cr. (3 and 0)
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; fundamentals of engineering design with respect to groundwater 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)
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. **Prerequisite:** MTH SC 453/653 or 434/634 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)
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

Andreas F. von Recum, Head, Department of Bioengineering

Major
Bioengineering

Degrees
M.S., Ph.D.

The bioengineering program is devoted to the application of engineering science, methods and techniques to problems ranging from basic biomedical research to applied health care delivery. The principle areas of concentration are biomaterials, biomechanics and artificial intelligence. 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. Artificial intelligence is applied to medical diagnostic problems and to assist in the design, evaluation and fabrication of custom implants. Heavy reliance is placed on considerable direct laboratory experience.

The faculty is augmented by eight adjunct medical faculty, and most research programs are conducted in collaboration with medical, clinical or research-oriented institutions. All students have some direct experience with an appropriate aspect of this medical involvement. A three-month clinical internship is available to all students through the Bioengineering Alliance of South Carolina.

Students enrolling in this program usually have a strong background in the more traditional engineering disciplines. Some background in general biology and physiology is recommended but is not a prerequisite. Students with degrees in science may be considered for admission if they can demonstrate proficiency in certain prescribed engineering courses.

Candidates are allowed wide flexibility in planning their programs but are encouraged to seek advice and direction from the faculty because of the rapid evolution of this emerging discipline. The master's degree curriculum offers both a thesis and a nonthesis option.

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| 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)
Structure and properties of the main classes of materials used in artificial organs and surgical implants; metals, ceramics, polymers, composites and materials of biological origin; mechanical properties, corrosion and design is emphasized. Prerequisites: CR E 310 and permission of instructor. |
| BIO E 802 | COMPATIBILITY OF BIOMATERIALS
3 cr. (1 and 6)
Techniques employed in determining compatibility of biomaterials with the physiological environment; optical microscopy, microradiography and ultraviolet fluorescence; normal histology of tissues, basic pathological reactions and tissue reactions to materials. |

BIOENGINEERING

- BIO E 803 POLYMERIC BIOMATERIALS
3 cr. (3 and 0)
Interplay of physicochemical properties of polymeric materials and the design of biomedical devices and their in vitro and in vivo performance; critical manufacturing aspects of selected augmentation and prosthetic devices for soft and hard tissues; analysis of case studies and reports on recent research findings. **Prerequisite:** Permission of instructor.
- BIO E 804 METALLIC AND CERAMIC IMPLANT MATERIALS
3 cr. (3 and 0)
Interaction between implant material and host tissue, selection of materials for different applications, influences of material and host tissue performance on implant design and on in vitro testing of implant materials and devices. **Prerequisites:** CR E 310, BIO E 801 and permission of instructor.
- BIO E 812 ORTHOPEDIC PATHOLOGY
3 cr. (3 and 0)
Gross, microscopic and radiographic study of bone growth and development, trauma, inflammation; collagen disease and osteoarthritis, metabolic diseases, circulatory disturbances, tumors and other miscellaneous disorders. **Prerequisite:** BIO E 802.
- 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 821 DYNAMICS AS APPLIED TO THE HUMAN BODY
3 cr. (3 and 1)
Elements of kinetics and kinematics, anthropometry — body segment parameters, link segment model development synthesis of human movement, muscle mechanics, sports mechanics, blood flow and other delivery systems, organ motion and other topics of particular interest to students, all with reference to the human body in health and disease. **Prerequisites:** BIO E 820 or equivalent and 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; physiology 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 ZOOL 459/659.

- BIO E 840 CREATIVE BIOMEDICAL ENGINEERING DESIGN
3 cr. (2 and 2)
Design philosophy, product liability, need analysis and specifications, feasibility studies, patent law, creativity and inventions, modelling and reliability, and human factors; students complete a biomedical design project with hands-on CAD/CAM experience. **Prerequisite:** Permission of instructor.
- BIO E 847 ELEMENTS OF BIOENGINEERING
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 by-pass devices; renal function and control; artificial kidney devices; heat flow and temperature regulation; and mathematical models. **Prerequisite:** ZOOL 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 882 BIOMATERIALS IMPLANTOLOGY
4 cr. (2 and 6)
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. Credit 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.

BIOENGINEERING

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 departmental headings.

AN PH 801 (BIO SC 801)	ELECTRON MICROSCOPY OF BIOLOGICAL SPECIMENS 3 cr. (1 and 6) F, S
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)
E&CE 870	BIOSYSTEMS ANALYSIS 3 cr. (3 and 0) F
IE 860	DYNAMIC PROGRAMMING 3 cr. (3 and 0)
MAT E 605	PHYSICAL METALLURGY 3 cr. (3 and 0)
BIO SC 661	CELL BIOLOGY 4 cr. (3 and 3)
ZOOL 659	SYSTEMS PHYSIOLOGY 4 cr. (3 and 3)

CERAMIC ENGINEERING

Gordon Lewis, Head, Department of Ceramic Engineering

Major	Degrees
Ceramic Engineering	M.Engr., M.S., Ph.D.

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 programs toward traditional fields of ceramic engineering or toward multidisciplinary fields such as biomedical or materials engineering. The latter is an area of concentration within the ceramic engineering degree program and provides a multidisciplinary approach to the study of the relation between properties of materials and their structure and composition. Emphasis is placed on the design of material components to be compatible with a variety of application environments. Courses in chemistry, physics and mathematics as well as engineering provide background for learning the behavior of materials. The study includes research into selected material topics in ceramics, metals or polymers with the preparation of a thesis as a major part of the program.

CR E 602	SOLID STATE CERAMICS 3 cr. (3 and 0)
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- 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 614 PROCESSING OF CERAMICS
3 cr. (3 and 0)
- CR E 616 ELECTRONIC CERAMICS
3 cr. (3 and 0)
- CR E 617 INDUSTRIAL FUELS AND COMBUSTION
3 cr. (3 and 0)
- CR E 618 PROCESS CONTROL
3 cr. (3 and 0)
- CR E 619 SCIENCE OF ENGINEERING MATERIALS I
3 cr. (3 and 0)
- CR E 620 SCIENCE OF ENGINEERING MATERIALS II
3 cr. (3 and 0)
- CR E 625 SPECIALIZED PROCESSING OF CERAMIC MATERIALS
3 cr. (2 and 2)
- CR E 630 FINE PARTICLE PROCESSING IN CERAMIC SYSTEMS
3 cr. (3 and 0)
- CR E 690 SPECIALIZED TOPICS IN CERAMIC ENGINEERING
1-3 cr. (1-3 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, interests and experience of students and instructor. May be repeated for additional credit.
- CR E 800 CERAMIC ENGINEERING SEMINAR
1 cr. (1 and 0)
Discussions and presentations of current topics of ceramic science and engineering by students, faculty members and guest speakers. Required of all graduate students. Graded on a pass/fail basis.
- 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.

CERAMIC ENGINEERING

- 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 MATERIALS
3 cr. (3 and 0)
Application of magnetic and electrical theory to ceramic insulators, semiconductors, and ferroelectric and ferromagnetic products.
- CR E 826 CERAMIC COATINGS
3 cr. (3 and 0)
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 832 CERAMIC REACTION THERMODYNAMICS
3 cr. (3 and 0)
Stability of ceramic materials is considered with respect to the processes of dissociation, crystallographic inversion, vaporization, oxidation-reduction and reaction with other materials. **Prerequisite:** Permission of instructor.

- CR E 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- CR E 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

CHEMICAL ENGINEERING

Charles H. Barron, Jr., Head, Department of Chemical Engineering

Major	Degrees
Chemical Engineering	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. Candidates for the M.S. degree must complete a thesis.

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 612 POLYMER ENGINEERING
3 cr. (3 and 0)
- CH E 615 INTRODUCTION TO NUCLEAR ENGINEERING
3 cr. (3 and 0)
- CH E 624 INTRODUCTION TO INDUSTRIAL POLLUTION
3 cr. (3 and 0)
- CH E 628 BIOCHEMICAL ENGINEERING
(AG E 628) 3 cr. (3 and 0)
- CH E 650 CHEMICAL ENGINEERING KINETICS
3 cr. (3 and 0)
- CH E 654 COMPUTER PROCESS CONTROL
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 ADVANCED TRANSPORT PHENOMENA
3 cr. (3 and 0)
Analysis of heat, mass and momentum transfer; derivation and application of the governing equations; solution of steady and unsteady-state multidimensional problems in fluid flow, heat transfer and mass transfer.

CHEMICAL ENGINEERING

- CH E 804 CHEMICAL ENGINEERING THERMODYNAMICS
3 cr. (3 and 0)
Equilibria of physical and chemical systems; generalized properties of hydrocarbons; 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 813 CHEMICAL ENGINEERING FINITE ELEMENT ANALYSIS
3 cr. (3 and 0)
Finite element techniques applied to the solution of the partial differential equations governing the flow of Newtonian and non-Newtonian fluids, heat transfer and mass transfer in the chemical process systems. **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 operations; laboratory experiments emphasize relation between synthesis and processing on the product properties using pilot-scale equipment. **Prerequisite:** Permission of instructor.
- CH E 818 POLYMER PROCESSING
3 cr. (3 and 0)
Processing of polymeric materials; polymer flow characterization; extrusion; mixing; filtration; injection molding; fiber and film formation; physical science principles such as fluid flow, heat transfer, crystallization and rheology applied to polymer processing operations.
- CH E 819 VISCOELASTIC PROPERTIES OF POLYMERS AND POLYMERIC COMPOSITES
3 cr. (3 and 0)
Time and frequency dependent behavior of structural polymers and their composites; interrelationship between various viscoelastic properties; influence of aging; prediction of composite viscoelastic response by application of the Viscoelastic Correspondence Principle. **Prerequisite:** Permission of instructor.
- CH E 820 COMPOSITE POLYMERIC MATERIALS
(TC 820) 3 cr. (3 and 0)
Morphology, chemistry, processing and physical characterization of engineered fibers and matrix materials; influence of fiber and

matrix properties on composite characteristics; application of surface chemistry to analyze fiber/matrix wetting and adhesion. **Prerequisite:** CHEM 224 or permission of instructor.

- 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; 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 829 MEMBRANE SEPARATION PROCESSES
3 cr. (3 and 0)
Fundamental principles, mathematical modeling and applications of microfiltration, ultrafiltration, reverse osmosis, gas permeation and pervaporation; introduction to other membrane processes, including dialysis, Donnan dialysis, electrodialysis, liquid membranes, facilitated transport, membrane reactor and controlled release technology. **Prerequisite:** CH E 401 or equivalent or permission of instructor.
- CH E 834 ADVANCED CHEMICAL ENGINEERING THERMODYNAMICS
3 cr. (3 and 0)
Classical and statistical thermodynamics applied to problems in chemical engineering with emphasis on modern methods of predicting thermophysical properties of gases and liquids. Students' and instructor's interests influence course content, but usually include fundamentals of applied statistical mechanics, molecular theory of dense fluids, descriptions of intermolecular forces, gas-liquid and liquid-liquid critical phenomena, theories of interfacial phenomena and adsorption, statistical mechanics of polymeric systems, statistical mechanics of polydispersed systems, computer simulation of fluids by Monte Carlo, molecular dynamics and stochastic dynamics methods. **Prerequisite:** CH E 804 or equivalent.
- 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.

CHEMICAL ENGINEERING

- CH E 890 SPECIAL PROJECTS
1-6 cr.
Comprehensive analytical and/or experimental treatment of phenomena of current interest in chemical engineering, emphasizing modern technological problems. May be repeated for maximum of six credits. Graded on a pass/fail basis. **Prerequisites:** Permission of instructor and department head.
- CH E 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- CH E 895 CHEMICAL ENGINEERING GRADUATE SEMINAR
1 cr. (1 and 0)
Series of weekly, one-hour seminars given by students, faculty and guests on topics of current interest. Graded on a pass/fail basis.
- 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

Russell H. Brown, 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 construction, structures, traffic and transportation, hydraulics, natural hazards and geotechnical engineering. A program also may encompass course work in several related interdisciplinary fields such as environmental systems engineering.

Two options are offered for the M.S. degree. The nonthesis option requires 33 hours of course work and a written and oral examination. The thesis option requires 30 hours of course work, six of which are thesis research. All graduate students are required to complete CE 895 and an oral examination as a requirement for any graduate degree.

Excellent facilities for graduate work are available, and each student's educational and research program can be arranged to suit his or her personal and professional goals.

- CE 603 USE OF COMPUTERS IN STRUCTURAL ANALYSIS AND DESIGN
3 cr. (3 and 0)
- CE 604 MASONRY STRUCTURAL DESIGN
3 cr. (3 and 0)

- CE 605 STRUCTURAL SYSTEMS DESIGN
3 cr. (3 and 0)
- 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) S
- CE 619 GENERAL PHOTOGRAMMETRY
3 cr. (2 and 3) F
- CE 622 HYDRAULICS AND HYDROLOGY
3 cr. (3 and 0)
- CE 623 APPLIED HYDROLOGY
3 cr. (2 and 3)
- CE 631 APPLIED SOIL MECHANICS
3 cr. (3 and 0)
- CE 632 CONSTRUCTION PROJECT ADMINISTRATION
3 cr. (3 and 0)
- CE 633 CONSTRUCTION PLANNING AND SCHEDULING
3 cr. (3 and 0)
- CE 634 CONSTRUCTION ESTIMATING AND PROJECT CONTROL
3 cr. (3 and 0)
- CE 635 ENGINEERING PROJECT ANALYSIS
3 cr. (3 and 0)
- CE 638 CONSTRUCTION SUPPORT OPERATIONS
3 cr. (3 and 0)
- CE 639 CONSTRUCTION EQUIPMENT SELECTION AND MAINTENANCE
3 cr. (3 and 0)
- CE 653 STRUCTURAL ANALYSIS II
3 cr. (3 and 0)
- CE 662 COASTAL ENGINEERING I
3 cr. (3 and 0)
- CE 664 PHYSICAL MODELS IN FLUID MECHANICS
3 cr. (2 and 2)
- CE 680 WIND ENGINEERING
3 cr. (2 and 2)
- CE 682
(ESE 682) GROUNDWATER AND CONTAMINANT TRANSPORT
3 cr. (3 and 0)

- CE 801 **MATRIX METHODS OF STRUCTURAL ANALYSIS**
3 cr. (3 and 0)
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; 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; behavior and design of two-way floor systems. **Prerequisite:** CE 402.
- CE 804 **THEORY OF PLATES AND SHELLS**
3 cr. (3 and 0)
Development of plate equations for thin rectangular, circular and continuous plates by classical methods; use of finite difference and finite element techniques for plate solutions; linear buckling theory of plates; membrane theory of shells for hyperbolic-paraboloids, shells of revolution, cylindrical tanks and folded plate structures. **Prerequisite:** CE 453/653 or 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 multistory frames; plastic potential flow law, yield conditions and elastic-plastic stress-strain relations. **Prerequisites:** CE 302 and 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 IN STRUCTURES**
3 cr. (3 and 0)
Application of numerical methods to solutions of structural problems such as nonuniform beams, column and frame stability, beams on elastic foundations, and vibration of beams; approxi-

mate solutions using Newmark's method and numerical techniques adapted to the digital computer. **Prerequisite:** CE 453/653 or permission of instructor.

- CE 808 **FINITE ELEMENT METHOD 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 810 **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 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 410/610.
- CE 812 **AIRPHOTO INTERPRETATION II**
3 cr. (2 and 3)
Principles of airphoto interpretation applied to civil engineering project site selection and evaluation; projects include highway alignment, airport site selection, industrial site evaluation and others; application of radar imagery, infrared imagery, satellite imagery and space photographs.
- CE 813 **HIGHWAY AND AIRPORT PAVEMENT DESIGN**
3 cr. (3 and 0)
Structural design of rigid and flexible pavements; design of bases and subbases; theory of stresses and application of plate bearing, triaxial and California Bearing Ratio design methods to flexible pavements; Westergaard analysis for rigid pavements; pavement evaluation methods. **Prerequisite:** CE 330.
- CE 814 **TRAFFIC FLOW THEORY**
3 cr. (3 and 0)
Qualitative and quantitative description of traffic flow; 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.

CIVIL ENGINEERING

- 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; 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 823 ASPHALT CONCRETE PROPERTIES
3 cr. (3 and 0)
Identification and suitability of aggregates for construction; characteristics and properties of bituminous materials; materials behavior, construction and design problems; some use of microcomputers and the mainframe. **Prerequisite:** CE 320 or equivalent.
- CE 824 CONSTRUCTION AND PERFORMANCE OF CONCRETE
3 cr. (3 and 0)
Properties of concrete important to the optimum use of concrete as a construction material; includes material behavior, construction problems, construction practices and measures of concrete performance. **Prerequisite:** CE 320 or equivalent.
- 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 bulkheads; solution of problem by elastic theory. **Prerequisite:** CE 330.

- CE 831 FOUNDATION ENGINEERING
3 cr. (3 and 0)
Requirements for satisfactory foundations; theory and design of shallow foundations; pressure distribution beneath rigid and flexible shallow foundations; bearing capacity and settlement of deep foundations; foundation failures. **Prerequisite:** CE 830 or permission of instructor.
- CE 832 RELIABILITY ANALYSIS AND DESIGN IN CIVIL ENGINEERING
3 cr. (3 and 0)
Elements of probabilistic methods; classical theory of structural reliability and reliability-based design methods; term project required on reliability design in a relevant field of civil engineering. **Prerequisite:** Permission of instructor.
- CE 833 ANALYSIS AND DESIGN OF DEEP FOUNDATIONS
3 cr. (3 and 0)
Methods for predicting bearing capacity and settlement of single piles, pile groups and drilled shafts; analysis and design of pile and pier foundations for resisting axial, lateral and uplifting loads; load test interpretation and evaluation. **Prerequisite:** CE 830 or permission of instructor.
- CE 835 CONSTRUCTION PROJECT MODELING
3 cr. (3 and 0)
Mathematical and computer models to simulate construction operations; linear models and optimization applications to construction materials, scheduling and equipment allocation; typical computer models used in construction; simple modeling examples. **Prerequisite:** CE 324 or permission of instructor.
- CE 837 CONSTRUCTION SPECIFICATIONS AND CONTRACTS
3 cr. (3 and 0)
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 324 or equivalent.
- CE 838 MATERIALS MANAGEMENT
3 cr. (3 and 0)
Functions of construction materials management, including design interface, purchasing, expediting, transportation, field control and warehousing; design and application of integrated materials management computer systems; new technology that impacts materials management, including bar coding, electronic data interchange and voice recognition. **Prerequisite:** Permission of instructor.
- CE 840 PROJECT MANAGEMENT APPLICATIONS
3 cr. (3 and 0)
Quantitative tools for effective management and control of engineered projects from design through construction; cost coding and control, advanced schedule management techniques and quality management principles; extensive hands-on use of the microcomputer. **Prerequisites:** CE 433 and 434 or equivalent.

CIVIL ENGINEERING

- 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 852
(EM 852) ADVANCED FINITE ELEMENT ANALYSIS
3 cr. (3 and 0)
See EM 852 for description.
- CE 860 ADVANCED FLUID MECHANICS
3 cr. (3 and 0)
Laminar and turbulent flows; boundary layer and free shear flows (jets, wakes, etc.); descriptions of velocity, shear stress and pressure measurements, and aerodynamic drag.
- CE 861 MECHANICS OF SEDIMENT TRANSPORT
3 cr. (3 and 0)
Characterization of sediments; physical principles governing processes of aeolian, fluvial and estuarine sediment transport. **Prerequisite:** CE 422/622 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 863 COASTAL ENGINEERING II
3 cr. (3 and 0)
Littoral processes; coastal structures; port engineering; estuarial hydromechanics; littoral transport; port and harbor design; functional design of coastal structures; tidal dynamics in estuaries. **Prerequisite:** CE 462/662.
- 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 groundwater hydrology and surface water hydrology; infiltration; soil moisture and evapotranspiration; probability analysis and system synthesis by convolution. **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; 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 875 NUMERICAL MODELS IN HYDRAULICS
3 cr. (3 and 0)
Finite difference and finite element methods used to solve hydraulic engineering problems. Class assignments include the development of a finite difference model and the use of an existing finite element model to solve problems in coastal engineering and river mechanics. **Prerequisite:** CE 422/622.
- 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 895 CIVIL ENGINEERING SEMINAR
1 cr. (1 and 0)
Current advances and research in the various areas of civil engineering; speakers include off-campus experts, faculty and graduate students; a seminar presentation is required. Graded on a pass/fail basis.
- CE 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

COMPUTER ENGINEERING

L. Wilson Pearson, Head, Department of Electrical and Computer Engineering

Major	Degrees
Computer Engineering	M.S., Ph.D.

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 engineering and/or science background.

Students in the M.S. degree program may write a thesis or follow the all-course-work option.

E&CE 606	INTRODUCTION TO MICROELECTRONICS PROCESSING 3 cr. (3 and 0) S
E&CE 607	VLSI RELIABILITY 3 cr. (3 and 0) S
E&CE 614	ANALYSIS OF ROBOTIC SYSTEMS 3 cr. (3 and 0) S
E&CE 617	SOFTWARE DESIGN 3 cr. (3 and 0) F, S
E&CE 618	POWER SYSTEM ANALYSIS 3 cr. (3 and 0) F
E&CE 619	ELECTRIC MACHINERY 3 cr. (3 and 0) S
E&CE 622	OPERATIONAL AMPLIFIER CIRCUITS 3 cr. (2 and 2) S
E&CE 623	POWER SYSTEM PROTECTION 3 cr. (3 and 0) S
E&CE 625	MICROCOMPUTER INTERFACING 3 cr. (2 and 2) F, S
E&CE 626	DIGITAL COMPUTER DESIGN 3 cr. (3 and 0) F, S
E&CE 629	COMPUTER ORGANIZATION 3 cr. (3 and 0) F, S
E&CE 631	DIGITAL ELECTRONICS 3 cr. (2 and 2) F, S
E&CE 633	SENSORS AND MICROCOMPUTER CONTROL FOR ROBOTS 3 cr. (1 and 4) F
E&CE 635	OPTOELECTRONICS 3 cr. (3 and 0)
E&CE 636	TRANSMISSION LINES AND MICROWAVE CIRCUITS 3 cr. (3 and 0) F

E&CE 638	COMPUTER COMMUNICATIONS 3 cr. (3 and 0) F
E&CE 639	FIBER OPTICS 3 cr. (3 and 0) F
E&CE 640	PERFORMANCE ANALYSIS OF LOCAL COMPUTER NETWORKS 3 cr. (3 and 0) S
E&CE 641	THEORY OF SEQUENTIAL MACHINES 3 cr. (3 and 0)
E&CE 642	KNOWLEDGE ENGINEERING 3 cr. (3 and 0) F
E&CE 646	ANTENNAS AND PROPAGATION 3 cr. (3 and 0) S
E&CE 650	COMPUTER 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 660	COMPUTER-AIDED ANALYSIS AND DESIGN 3 cr. (3 and 0) F
E&CE 663	MICROCOMPUTERS 3 cr. (2 and 2)
E&CE 667	INTRODUCTION TO DIGITAL SIGNAL PROCESSING 3 cr. (3 and 0) F, S
E&CE 668	THE EMBEDDED MICROPROCESSOR 3 cr. (2 and 2) S
E&CE 671	MICROCOMPUTER APPLICATIONS IN MEDICAL INSTRUMENTATION 3 cr. (3 and 0)
E&CE 692	SPECIAL PROBLEMS 1-3 cr. (0 and 2)
E&CE 693	SELECTED TOPICS 1-3 cr. (1-3 and 0)
E&CE 801	ANALYSIS OF LINEAR SYSTEMS* 3 cr. (3 and 0) F
E&CE 802	ELECTRIC MOTOR CONTROL* 3 cr. (3 and 0)

* Descriptions of these 800-level courses are listed under Electrical Engineering.

COMPUTER ENGINEERING

- E&CE 811 INTEGRATED CIRCUIT DESIGN
 3 cr. (2 and 2)
 Design concepts and factors influencing the choice of technology; fundamental MOS device design; silicon foundries, custom and semicustom integrated circuits; computer-aided design software/hardware trends and future developments; the hands-on use of CAD tools to design MOS standard cells; systems design, testing and packaging. **Prerequisite:** E&CE 459/659.
- E&CE 838 SPECIAL TOPICS IN ELECTROMAGNETICS*
 1 cr. (1 and 0)
- E&CE 839 INTEGRAL EQUATIONS IN ELECTROMAGNETICS*
 3 cr. (3 and 0)
- E&CE 841 DISTRIBUTED COMPUTING AND NETWORKS
 3 cr. (3 and 0) S
 Design oriented toward distributed computing and computing concepts; design issues; implementation techniques; communication networks; analytical tools for system evaluation; data transmission principles; data concentration. **Prerequisite:** E&CE 438/638.
- E&CE 842 COMPUTER ARCHITECTURE
 3 cr. (3 and 0) S
 Fundamental issues that arise in the composition of logic elements into computer systems; design and analysis of processors, buses, memory hierarchies, communications controllers and associated software. **Prerequisite:** E&CE 429 or equivalent.
- 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; 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; performance evaluation; 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)

* Descriptions of these 800-level courses are listed under Electrical Engineering.

- E&CE 848 TELECOMMUNICATION NETWORK MODELING AND ANALYSIS
3 cr. (3 and 0)
Protocols, modeling and analysis of telecommunication networks, with emphasis on quantitative performance modeling of networks and systems using packet switching and circuit switching techniques. **Prerequisite:** E&CE 438/638 or CP SC 825.
- E&CE 849 ADVANCED TOPICS IN COMPUTER COMMUNICATIONS
3 cr. (3 and 0)
Performance analysis and design of computer communication networks with emphasis on recent developments. Topics include such issues as routing flow control, error control and end-to-end performance analysis, local area, packet radio and long haul store-and-forward networks. **Prerequisites:** E&CE 438/638 or 440/640, and permission of instructor.
- E&CE 850 COMPUTATION AND SIMULATION
3 cr. (3 and 0)
Computer modeling as related to engineering problems; matching problems and computers to obtain most effective solution.
- E&CE 851 ADVANCED TOPICS IN COMPUTER ARCHITECTURE
3 cr. (3 and 0)
Analysis and design of multiprocessor and modular computer systems. Topics include recent developments in integration, fabrication and application of multiprocessor systems. **Prerequisite:** E&CE 842.
- E&CE 852 SOFTWARE ENGINEERING
3 cr. (3 and 0) F
Design, construction verification and testing of large-scale computer software systems. Topics include software science, requirements writing, design graphics, the calculus of programs, verification proofs and symbolic execution. **Prerequisite:** Computer engineering major or permission of instructor.
- E&CE 853 COMPUTER DATA DISPLAYS
3 cr. (3 and 0)
Methods and hardware required for visually displaying computer output; cathode ray, discrete readout and large screen displays. **Prerequisite:** E&CE 422, 429 or approval of instructor.
- E&CE 855 ARTIFICIAL INTELLIGENCE
3 cr. (3 and 0)
Emulating intelligent behavior by computer. Topics include: models of cognitive processes; logical foundations; constraint satisfaction problems; natural language understanding; pattern directed inference and chaining paradigms; goal directed behavior, planning and search; learning; advanced data base structure and inference strategies; examples of LISP, PROLOG and OPS5. **Prerequisite:** E&CE 442/642.
- E&CE 856 PATTERN RECOGNITION*
3 cr. (3 and 0)

* Description of this 800-level course is listed under Electrical Engineering.

COMPUTER ENGINEERING

- E&CE 858 AUTOMATA THEORY
3 cr. (3 and 0) S
Structure and capabilities of sequential machines; machine identification; regular expressions; linear machines; stochastic machines.
- E&CE 890 ENGINEERING REPORT RESEARCH
Variable credit hours.
Research culminating in writing an engineering report to satisfy one of the requirements for the nonthesis option for the Master of Science degree; the engineering report is similar to the thesis but requires only departmental approval. Graded on a pass/fail basis.
- E&CE 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- E&CE 892 SPECIAL PROBLEMS IN ELECTRICAL AND COMPUTER ENGINEERING
1-3 cr. (1-3 and 0)
Term paper, special design or other problems in electrical and computer engineering approved by the instructor. Not to be used for investigation associated with the M.S. thesis or the engineering report. May be repeated for additional credit.
- 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.

ELECTRICAL ENGINEERING

L. Wilson Pearson, Head, Department of Electrical and Computer Engineering

Major	Degrees
Electrical Engineering	M.Engr., M.S., Ph.D.

Students in electrical engineering may direct their programs toward the fields of artificial intelligence, communications, controls, digital signal processing (classical, speech, radar), electromagnetics, image processing, microelectronics, power, robotics and VLSI reliability.

Students in the M.S. degree program may write a thesis or follow the all-coursework option.

- E&CE 604 SEMICONDUCTOR DEVICES
3 cr. (3 and 0) F
- E&CE 606 INTRODUCTION TO MICROELECTRONICS PROCESSING
3 cr. (3 and 0) S
- E&CE 607 VLSI RELIABILITY
3 cr. (3 and 0) S

- 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 614 ANALYSIS OF ROBOTIC SYSTEMS
3 cr. (3 and 0) S
- E&CE 616 ELECTRIC POWER DISTRIBUTION SYSTEM ENGINEERING
3 cr. (3 and 0) S
- E&CE 617 SOFTWARE DESIGN
3 cr. (3 and 0) F, S
- E&CE 618 POWER SYSTEM ANALYSIS
3 cr. (3 and 0) F
- E&CE 619 ELECTRIC MACHINERY
3 cr. (3 and 0) S
- E&CE 622 OPERATIONAL AMPLIFIER CIRCUITS
3 cr. (2 and 2) S
- E&CE 623 POWER SYSTEM PROTECTION
3 cr. (3 and 0) S
- E&CE 625 MICROCOMPUTER INTERFACING
3 cr. (2 and 2) F, S
- E&CE 626 DIGITAL COMPUTER DESIGN
3 cr. (3 and 0) F, S
- E&CE 628 MODULATION AND NOISE
3 cr. (3 and 0) F
- E&CE 629 COMPUTER ORGANIZATION
3 cr. (3 and 0) F, S
- E&CE 630 DIGITAL COMMUNICATIONS
3 cr. (3 and 0) S
- E&CE 631 DIGITAL ELECTRONICS
3 cr. (2 and 2) F, S
- E&CE 632 INSTRUMENTATION
3 cr. (3 and 0) F
- E&CE 633 SENSORS AND MICROCOMPUTER CONTROL FOR ROBOTS
3 cr. (1 and 4) F
- E&CE 634 POWER ELECTRONICS
3 cr. (3 and 0) F
- E&CE 635 OPTOELECTRONICS
3 cr. (3 and 0)

ELECTRICAL ENGINEERING

E&CE 636	TRANSMISSION LINES AND MICROWAVE CIRCUITS 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) F
E&CE 639	FIBER OPTICS 3 cr. (3 and 0) F
E&CE 640	PERFORMANCE ANALYSIS OF LOCAL COMPUTER NETWORKS 3 cr. (3 and 0) S
E&CE 641	THEORY OF SEQUENTIAL MACHINES 3 cr. (3 and 0)
E&CE 642	KNOWLEDGE ENGINEERING 3 cr. (3 and 0) F
E&CE 646	ANTENNAS AND PROPAGATION 3 cr. (3 and 0) S
E&CE 650	COMPUTER SYSTEM DESIGN PROJECT 2 cr. (0 and 4) F, S
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 658	CIRCUIT DESIGN OF MODERN ANALOG FILTERS 3 cr. (3 and 0)
E&CE 659	INTEGRATED CIRCUIT DESIGN 3 cr. (2 and 2) F, S
E&CE 660	COMPUTER-AIDED ANALYSIS AND DESIGN 3 cr. (3 and 0) F
E&CE 663	MICROCOMPUTERS 3 cr. (2 and 2)
E&CE 667	INTRODUCTION TO DIGITAL SIGNAL PROCESSING 3 cr. (3 and 0) F, S
E&CE 668	THE EMBEDDED MICROPROCESSOR 3 cr. (2 and 2) S
E&CE 671	MICROCOMPUTER APPLICATIONS IN MEDICAL INSTRUMENTATION 3 cr. (3 and 0)

- E&CE 692 SPECIAL PROBLEMS
1-3 cr. (0 and 2)
- E&CE 693 SELECTED TOPICS
1-3 cr. (1-3 and 0)
- E&CE 701 MASTER OF ENGINEERING DESIGN PROJECT
1-3 cr. F, S
Practical problems in engineering analysis and design, culminating in the written report required for the Master of Engineering (M.Engr.) degree. Graded on a pass/fail basis.
- 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 802 ELECTRIC MOTOR CONTROL
3 cr. (3 and 0)
Dynamic modeling and analysis of electrical machines for design of AC and DC drive systems; emphasis on implementation of such models on a digital computer; voltage-fed inverters; pulse width modulation and analysis techniques for inverters; harmonic generation and reduction. **Prerequisite:** E&CE 434/634.
- 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; transformations; notation of a basis; transfer functions; state variable formulation; Cayley-Hamilton theorem; Jordan canonical forms; controllability; observability; adjoint systems; stability; multiple input-output systems; design techniques. **Prerequisite:** E&CE 410/610 or equivalent.
- E&CE 804 METHODS OF APPLIED OPTIMIZATION AND OPTIMUM CONTROL
3 cr. (3 and 0)
Methods of optimizing systems with and without dynamics, including linear programming, nonlinear programming, integer programming, gradient and variational calculus, minimum principle, principle of optimality and dynamic programming. **Corequisite:** MTH SC 653.
- E&CE 805 METHODS OF STATE AND PARAMETER ESTIMATION OF STOCHASTIC SYSTEMS
3 cr. (3 and 0)
State and parameter estimations of both linear and nonlinear continuous-time and discrete-time systems, including model identification: Kalman and Wiener filters, fixed-interval, fixed-point and fixed-lag smoothers, stochastic approximation estimation, nonlinear estimation by statistical linearization and sensitivity analysis of Kalman filters. **Corequisite:** MTH SC 654.

- E&CE 806 IDENTIFICATION IN CONTROL
3 cr. (3 and 0)
Design techniques in determining the input-output parameters of systems used in control: mathematical concepts, classical methods, regression and sequential regression techniques, stochastic approximation, quasilinearization, invariant imbedding, gradient methods, and delay model techniques in identification. **Prerequisite:** E&CE 805.
- E&CE 807 COMPUTER METHODS FOR POWER SYSTEMS ANALYSIS
3 cr. (3 and 0)
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:** E&CE 418/618.
- E&CE 808 SELF-ORGANIZING CONTROL
3 cr. (3 and 0)
Advanced topics in the theory and design methodologies associated with adaptive learning and intelligent control systems, including parameter-adaptive and performance-adaptive self-organizing control; algorithms: Jenkins-Roy, Farison, Tse-Athans, Lainiotis, McLaren and Tsytkin stability. **Prerequisite:** E&CE 806.
- 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 811 INTEGRATED CIRCUIT DESIGN
3 cr. (2 and 2)
Design concepts and factors influencing the choice of technology; fundamental MOS device design; silicon foundries, custom and semicustom integrated circuits; computer-aided design software/hardware trends and future developments; the hands-on use of CAD tools to design MOS standard cells; systems design, testing and packaging. **Prerequisite:** E&CE 459/659.
- E&CE 817 POWER SYSTEM TRANSIENTS
3 cr. (3 and 0)
Electrical transients in power systems; frequency domain and time domain techniques for power systems transient analysis; study of capacitor switching, load switching, fault-induced transients, line reclosing and single pole switching. **Prerequisite:** Permission of instructor.
- E&CE 819 DETECTION AND ESTIMATION THEORY
3 cr. (3 and 0)
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)
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)
Continuation of E&CE 820.
- E&CE 822 INFORMATION THEORY
3 cr. (3 and 0)
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)
Physical and chemical principles underlying the major processing operations used in the fabrication of integrated circuit semiconductor devices, process simulation, diagnostic testing, and factors affecting device yield and reliability. **Prerequisite:** Permission of instructor.
- E&CE 825 SOLID-STATE ELECTRONICS
3 cr. (3 and 0)
Modern physics approach to electrons in solids; elementary quantum mechanics; statistics; plasmas; 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)
Vector analysis; electrostatics; electrostatic fields in material bodies; solution of boundary-value problems; stationary currents; static magnetic fields; magnetic fields in material bodies; quasi-stationary magnetic fields. **Prerequisite:** Permission of instructor.
- E&CE 831 ADVANCED ELECTROMAGNETIC THEORY
3 cr. (3 and 0)
Advanced boundary-value problems in cylindrical and spherical coordinates, special functions, Sommerfeld integrals, Green's functions and integral equations. **Prerequisite:** E&CE 830.
- E&CE 832 ELECTROMAGNETIC MEASUREMENTS
3 cr. (3 and 0)
A wide range of microwave devices presented from a measurements standpoint; discussion of methods currently used to measure electromagnetic parameters in free space and within guides; consideration of measurement of static fields as well as modeling and approximation techniques. **Prerequisite:** Permission of instructor.

ELECTRICAL ENGINEERING

- E&CE 834 **ASYMPTOTIC METHODS AND DIFFRACTION THEORY**
 3 cr. (3 and 0)
 Canonical diffraction problems for which exact solutions are available; asymptotic reevaluation of these solutions in terms of incident, reflected and diffracted rays leads to Keller's postulates for an extended theory or geometrical theory of diffraction; diffraction from edges and curved surfaces is applied to scattering and antenna problems. **Prerequisites:** E&CE 830.
- E&CE 836 **MICROWAVE CIRCUITS AND SYSTEMS**
 3 cr. (3 and 0)
 Application of the mathematics and physical principles of electromagnetic field theory and electrical circuit analysis to the geometries that are of interest in modern microwave engineering; transmission lines, waveguides, discontinuities, interconnection of multiports and periodic structures. **Prerequisite:** E&CE 436. **Corequisite:** E&CE 830.
- E&CE 837 **ADVANCED ANTENNA THEORY**
 3 cr. (3 and 0)
 The antenna as a radiating and receiving device; examination by classical and numerical techniques of the relations between structure and performance, gain and terminal conditions. **Prerequisite:** E&CE 446. **Corequisite:** E&CE 830.
- E&CE 838 **SPECIAL TOPICS IN ELECTROMAGNETICS**
 1 cr. (1 and 0)
 Methods of solving selected electromagnetic problems with emphasis on Green's functions, equivalence principle, dynamic potential theory and boundary value techniques. May be repeated for credit. **Prerequisite:** Permission of instructor.
- E&CE 839 **INTEGRAL EQUATIONS IN ELECTROMAGNETICS**
 3 cr. (3 and 0)
 Integral equation formulation in electromagnetics, solution techniques, moment methods and application to practical problems. **Prerequisite:** E&CE 830 or 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) S
- E&CE 842 **COMPUTER ARCHITECTURE***
 3 cr. (3 and 0) S

* 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 wave forms; Fourier analysis; homomorphic processing; linear predictive coding; algorithms for recognizing isolated words and continuous speech; man-machine communications by voice. **Prerequisite:** E&CE 467.
- 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.
- E&CE 849 ADVANCED TOPICS IN COMPUTER COMMUNICATIONS*
3 cr. (3 and 0)
- E&CE 850 COMPUTATION AND SIMULATION*
3 cr. (3 and 0)
- E&CE 851 ADVANCED TOPICS IN COMPUTER ARCHITECTURE*
3 cr. (3 and 0)
- E&CE 852 SOFTWARE ENGINEERING*
3 cr. (3 and 0) F
- E&CE 853 COMPUTER DATA DISPLAYS*
3 cr. (3 and 0)
- E&CE 855 ARTIFICIAL INTELLIGENCE*
3 cr. (3 and 0)
- E&CE 856 PATTERN RECOGNITION
3 cr. (3 and 0)
Several approaches to general pattern recognition problems with practical computer-oriented applications; feature extraction; classification algorithms; discriminant functions; learning schemes; statistical methods; information theoretic approaches; applications; current developments.

* Descriptions of these 800-level courses are listed under Computer Engineering.

ELECTRICAL ENGINEERING

- E&CE 857 CODING THEORY
 3 cr. (3 and 0)
 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 859 INTELLIGENT ROBOTIC SYSTEMS
 3 cr. (3 and 0)
 Integration and fusion of data from multiple sensors on multiple robots; intelligent decision making on motion planning and execution based on sensed data, involving mutual compliance, simultaneous force and position controls using computers. **Prerequisite:** E&CE 414/614.
- E&CE 861 COMPUTER RELAYING OF POWER SYSTEMS
 3 cr. (3 and 0)
 Principles of digital protection schemes; application to the digital protection of power system components; transmission lines, generators, motors and transformers; detection of power system frequency deviation and load shedding techniques; fault location techniques and identification of power systems disturbances. **Prerequisites:** E&CE 418/618 and permission of instructor.
- E&CE 862 REAL TIME COMPUTER APPLICATION IN POWER SYSTEMS
 3 cr. (3 and 0)
 Principles of monitoring, control and operation of power systems; load frequency control, on-line load flow, power system state estimation, unit commitment and load forecasting. **Prerequisite:** E&CE 418/618.
- E&CE 863 POWER SYSTEM DYNAMICS AND STABILITY
 3 cr. (3 and 0)
 Modeling of synchronous machines and their control systems; study of power system stability for small and large disturbances; excitation systems, governor control, power system stabilizers and state variables formulation for power systems dynamic stability studies. **Prerequisites:** E&CE 418/618 and 419/619.
- 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.

* Description of this 800-level course is listed under Computer Engineering.

- E&CE 890 ENGINEERING REPORT RESEARCH
Variable credit hours.
Research culminating in writing an engineering report to satisfy one of the requirements for the nonthesis option for the Master of Science degree. The engineering report is similar to the thesis but requires only departmental approval. Graded on a pass/fail basis.
- E&CE 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- E&CE 892 SPECIAL PROBLEMS IN ELECTRICAL AND COMPUTER ENGINEERING
1-3 cr. (1-3 and 0)
Term paper, special design or other problems in electrical and computer engineering approved by the instructor. Not to be used for investigation associated with the M.S. thesis or the engineering report. May be repeated for additional credit.
- 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 GRAPHICS

William F. Beckwith, Director, Engineering Graphics Program

Advanced degrees are not awarded in engineering graphics. Courses are offered as electives for students in engineering and other areas.

- EG 612 INTERACTIVE COMPUTER GRAPHICS
3 cr. (3 and 0)
- EG 690 SPECIAL TOPICS IN ENGINEERING AND COMPUTER GRAPHICS
1-3 cr.
May be repeated for a maximum of six credits.
- EG 823 COMPUTER-AIDED GEOMETRIC MODELING
3 cr. (3 and 0)
Shape modeling and design by computer; curve and surface representation, methods of solid modeling by computer, database representation and integral properties of solid models. **Prerequisite:** Graduate standing.

ENGINEERING MECHANICS

Christian E. Przirembel, 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.

General areas of concentration are solid mechanics, composite materials, numerical methods and dynamics. Some limitations are imposed on the selection of courses to reflect the particular concentration. The usual minor is mathematics. Suitable minor programs also may be arranged in physics, civil engineering or mechanical engineering.

Candidates for the M.S. degree are required to write a thesis.

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|--------|---|
| EM 625 | ADVANCED STRENGTH OF MATERIALS
3 cr. (3 and 0) |
| EM 630 | MECHANICS OF COMPOSITE 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; 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 PHYS 812. |

- 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 852
(CE 852) ADVANCED FINITE ELEMENT ANALYSIS
3 cr. (3 and 0)
Application of variational and weighted residuals methods; nonlinear analysis, steady-state and time-dependent problems; application of commercial finite element codes; advanced computational procedures. **Prerequisite:** ME 418/618, CE 808 or equivalent, or permission of instructor.
- EM 860 MECHANICS OF PLASTICITY
3 cr. (3 and 0)
Behavior of materials in the plastic stress range, including large and small strain theories; deformation and flow theories of plasticity; yield criteria, Prandtl-Reuss and Levy-Mises stress-strain relations; analytical and numerical solution methods. **Prerequisite:** EM 831 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 901 FOUNDATIONS OF NONLINEAR SHELL THEORY
3 cr. (3 and 0)
Development of classical linear and nonlinear foundations used to analyze thin shells of arbitrary geometric shape; general equations are specialized for thin shells made from isotropic and orthotropic materials and nonhomogeneous shells such as sandwich and fiber-reinforced composite shells. **Prerequisites:** EM 829 and 831.
- EM 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

ENVIRONMENTAL SYSTEMS ENGINEERING

Thomas M. Keinath, Head, Department of Environmental Systems Engineering

Major	Degrees
Environmental Systems Engineering	M.Engr., M.S., Ph.D.

Environmental systems engineering is concerned with the engineering aspects of the control of the environment. Emphasis is placed on applying fundamental principles of the basic and engineering sciences through research and design to environmental engineering problems.

The M.Engr. program is designed to build on an ABET-accredited engineering baccalaureate background, while the M.S. degree builds on a student's previous engineering or science background. 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. Students usually elect to specialize in one of seven areas: (1) water and wastewater treatment systems, (2) hazardous waste treatment systems, (3) hazardous waste management, (4) air pollution control, (5) environmental biology, (6) environmental chemistry, and (7) nuclear environmental engineering. Master's degree candidates must complete 24 hours of course work and six hours of research culminating in the presentation of a satisfactory thesis for M.S. candidates or a special problem report for M.Engr. candidates. A nonthesis option is available.

The Ph.D. program is directed toward providing the student with a comprehensive background in the fundamental aspects of environmental engineering. The major field of study is generally interdisciplinary in nature, consisting of course work in several areas of engineering and the basic sciences. Each student's research program is tailored to suit his or her personal and professional goals. Qualifying, comprehensive and final examinations are required. No foreign language is required.

ESE 601	ENVIRONMENTAL ENGINEERING 3 cr. (3 and 0)
ESE 602	WATER AND WASTE TREATMENT SYSTEMS 3 cr. (3 and 0)
ESE 608 (AG E 608) (AGRON 608)	LAND TREATMENT OF WASTEWATER AND SLUDGES 3 cr. (3 and 0)
ESE 610	ENVIRONMENTAL RADIATION PROTECTION 3 cr. (3 and 0)
ESE 611	IONIZING RADIATION DETECTION AND MEASUREMENT 2 cr. (1 and 3)
ESE 630	AIR POLLUTION ENGINEERING 3 cr. (3 and 0)
ESE 651 (AG E 651) (FOR 651)	NEWMAN SEMINAR AND LECTURE SERIES IN NATURAL RESOURCES ENGINEERING 1 cr. (0 and 2) S, F
ESE 670	WATER RESOURCES ENGINEERING 3 cr. (3 and 0)

- ESE 682
(CE 682) GROUNDWATER AND CONTAMINANT TRANSPORT
3 cr. (3 and 0)
- ESE 684 MUNICIPAL SOLID WASTE MANAGEMENT
3 cr. (3 and 0)
- ESE 685 HAZARDOUS WASTE MANAGEMENT
3 cr. (3 and 0)
- ESE 701 SPECIAL PROBLEMS
1-6 cr. (1-6 and 0)
Environmental engineering problems selected to meet the interests and experience of student and instructor. Formal report required. Restricted to Master of Engineering students. Graded on a pass/fail basis.
- ESE 802 ENVIRONMENTAL ENGINEERING PRINCIPLES
3 cr. (3 and 0)
Fundamental principles required for simulation and modeling of environmental engineering phenomena. Topics include mass transfer, reactor kinetics, simulation techniques and applications to various natural and engineered systems.
- ESE 803 PHYSICOCHEMICAL OPERATIONS IN WATER AND WASTEWATER TREATMENT SYSTEMS
4 cr. (4 and 0)
Principles of physicochemical operations used in water and wastewater treatment, including sedimentation, filtration, mixing, gas transfer, adsorption, ion exchange, coagulation, precipitation, disinfection and oxidation. **Prerequisites:** ESE 802 and 843.
- ESE 804 BIOCHEMICAL OPERATIONS IN WASTEWATER TREATMENT SYSTEMS
3 cr. (3 and 0)
Principles of biochemical operations used in wastewater treatment; includes modeling of ideal biochemical reactors and design criteria for aerated lagoons, activated sludge, trickling filters, rotating biological contactors, nitrification, denitrification and digestion. **Prerequisites:** ESE 802 and either ESE 851 or permission of instructor.
- ESE 805 LABORATORY IN WATER AND WASTEWATER TREATMENT OPERATIONS
2 cr. (0 and 6)
Laboratory exercises in selected water and wastewater treatment operations, including sedimentation, filtration, adsorption, coagulation, softening, aeration, activated sludge, aerobic digestion and anaerobic digestion. **Corequisites:** ESE 803 and 804.
- ESE 806 INTEGRATED DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS
4 cr. (4 and 0)
Integration of unit operations into complex systems for treatment of industrial/domestic water and wastewater, contaminated groundwater, landfill leachate and toxic liquid wastes; the team approach is employed in the design of one integrated system for either water/wastewater or a hazardous/toxic waste. **Prerequisites:** ESE 803 and 804.

ENVIRONMENTAL SYSTEMS ENGINEERING

- ESE 809 INDUSTRIAL WASTEWATER TREATMENT
3 cr. (3 and 0)
Industrial wastewater management and the application of liquid treatment processes to the solution of specific industrial wastewater problems; case studies of industrial wastewater treatment strategies. **Prerequisites:** ESE 803 and 804.
- 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
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 wash-out of pollutants; air chemistry; 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 843 ENVIRONMENTAL ENGINEERING CHEMISTRY
3 cr. (3 and 0)
Principles of chemical kinetics and thermodynamics applied to fundamental understanding of aqueous environmental samples including natural waters, wastewaters and treated waters; factors controlling chemical concentrations, acid-base equilibria, solubility equilibria, complex formation, electrochemistry, adsorption phenomena. **Prerequisites:** CHEM 101 and 102 or equivalent.
- ESE 844 ENVIRONMENTAL ENGINEERING CHEMISTRY LABORATORY I
2 cr. (1 and 3)
Laboratory exercises in common analytical methods used for environmental samples with emphasis on waters and wastewaters; lec-

- tures provide background and theory for the laboratory sessions and cover selection and evaluation of parameters and methods, interpretation of data and quality assurance in sample collection and analysis. **Prerequisite:** Two semesters of general chemistry.
- ESE 847 **ADVANCED TOPICS IN ENVIRONMENTAL ENGINEERING CHEMISTRY**
3 cr. (3 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 843 or equivalent.
- ESE 849 **ENVIRONMENTAL 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; 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 nonconservative materials through estuarine systems; the estuary as a resource, and techniques for its management.
- ESE 851 **BIOLOGICAL PRINCIPLES OF ENVIRONMENTAL ENGINEERING**
3 cr. (3 and 0)
Basic principles of biology and biochemistry as applied to problems of environmental control and wastewater treatment; kinetic and energetic aspects are emphasized.
- 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.

ENVIRONMENTAL SYSTEMS ENGINEERING

- ESE 861 ENVIRONMENTAL SYSTEMS ENGINEERING SEMINAR
1 cr. (1 and 0)
Current advances and research developments in various areas of environmental engineering; off-campus speakers, students and faculty participate. Graded on a pass/fail basis.
- ESE 862 ENVIRONMENTAL QUALITY CASE STUDY
1 cr. (0 and 3)
Analysis and investigation of a significant current or recent situation affecting or involving some facet of environmental quality. Study is conducted by a team of students and results 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 processes; 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 880 ENVIRONMENTAL RISK ASSESSMENT
3 cr. (3 and 0)
Methodology of quantitative risk assessment, including identification and quantification of the source term, calculation of environmental transport and estimation of health effects; applications involve various classes of contaminants in atmospheric and aquatic environmental pathways. **Prerequisites:** MTH SC 208 and graduate-level standing in engineering or science.
- ESE 881 SPECIAL PROBLEMS
1-4 cr.
Problems selected to meet interests and experience of student and instructor.
- ESE 883 SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING
1-4 cr.
A topic in environmental engineering not covered in another course. Topic varies 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 topic in environmental engineering not covered in another course. Topic varies 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.

INDUSTRIAL ENGINEERING

Michael Steven Leonard, Head, Department of Industrial Engineering

Major	Degrees
Industrial Engineering	M.S., Ph.D.

Industrial engineering is concerned with the design, improvement and installation of integrated systems of people, materials, equipment and information. It draws upon specialized knowledge and skill in the mathematical, physical and social sciences, together with the principles and methods of engineering analysis and design, to specify, predict and evaluate the results obtained from such systems.

The focus of the graduate program in industrial engineering is on integrated manufacturing. In general, students concentrate their studies in one of three areas: human factors engineering, manufacturing systems and operations research. They choose supporting course work from these fields and from other departments. Areas of research interest among the faculty include: applied optimization, computer-integrated manufacturing, design methodology, engineering economic analysis, facility planning and material handling, health care and information systems design, human-computer interaction, human-machine systems engineering, industrial ergonomics, maintenance systems design, manufacturing systems engineering, production planning and control, quality engineering, solid and hazardous waste management, and systems modeling and simulation. A variety of laboratory facilities are available within the department to support research in these areas.

Students with a bachelor's degree in engineering or the physical sciences may be accepted. Those with other backgrounds may be accepted or may be required to successfully complete certain prerequisite courses before acceptance into the program. Entering graduate students are assumed to have competency in the following areas: mathematics, including calculus, linear algebra, differential equations, probability and statistics; calculus-based physics; and computer programming. A student with deficiencies in these areas will be required to take additional undergraduate course work as a condition of admission to the graduate program. All graduate students who do not have a bachelor's degree in industrial engineering must successfully complete IE 666. This course cannot be used to fulfill credit hour requirements for a graduate degree.

Students may pursue an M.S. degree with a thesis, requiring a minimum of 24 credit hours of course work, six credit hours of master's thesis research and one credit hour of seminar. Alternatively, students may pursue an M.S. degree without a thesis, requiring a minimum of 30 credit hours of course work, three credit hours of project work and one credit hour of seminar. The prescribed credit hours of course

INDUSTRIAL ENGINEERING

work are agreed upon by the student and his or her advisory committee and are in addition to any needed to compensate for undergraduate deficiencies.

Work leading to the Ph.D. degree is planned to give the student a comprehensive knowledge of the field of industrial engineering and a mastery of the methods of research. The advisory committee will aid the student in developing a doctoral degree curriculum. No minimum course work requirements exist for the doctoral degree. A dissertation is mandatory for all Ph.D. candidates and requires 18 credit hours of doctoral research.

IE 601	WORK METHODS AND MEASUREMENT II 3 cr. (2 and 3)
IE 652	RELIABILITY ENGINEERING 3 cr. (3 and 0)
IE 661	QUALITY ENGINEERING 3 cr. (3 and 0)
IE 665	FACILITIES PLANNING AND DESIGN 4 cr. (3 and 3)
IE 666	PRODUCTION SYSTEMS ENGINEERING 3 cr. (2 and 3)
IE 673	MICROCOMPUTER APPLICATIONS IN INDUSTRIAL ENGINEERING 3 cr. (2 and 3)
IE 674	ADVANCED MANUFACTURING SYSTEMS 3 cr. (2 and 3)
IE 675	MANUFACTURING CONTROL SYSTEMS 3 cr. (2 and 3)
IE 680	METHODS OF OPERATIONS RESEARCH I 3 cr. (3 and 0)
IE 681	METHODS OF OPERATIONS RESEARCH II 3 cr. (3 and 0)
IE 682	SYSTEMS MODELING 3 cr. (3 and 0)
IE 683	CASE STUDIES IN INDUSTRIAL ENGINEERING 3 cr. (3 and 0)
IE 685	INDUSTRIAL SYSTEMS ENGINEERING 3 cr. (3 and 0)
IE 686	PRODUCTION PLANNING AND CONTROL 3 cr. (3 and 0)
IE 688	HUMAN FACTORS ENGINEERING 3 cr. (2 and 3)

- IE 689 INDUSTRIAL ERGONOMICS
3 cr. (2 and 3)
- IE 691 SELECTED TOPICS IN INDUSTRIAL ENGINEERING
1-3 cr. (0-3 and 0-9)
- IE 692 DESIGN TOPICS IN INDUSTRIAL ENGINEERING
1-3 cr. (1-3 and 0)
- IE 703 ENGINEERING PROJECT OPERATIONS
3 cr. (3 and 0)
Project organization and planning; project engineering; decision-making process; patterns of leadership; project financial analysis; time-cost-performance trade-offs and sensitivity analysis; project scheduling and control techniques; project documentation; communication; communication skills. **Prerequisite:** B.S. degree in engineering.
- IE 801 ANALYSIS, MODELING AND DESIGN OF HUMAN-MACHINE SYSTEMS
3 cr. (3 and 0)
Human factors engineering methodology used in the design and evaluation of human-machine systems, including function and task analysis; mathematical, simulation and cognitive models of human performance; subjective and objective observations; critical incident and statistical techniques; and ethical principles in research involving human participants. **Prerequisite:** IE 688 or permission of instructor.
- IE 802 DESIGN OF HUMAN-COMPUTER SYSTEMS
3 cr. (3 and 0)
Issues in designing, implementing, maintaining and refining the user interface of interactive computer systems, including interface design theories, models, principles and guidelines; interaction styles; input and output devices; system messages; screen design, manuals, on-line help and tutorials; and iterative design, testing and evaluation. **Prerequisites:** IE 801 and MA SC 814 or permission of instructor.
- IE 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; implicit enumeration. **Prerequisite:** Multivariate calculus or permission of instructor.
- IE 804 MANUFACTURING SYSTEMS PLANNING AND DESIGN
3 cr. (3 and 0)
Concepts and principles associated with the design of manufacturing systems with a focus on operational methodologies, selection criteria and implementation concerns. Topics include computerized manufacturing systems, process planning, MRP, CRP and design for manufacturing. **Prerequisites:** IE 306 and 473 or permission of instructor.

- IE 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, SLAM and/or SIMAN. **Prerequisite:** Introductory statistics or permission of instructor.
- IE 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 SIMAN, SLAM and/or DYNAMO. **Prerequisite:** IE 807 or permission of instructor.
- IE 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:** IE 680 and multivariate calculus or permission of instructor.
- IE 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; accelerating adaptive direct search methods. **Prerequisites:** IE 680 and multivariate calculus or permission of instructor.
- IE 865 FACILITY PLANNING AND MATERIAL HANDLING
3 cr. (3 and 0)
Planning and design of production facilities with emphasis on material handling and automated manufacturing systems; quantitative approaches to equipment design and evaluation of system performance. **Prerequisites:** IE 480/680 and 486/686.
- IE 871 INDUSTRIAL TESTING AND QUALITY
3 cr. (3 and 0)
Design and use of component and product tests; automated inspection; test and inspection in integrated systems; cost-based models. **Prerequisite:** IE 661.
- IE 873 COMPUTER-AIDED MANUFACTURING
3 cr. (2 and 3)
Process planning; group technology; materials planning and control systems; automated manufacturing systems planning and control. **Prerequisite:** IE 482/682.
- IE 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:** IE 681 or permission of instructor.

- IE 884 **ADVANCED ENGINEERING ECONOMIC ANALYSIS**
3 cr. (3 and 0)
Engineering economic analysis for engineering research, development and construction projects, emphasizing detailed treatment of tax effects, methods for determining discount rates, proper use of economic criteria in various decision environments (certainty vs. uncertainty, single vs. multiple project selections, etc.). **Prerequisite:** Permission of instructor.
- IE 885 **DESIGN AND ANALYSIS OF SIMULATION MODELS**
3 cr. (3 and 0)
Design and validation of operations research-type simulation models; statistical analysis of input and output data of these models. **Prerequisites:** IE 807 and MA SC 814 or permission of instructor.
- IE 886 **OPERATIONS RESEARCH IN PRODUCTION CONTROL**
3 cr. (3 and 0)
Latest techniques in scientific inventory management, scheduling and forecasting; operations research; statistics; computer methods; case studies. **Prerequisites:** IE 680 and multivariate calculus or permission of instructor.
- IE 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, value and policy iteration techniques. **Prerequisites:** IE 680 and multivariate calculus or permission of instructor.
- IE 890 **SPECIAL PROBLEMS IN INDUSTRIAL ENGINEERING**
1-3 cr. (1-3 and 0)
Principles and methods of industrial engineering applied to analysis of a current interest problem. May be repeated for additional credit. **Prerequisite:** Permission of instructor.
- IE 891 **MASTER'S THESIS RESEARCH**
Credit to be arranged.
- IE 893 **SELECTED TOPICS IN INDUSTRIAL ENGINEERING**
1-3 cr. (1-3 and 0)
Selected topics in industrial engineering emphasizing new developments in systems science, systems analysis and operations research. May be repeated for additional credit. **Prerequisite:** Permission of instructor.
- IE 895 **INDUSTRIAL ENGINEERING SEMINAR**
1 cr. (1 and 0)
Series of weekly, one-hour seminars given by students, faculty and guests on topics of current interest. Graded on a pass/fail basis.
- IE 907 **PRODUCTION SYSTEMS SIMULATION**
3 cr. (2 and 3)
Simulation modeling of production systems with emphasis on significant design and control issues in automated manufacturing. **Prerequisite:** IE 807.
- IE 991 **DOCTORAL DISSERTATION RESEARCH**
Credit to be arranged.

MECHANICAL ENGINEERING

Christian E. Prziembel, 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. Students in the M.S. degree program may choose the thesis or nonthesis option.

Programs may be selected with concentrations in mechanical and manufacturing systems design (CAD/CAM, kinematics and dynamics, materials, robotics and vibrations) or thermal/fluid sciences (fluid mechanics, heat transfer, thermodynamics and energy systems).

ME 604	CONTROL SYSTEMS DESIGN 3 cr. (3 and 0)
ME 607	APPLIED HEAT TRANSFER 3 cr. (3 and 0)
ME 610	FRACTURE AND FATIGUE CONTROL IN ENGINEERING STRUCTURES 3 cr. (3 and 0)
ME 611	GAS POWER SYSTEMS 3 cr. (3 and 0)
ME 618	FINITE ELEMENT ANALYSIS OF MECHANICAL ENGINEERING SYSTEMS 3 cr. (3 and 0)
ME 620	ENERGY SOURCES AND THEIR UTILIZATION 3 cr. (3 and 0)
ME 621	INTRODUCTION TO COMPRESSIBLE FLOW 3 cr. (3 and 0)
ME 622	DESIGN OF GAS TURBINES 3 cr. (3 and 0)
ME 623	INTRODUCTION TO AERODYNAMICS 3 cr. (3 and 0)
ME 625	KINEMATICS AND DYNAMICS OF MACHINERY II 3 cr. (3 and 0)
ME 629	THERMAL ENVIRONMENTAL CONTROL 3 cr. (3 and 0)
ME 653	DYNAMIC PERFORMANCE OF VEHICLES 3 cr. (3 and 0)
ME 654	DESIGN OF MACHINE ELEMENTS 3 cr. (3 and 0)

- ME 655 DESIGN FOR COMPUTER-AUTOMATED MANUFACTURING
3 cr. (3 and 0)
- ME 656 DESIGN AND APPLICATION OF INDUSTRIAL ROBOTS
3 cr. (3 and 0)
- ME 659 MATERIALS SELECTION IN DESIGN
3 cr. (3 and 0)
- ME 660 DEFORMATION PROCESSING
3 cr. (3 and 0)
- ME 693 SELECTED TOPICS IN MECHANICAL ENGINEERING
1-6 cr.
- 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 multidimensional 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 807 MECHANICAL SYSTEMS
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; 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. **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:** Undergraduate course in fluid mechanics.
- ME 812 EXPERIMENTAL METHODS IN THERMAL SCIENCE
3 cr. (2 and 2)
Theories of measurements and instrumentation and techniques for measuring temperature, pressure and velocity on a practical graduate engineering level; mathematical presentation of data, uncertainty analysis, data acquisition techniques, and theory and state-of-the-art measuring systems.

MECHANICAL ENGINEERING

- ME 814 CONCEPTS OF TURBULENT FLOW
 3 cr. (3 and 0)
 Concepts of fluid turbulence; turbulent transport mechanisms, dynamics of turbulence and experimental techniques pertinent to existing theories. Topics address classification of shear flows and their prediction methods. **Prerequisite:** ME 801.
- ME 815
 (PHYS 815) STATISTICAL THERMODYNAMICS I
 3 cr. (3 and 0)
 See PHYS 815 for description.
- 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 817 COMBUSTION THEORY
 3 cr. (3 and 0)
 Study of combustion theory and fundamentals, particularly in fluid flow situations; review of turbulent flame empirical results in combustion systems. **Prerequisites:** ME 801 and 810.
- ME 819 COMPUTATIONAL METHODS IN THERMAL SCIENCES
 3 cr. (3 and 0)
 Numerical techniques as applied to the solution of fluid flow and heat transfer problems. Emphasis is primarily on the use of finite difference methods. **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 822 COMPUTER CONTROL OF AUTOMATED MACHINES
 3 cr. (3 and 0)
 Concepts for control of automated manufacturing machines, cells and processes; logic and switching control; programmable controllers; supervisory hierarchical and expert control systems concepts for manufacturing; closed-loop direct digital control design, including sampling, stability and response of discrete system models; design and application of computer control algorithms; computer requirements; sensors and signal conversion. **Prerequisite:** ME 820 or permission of instructor.

- ME 830 CONDUCTION HEAT TRANSFER
3 cr. (3 and 0)
Analytical and numerical solutions of conduction heat transfer problems; steady one- and two-dimensional systems; extended surfaces; transient solutions; numerical solutions; transform methods. **Prerequisites:** ME 304 or equivalent and Graduate School enrollment.
- 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 non-condensable 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 class discussion and evaluation; principles of mechanical and engineering sciences introduced and applied as required for case considerations. **Prerequisite:** ME 306 or equivalent or permission of instructor.
- ME 843 NONLINEAR DYNAMICS OF MECHANICAL SYSTEMS
3 cr. (3 and 0)
Behavior of nonlinear mechanical systems analyzed with numerical, graphical and analytical methods; emphasis on understanding nonlinear effects and methods of analysis. **Prerequisite:** Graduate standing and/or permission of instructor.

MECHANICAL ENGINEERING

- ME 844 RANDOM VIBRATION: THEORY AND MEASUREMENT
3 cr. (3 and 0)
Analysis and measurement of random phenomena. Topics include description of random phenomena (probability theory, response of systems to random phenomena and digital signal processing theory); use of spectrum analyzer and other digital signal recording instruments. **Prerequisites:** ME 302 or MTH SC 208 and 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 wave in solids and fluids; free forced oscillation of flexible strings, bars, membranes and plates; theory of wave motion in liquids and gases. **Prerequisite:** Permission of instructor.
- ME 851 TRIBIOLOGY
3 cr. (3 and 0)
Friction and wear processes are addressed from both microscopic and macroscopic viewpoints; study of the behavior of metallic components in tribosystems commonly associated with engineering machine design, also other classes of materials, especially those associated with antifriction or antiwear coating systems. **Prerequisites:** Graduate standing and 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 931 ADVANCED TOPICS IN FLUID MECHANICS
3 cr. (3 and 0)
Topics not covered in other courses. May be repeated for a maximum of six credits.
- ME 932 ADVANCED TOPICS IN THERMODYNAMICS
3 cr. (3 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.

- 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 NONFERROUS METALLURGY
3 cr. (3 and 0)
- MAT E 662 FERROUS METALLURGY
3 cr. (2 and 3)
- MAT E 663 METALLURGY OF WELDING AND NONDESTRUCTIVE TESTING
3 cr. (2 and 3)
- MAT E 664 INDUSTRIAL CORROSION OF METALS
3 cr. (3 and 0)
- 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. 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 nonmetals; ductile and brittle fractures; fatigue, creep and stress corrosion cracking of 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.

MECHANICAL ENGINEERING

- MAT E 826 PHASE EQUILIBRIA IN MATERIALS SYSTEMS
3 cr. (3 and 0)
Advanced treatment of phase equilibria in materials systems, phase diagrams, thermodynamics of defects, surfaces, interfaces and solutions. **Prerequisites:** CR E 310 and permission of instructor. **Corequisite:** ME 810.
- MAT E 827 KINETICS OF PHASE TRANSFORMATION
3 cr. (3 and 0)
Advanced treatment of the kinetics of phase transformation in materials systems, including nucleation, growth and spinodal decomposition. **Prerequisites:** MAT E 826 or equivalent, graduate standing and permission of instructor.

COLLEGE OF FOREST AND RECREATION RESOURCES

FOREST RESOURCES PARKS, RECREATION AND TOURISM MANAGEMENT

Course Number	Course Title	Prerequisites
FOR 201	FOREST RESOURCES	
FOR 202	FOREST MANAGEMENT	FOR 201
FOR 203	FOREST SOILS SEMINAR	FOR 201
FOR 204	FOREST ECONOMICS	FOR 201
FOR 205	FOREST UTILITIES	FOR 201
FOR 206	WOOD AND WOOD TECH IDENTIFICATION	FOR 201
FOR 207	FOREST OPERATIONS	FOR 201
FOR 208	PUBLIC RELATIONS IN WILDLIFE MANAGEMENT	FOR 201
FOR 209	FOREST RECREATION	FOR 201

COLLEGE OF FOREST AND RECREATION RESOURCES

Benton H. Box, Dean

The College of Forest and Recreation Resources offers advanced degrees in the following areas of study:

Forest Resources
Parks, Recreation and Tourism Management

The Master of Science and Doctor of Philosophy degrees are offered in forest resources and in parks, recreation and tourism management. The college also offers two professional degrees, the Master of Forest Resources and the Master of Parks, Recreation and Tourism Management.

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 forests and our recreation resources for their maximum service to present and future generations.

FOREST RESOURCES

William A. Leuschner, Head, Department of Forest Resources

Major	Degrees
Forest Resources	M.F.R., M.S., Ph.D.

Enrollment in the Master of Forest Resources and Master of Science programs is open to students having baccalaureate degrees in forestry, wood utilization or disciplines related to these fields. A master's degree, preferably in some forestry discipline, is required for enrollment in the Ph.D. program. The candidate may be required to satisfy undergraduate deficiencies before being admitted to full status.

A formal thesis is required for the M.S. and the Ph.D. degrees. For the M.F.R., a nonthesis 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 600	PUBLIC RELATIONS IN NATURAL RESOURCES 3 cr. (3 and 0)
FOR 602	FOREST MENSURATION 3 cr. (2 and 1) S
FOR 603	FOREST SOILS SEMINAR 1 cr. (1 and 0) S
FOR 604	FOREST ECONOMICS 3 cr. (3 and 0) F
FOR 605	FOREST INFLUENCES 2 cr. (2 and 0) F
FOR 606	WOOD AND WOOD FIBER IDENTIFICATION 2 cr. (1 and 3) S, F
FOR 607	FOREST OPERATIONS 3 cr. (2 and 1) F

- FOR 608 AERIAL PHOTOGRAPHS IN FORESTRY
3 cr. (2 and 3) S
- FOR 609 MULTIPLE-USE FORESTRY
2 cr. (2 and 0) S
- FOR 610 SILVICULTURE
4 cr. (3 and 3) S
- FOR 611 HARVESTING FOREST PRODUCTS
3 cr. (2 and 3) S
- FOR 612 FOREST PROTECTION
2 cr. (2 and 0) S
- FOR 613 INTEGRATED FOREST PEST MANAGEMENT
4 cr. (3 and 3) F
- FOR 614 FOREST MANAGEMENT PLANS
2 cr. (2 and 0) S
- FOR 615 FOREST WILDLIFE HABITAT MANAGEMENT
3 cr. (2 and 3) S
- FOR 616 FOREST POLICY AND ADMINISTRATION
2 cr. (2 and 0) F
- FOR 617 FOREST MANAGEMENT AND REGULATION
3 cr. (3 and 0) F
- FOR 618 FOREST VALUATION
3 cr. (3 and 0) F
- FOR 620 FOREST PRODUCTS
3 cr. (2 and 3) S
- FOR 621 BIOLOGY AND SILVICULTURE OF HARDWOOD FORESTS
2 cr. (1 and 2) F
- FOR 622 FOREST PRODUCTS INTERNATIONAL TRADE
3 cr. (3 and 0) F
- FOR 623 LECTURES IN FORESTRY
2 cr. (2 and 0) F
- FOR 624 FOREST GENETICS AND TREE BREEDING
3 cr. (3 and 0) S (even numbered years)
- FOR 629 WOOD DESIGN
3 cr. (2 and 3) F (odd numbered years)
- FOR 630 COMPOSITE WOOD MATERIALS
3 cr. (2 and 3) F (even numbered years)
- FOR 631 RECREATION RESOURCE PLANNING IN FOREST MANAGEMENT
2 cr. (1 and 3) F

FOREST RESOURCES

- FOR 632 FOREST SITE CAPABILITY
2 cr. (2 and 0) S
- FOR 634 FOREIGN WOODS AND THEIR PROPERTIES
2 cr. (1 and 3) S (odd numbered years)
- FOR 635 PARK AND FOREST STRUCTURES
2 cr. (2 and 0) F
- FOR 636 WOOD AS AN ENERGY SOURCE
2 cr. (2 and 0) S (odd numbered years)
- FOR 651
(AG E 651)
(ESE 651) NEWMAN SEMINAR AND LECTURE SERIES IN NATURAL
RESOURCES ENGINEERING
1 cr. (0 and 2) S, F
- FOR 707 SPECIAL PROBLEMS IN FORESTRY
1-3 cr. (1-3 and 0)
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) S
Illustration, analysis and discussion of specific approaches used in
forestry problems for handling, arranging and analyzing large vol-
umes of field data and for presentation in concise, meaningful
form. **Prerequisite:** Permission of instructor.
- FOR 802 ADVANCED MENSURATION
3 cr. (2 and 3) S (even numbered years)
Continuation of FOR 602, emphasizing specialized sampling tech-
niques and statistical methods often required only in forestry; com-
pilation of timber volume tables; forest survey problems. **Prerequi-
sites:** EX ST 301 and 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; using aerial
photographs in timber inventories and cruising. **Prerequisites:**
EX ST 301 and 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 in
problems of resource allocation and efficiency in forest manage-
ment. **Prerequisites:** FOR 304/604 and 418/618 or permission of
instructor.
- FOR 805 FOREST LANDSCAPE ECOSYSTEMS
3 cr. (3 and 0) F (even numbered years)
The three basic landscape components of soils, landform and veg-
etation and their interrelationships in forest ecosystems, empha-
sizing factors and processes of soils as interacting components with
landform and vegetation. **Prerequisite:** Graduate standing or per-
mission of instructor.

- FOR 806 **ADVANCED SILVICULTURE—FOREST TREE GROWTH AND DEVELOPMENT**
3 cr. (3 and 0) F (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.
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 809 **PRODUCTS BIODETERIORATION**
2 cr. (1 and 3) F (even numbered years)
The role of microorganisms in reducing the strength, aesthetics and value of products in service. Emphasis is on deterioration of wood.
- FOR 810 **FOREST LANDSCAPE ECOSYSTEMS OF THE GREAT SMOKY MOUNTAINS**
2 cr. (1 and 1)
Observation and measurements of species composition, community structure, soil-site relationships, land use practices within the forest ecosystems of Great Smoky Mountains National Park; field data interpreted and illustrated using ordination and classification techniques common in ecological studies. **Prerequisite:** Permission of instructor.
- FOR 814 **ADVANCED FOREST RESOURCE MANAGEMENT AND PLANNING**
3 cr. (3 and 0)
Current forest resource management and planning topics; operational emphasis on application of various quantitative tools to solve economic and management problems; advanced topics in forest regulation, forest valuation, mathematical programming and harvest scheduling, simulation, multiple-use alternatives and selected areas. **Prerequisite:** FOR 417/617 or permission of instructor.
- FOR 825 **WOOD CHEMISTRY**
3 cr. (2 and 1) F (even numbered years)
Chemical composition of wood and related lignocellulosic substances and the chemistry of individual wood components; chemical reactions and applications of cellulose, hemicelluloses, lignin and extractives.
- FOR 891 **MASTER'S THESIS RESEARCH**
Credit to be arranged.
- FOR 991 **DOCTORAL DISSERTATION RESEARCH**
Credit to be arranged.

PARKS, RECREATION AND TOURISM MANAGEMENT

Lawrence R. Allen, Head, Department of Parks, Recreation and Tourism Management

Major	Degrees
Parks, Recreation and Tourism Management	M.P.R.T.M., M.S., Ph.D.

The department offers a professional master's degree (M.P.R.T.M.), a Master of Science degree (M.S.) and a Doctor of Philosophy degree (Ph.D.). Flexibility permits individual development in professional interest areas such as therapeutic recreation, travel and tourism management, recreation resource management and interpretation, and administration of recreation, park or tourism systems. Each student's program is tailored to suit his or her personal and professional goals. Applicants from nonrecreation disciplines are required to develop background knowledge of recreation through undergraduate course work. All applicants must submit scores from the Graduate Record Examination.

The professional master's degree (Master of Parks, Recreation and Tourism Management) should be selected by individuals who intend to enter or reenter the workplace upon the completion of degree requirements. Each candidate completes an independent project to meet degree requirements. A minimum of 36 hours of course work is required.

The Master of Science is a research degree with a research thesis requirement. This degree is designed for individuals planning to undertake doctoral study or seek employment in a research-related position. Candidates must complete a minimum of 30 hours of course work and six hours of research culminating in a thesis.

The Doctor of Philosophy is an advanced research degree requiring performance of original research leading to a dissertation. Comprehensive and final examinations and 18 hours of dissertation research are required. Course work is determined by each student's doctoral committee.

PRTM 600	SUPERVISION OF RECREATION PERSONNEL PATTERNS AND PROCESSES 3 cr. (3 and 0)
PRTM 601	WORLD GEOGRAPHY OF RECREATION AND PARKS 3 cr. (3 and 0)
PRTM 602	CAMPUS RECREATION 3 cr. (3 and 0)
PRTM 611	THERAPEUTIC RECREATION FOR SELECTED POPULATIONS 3 cr. (2 and 3)
PRTM 612	THERAPEUTIC RECREATION AND MENTAL HEALTH 3 cr. (3 and 0)
PRTM 613	THERAPEUTIC RECREATION FOR PHYSICALLY DISABLED 3 cr. (2 and 3)
PRTM 614 (ED 614)	RECREATION AND LEISURE FOR SPECIAL POPULATIONS 3 cr. (3 and 0)
PRTM 621	RECREATION FINANCIAL RESOURCE MANAGEMENT 3 cr. (3 and 0)

- PRTM 631 METHODS OF ENVIRONMENTAL INTERPRETATION
3 cr. (2 and 3)
- PRTM 632 HISTORIC SITE INTERPRETATION
3 cr. (3 and 0)
- PRTM 633 INTRODUCTION TO MUSEOLOGY
3 cr. (2 and 3)
- PRTM 641 COMMERCIAL RECREATION
3 cr. (3 and 0)
- PRTM 643 RESORTS IN NATIONAL AND INTERNATIONAL TOURISM
3 cr. (3 and 0)
- PRTM 644 TOUR PLANNING AND OPERATIONS
3 cr. (3 and 0)
- PRTM 645 CONFERENCE/CONVENTION PLANNING AND MANAGEMENT
3 cr. (3 and 0)
- PRTM 646 COMMUNITY TOURISM DEVELOPMENT
3 cr. (3 and 0)
- PRTM 647 PERSPECTIVES ON INTERNATIONAL TRAVEL
3 cr. (3 and 0)
- PRTM 648 MICRO-ORGANIZATION OF THE TOURISM INDUSTRY
3 cr. (3 and 0)
- PRTM 649 TOURISM AND REGIONAL DEVELOPMENT
3 cr. (3 and 0)
- PRTM 701 FOUNDATIONS OF PARKS, RECREATION AND TOURISM
MANAGEMENT
2 cr. (2 and 0)
Basic concepts and principles in the parks, recreation and tourism
management field. Does not count toward degree requirements for
PRTM students. **Prerequisite:** Graduate standing.
- PRTM 705 INTERNSHIP
1-3 cr. (0 and 9+)
Field placement in an approved agency under qualified supervi-
sion. Graded on a pass/fail basis. **Prerequisite:** PRTM student or
permission of instructor.
- PRTM 706 COMPUTER-ASSISTED ADMINISTRATION IN LEISURE SERVICES
3 cr. (2 and 3)
Decision-making and administrative techniques featuring the use
of the microcomputer and related software to resolve administra-
tive problems in the field of leisure services.
- PRTM 707 PRINCIPLES OF ENVIRONMENTAL INTERPRETATION
3 cr. (3 and 0)
Methods of providing learning experiences in the out-of-doors,
focusing on meaning, scope and values of interpretation.

- PRTM 708 **SELECTED TOPICS**
 1-3 cr. (1-3 and 0)
 Topics in recreation, leisure and tourism; students study an area not covered in other courses; a written report of findings is required. May be repeated for a maximum of three credits. **Prerequisite:** Permission of the supervising faculty before registration.
- PRTM 709 **SPECIAL PROBLEMS**
 1-3 cr. (1-3 and 0)
 Directed, individual comprehensive investigation of a special problem to use knowledge gained in formal courses, provide experience and training in research, and prepare for professional goals; report of findings required. May be repeated with a maximum of three credit hours applied toward graduation requirements. Graded on a pass/fail basis.
- PRTM 710 **CURRENT ISSUES IN RECREATION**
 1 cr. (1 and 0)
 Seminar in current topics, 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.
- PRTM 801 **PHILOSOPHICAL FOUNDATIONS OF RECREATION AND PARK ADMINISTRATION**
 3 cr. (3 and 0)
 Current theories and philosophies in recreation as they are influenced by and have influence on leisure and the changing environment in America. Student develops his or her own professional philosophy of recreation and leisure.
- PRTM 802 **GROUP PROCESSES IN LEISURE SERVICES**
 3 cr. (3 and 0)
 Improvement in human relations skills; knowledge of interpersonal needs and problems of individuals and groups; students gain understanding of how others affect them and how they affect others and become more effective professional recreators, park administrators, supervisors, interpreters and educators.
- PRTM 803 **SEMINAR IN RECREATION AND PARK ADMINISTRATION**
 3 cr. (3 and 0)
 Case problems relating to administration of a park, recreation or tourism agency.
- PRTM 804 **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 government agencies.
- PRTM 805 **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.

- PRTM 806 URBAN RECREATION ANALYSIS
3 cr. (3 and 0)
Interrelationship of social, political and economic factors in providing public or private recreation services in urban areas.
- PRTM 807 RECREATION BEHAVIOR IN NATURAL ENVIRONMENTS
3 cr. (3 and 0)
The social, psychological and environmental influences on human behavior; identification of theoretical perspectives to explain behavior and to resolve problems in recreation resource management. **Prerequisite:** Graduate standing.
- PRTM 808 BEHAVIORAL ASPECTS OF PARKS, RECREATION AND TOURISM MANAGEMENT
3 cr. (3 and 0)
Behavioral aspects of recreation, focusing on the social and psychological dimensions of the recreation experience in a variety of environments and activities. **Prerequisite:** Graduate standing.
- PRTM 811 RESEARCH METHODS IN PARKS, RECREATION AND TOURISM MANAGEMENT
3 cr. (3 and 0)
Principles, methods and strategies for planning, designing, evaluating and applying studies of recreation. **Prerequisite:** A graduate-level statistics course or permission of instructor.
- PRTM 812 LEISURE SERVICES FOR THE ELDERLY
3 cr. (3 and 0)
The elderly and the role of leisure services in later life; needs of community-based and institutionalized elderly; service delivery systems to meet these needs.
- PRTM 815 THERAPEUTIC RECREATION AND ACTIVITY THERAPY ADMINISTRATION
3 cr. (3 and 0)
Service delivery structures; interdisciplinary relationships; consultation methods; in-service training; funding sources; service evaluation in therapeutic recreation and activity therapy programs.
- PRTM 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.
- PRTM 840 TOURISM PLANNING
3 cr. (3 and 0)
Tourism planning procedures and techniques. Topics include the planning process and associated concerns such as market, facility, infrastructure, environment, culture and economics. **Prerequisite:** Graduate standing.

PARKS, RECREATION AND TOURISM MANAGEMENT

- PRTM 841 SEMINAR IN EXPOSITION MANAGEMENT
3 cr. (3 and 0)
Students gain an understanding of the theory, concepts and practices necessary to assume positions with world fairs, agricultural fairs and arenas, trade shows, national and world trade centers, or consumer and industrial exhibitions.
- PRTM 843 TOURISM ANALYSIS
3 cr. (3 and 0)
Selected theories, methods, techniques, practices and principles which govern tourism behavior. **Prerequisite:** Graduate standing or one graduate level statistics course or permission of instructor.
- PRTM 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- PRTM 908 ADVANCED TOPICS
1-3 cr. (1-3 and 0)
Advanced study of topics not covered in other PRTM courses and not directly related to a thesis or dissertation topic; a formal paper is required. May be taken for a maximum of three credits per semester. May be repeated for a maximum of six credits. **Prerequisite:** Permission of instructor.
- PRTM 910 RESEARCH SEMINAR
1 cr. (1 and 0)
Current research developments in PRTM and presentation of research projects. May be taken for credit for two semesters. Graded on a pass/fail basis.
- PRTM 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged

COLLEGE OF LIBERAL ARTS

APPLIED PSYCHOLOGY
APPLIED SOCIOLOGY
ENGLISH
HISTORY
LANGUAGES
PHILOSOPHY AND RELIGION
POLITICAL SCIENCE

COLLEGE OF LIBERAL ARTS

Robert A. Waller, Dean

The College of Liberal Arts offers advanced degrees in the following areas of study:

Applied Psychology
Applied Sociology
English
History

Graduate courses also are offered in geography, languages, philosophy, political science, religion and speech to accommodate special programs and to provide elective courses for students enrolled in other graduate areas.

APPLIED PSYCHOLOGY

Eugene H. Galluscio, Head, Department of Psychology

Major	Degree
Applied Psychology	M.S.

The Psychology Department offers an M.S. degree in applied psychology with areas of concentration in industrial/organizational and human factors psychology. Both areas of concentration are specifically designed to provide the student with the requisite theoretical foundations, skills in quantitative techniques and experimental design, and practical problem-solving skills to address human problems related to work in industry, business and government. The Psychology Department is a member of the Council on Applied Master's Programs in Psychology.

Applicants for the M.S. degree in applied psychology should have an undergraduate degree from an accredited college or university with a major in psychology or a related field. Students with a major other than psychology should have a minimum of 15 semester hours of undergraduate psychology courses beyond the introductory survey course.

M.S. students complete 45 semester hours, including six semester hours of thesis credit and three to eight semester hours of credit for completion of a supervised field internship. The location of the internship site is coordinated, in advance, by the student, the student's major advisor and the on-site supervisor. Typically, the internship is completed in the summer between the first and second years of the program. In some cases, six semester hours of approved electives may be substituted for the field internship. The core requirements for the two areas of concentration are:

1. Industrial/Organizational Psychology — PSYCH 671, 810, 811, 860, 861, 862, 863, 891 and 895; and
2. Human Factors Psychology — IE 688, PSYCH 635, 671, 810, 811, 822, 833, 891 and 895.

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 635 HUMAN FACTORS PSYCHOLOGY
3 cr. (3 and 0)
- PSYCH 659 GROUP DYNAMICS
3 cr. (3 and 0)
- PSYCH 670 THEORIES OF PERSONALITY
3 cr. (3 and 0)
- PSYCH 671 PSYCHOLOGICAL TESTING
3 cr. (3 and 0)
- PSYCH 680 HEALTH PSYCHOLOGY
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)
- PSYCH 810 RESEARCH DESIGN AND QUANTITATIVE METHODS I
3 cr. (3 and 0)
Bivariate and multivariate data analysis applied to industrial and other work-related settings. Topics include the major data analytic tools needed for research in applied psychology. **Prerequisite:** Six credits of statistics, research methods or equivalent.
- PSYCH 811 RESEARCH DESIGN AND QUANTITATIVE METHODS II
3 cr. (3 and 0)
Research methodologies, experimental, quasi-experimental and nonexperimental designs, with an emphasis on applied psychological research. Special topics include scientific method, basic versus applied research, technical writing, grant writing and ethics. **Prerequisite:** PSYCH 810.
- PSYCH 822 HUMAN PERCEPTION AND PERFORMANCE
3 cr. (3 and 0)
Basic research on human perception as applied to task performance. Focus is on vision and audition in adults, examining basic knowledge of human sensory and perceptual characteristics as applied to such tasks as machine operation, task performance, etc.
- PSYCH 833 COGNITIVE PSYCHOLOGY
3 cr. (3 and 0)
Research and theory concerning perception, memory, reasoning, problem solving, knowledge representation, psychology of language, semantics, attention, concept formation and other high-level mental processes; applications of these areas are considered.
- PSYCH 860 PSYCHOLOGY OF TRAINING AND EVALUATION
3 cr. (3 and 0)
Evaluation issues such as criteria development, organizational assessment, process and outcome criteria along with instructional methodologies, such as fairness in training, special populations, second careers, hard-core unemployment, and ethics of organizational and industrial change. **Prerequisite:** A course in industrial psychology, personnel psychology or equivalent.

APPLIED PSYCHOLOGY

- PSYCH 861 PERSONNEL PSYCHOLOGY
3 cr. (3 and 0)
Theory, techniques and legal issues involved in the effective matching of individuals' needs, preferences, skills and abilities with the needs and preferences of organizations. Topics include research methods, prediction issues, tests and other predictors, decision making and job evaluation. **Prerequisite:** PSYCH 810.
- PSYCH 862 ORGANIZATIONAL DEVELOPMENT
3 cr. (3 and 0)
Forms of organizational structure and basic theories of organizations; theories and technologies of organizational development and change are stressed; course analyzes the relationships between organizational design and technology. **Prerequisite:** A course in industrial/organizational psychology or equivalent.
- PSYCH 863 WORK MOTIVATION AND SATISFACTION
3 cr. (3 and 0)
Explanations for absenteeism, productivity, job satisfaction and withdrawal, as well as their interrelations; methods of measuring attitudes and opinions and general theories of human motivation. **Prerequisite:** An industrial/organizational psychology course or equivalent.
- PSYCH 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- PSYCH 895 APPLIED PSYCHOLOGY INTERNSHIP
3-6 cr. (0 and 3-6)
Supervised field experience in industry, business or government; site location, on-site supervision and credit hours must be approved in advance by the graduate coordinator.
- PSYCH 897 SPECIAL PROBLEMS IN APPLIED PSYCHOLOGY
1-3 cr. (1-3 and 0)
Study of a particular topic under the direction of a faculty member; specific program is organized by the student and faculty member and submitted to the graduate coordinator for approval; project is not used to support M.S. thesis. May be repeated for a maximum of six credits.
- PSYCH 899 SELECTED TOPICS IN PSYCHOLOGY
3 cr. (3 and 0)
Selected current and classic topics not covered in other courses. May be repeated for a maximum of six credits.

APPLIED SOCIOLOGY

Richard F. Larson, Head, Department of Sociology

Major	Degree
Applied Sociology	M.S.

The Department of Sociology offers the M.S. degree in applied sociology, emphasizing practical and theoretical knowledge in the areas of industrial and

organizational sociology, and focusing on the acquisition of social research skills, theory application and practical field experience. Students are prepared for employment in federal, state and local government agencies, in industry and related agencies, and to pursue a doctorate.

Applicants must hold a bachelor's degree from an accredited degree program; have completed a minimum of 15 undergraduate semester hours in sociology or other social science discipline that includes at least one course each in statistics, research, methods and sociological theory; submit Graduate Record Examination scores on the verbal, quantitative and analytical sections (satisfactory scores normally include a minimum of 500 on each section of the test); submit three letters of recommendation, at least two of which are from faculty members of the applicant's previously attended college or university; and submit a 500-word essay on career aspirations and goals and how completion of this program in applied sociology will assist in achieving these goals.

Students may select the thesis or nonthesis option. The thesis option requires a minimum of 49 hours, and the nonthesis option requires 55 hours of graduate credit. Both options require a 12-hour placement in an applied context. The location of the placement is coordinated, in advance, by the student, the departmental field placement supervisor and the on-site supervisor. Typically, the internship is completed in the summer between the first and second years of the program but only after completing a minimum of 12 credit hours of 800-level sociology course work. In exceptional circumstances the graduate coordinator may approve the substitution of 12 hours of appropriate course work for the field placement when the student has had work experience comparable to the placement.

SOC 601 (RS 601)	HUMAN ECOLOGY 3 cr. (3 and 0) S
SOC 603 (RS 603)	METHODS OF SOCIAL RESEARCH II 3 cr. (3 and 0)
SOC 604	SOCIOLOGICAL THEORY 3 cr. (3 and 0)
SOC 630	SOCIOLOGY OF ORGANIZATIONS 3 cr. (3 and 0)
SOC 633	DEVELOPING SOCIETIES 3 cr. (3 and 0)
SOC 640	LEISURE, THE MASS MEDIA AND CULTURE 3 cr. (3 and 0)
SOC 641	SOCIOLOGY OF SPORT 3 cr. (3 and 0)
SOC 659 (RS 659)	THE COMMUNITY 3 cr. (3 and 0) F
SOC 660	RACE, ETHNICITY AND CLASS 3 cr. (3 and 0)
SOC 671 (RS 671)	DEMOGRAPHY 3 cr. (3 and 0) S
SOC 680	MEDICAL SOCIOLOGY 3 cr. (3 and 0)

APPLIED SOCIOLOGY

- SOC 681 AGING AND DEATH
3 cr. (3 and 0)
- SOC 803 SURVEY DESIGNS FOR APPLIED SOCIAL RESEARCH
3 cr. (3 and 0)
Survey research design principles, procedures and techniques used in applied sociology; emphasis is on instrumentation, data collection and management, and their interpretation. **Prerequisite:** SOC 603 or permission of instructor.
- SOC 805 EVALUATION RESEARCH
3 cr. (3 and 0)
Research methods and techniques of computer-assisted data management, and analyses used in evaluating policies, operation, organization and effectiveness of social programs in the private and public sectors; special emphasis is on microcomputer software packages available for these purposes. **Prerequisite:** SOC 603 or permission of instructor.
- SOC 810 THEORETICAL MODELS IN APPLIED SOCIAL RESEARCH
3 cr. (3 and 0)
Comparative analysis of theoretical models in sociology and their uses in applied research; particular attention is given to the uses of these models in research concerned with the processes of industrial and economic growth and development.
- SOC 812 SEMINAR ON MARRIAGE AND THE FAMILY
3 cr. (3 and 0)
Current family research and theory in areas such as problem-solving strategies, developmental processes, family and work life, changes throughout the lifespan, including premarital sexuality, pregnancy, divorce, marriage enrichment and courtship. Topics vary from year to year. May be repeated for credit. **Prerequisite:** SOC 311 or permission of instructor.
- SOC 814 POLICY AND SOCIAL ACTION
3 cr. (3 and 0)
Policy formation, implementation and evaluation in public and private sectors with a focus on outcomes of policy formation, social planning and implementation. **Prerequisite:** SOC 810 or permission of instructor.
- SOC 830 HUMAN SYSTEMS DEVELOPMENT: ORGANIZATIONS AND SOCIETY
3 cr. (3 and 0)
Complex organizations such as human systems, with primary focus on development and change, interorganizational relations, and the influence of these structures on the community life. **Prerequisite:** SOC 430 or permission of instructor.
- SOC 833 WORK AND SOCIETY
3 cr. (3 and 0)
The history of industrial development and its consequences at the societal, community and individual levels; current issues involved in the relationship between work and society, and strategies for developing research and policy related to these issues. **Prerequisite:** SOC 430 or permission of instructor.

- SOC 835 SEMINAR ON WORK, LEISURE AND THE FAMILY
3 cr. (3 and 0)
Current topics and research on work, leisure and the family. Topics vary from year to year. May be repeated for credit. **Prerequisite:** SOC 440 or permission of instructor.
- SOC 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- SOC 895 FIELD EXPERIENCE
12 cr. (0 and 36)
Supervised full-time work experience in a public agency concerned with economic and industrial development or in a private enterprise to gain hands-on experience in planning, needs assessment, evaluation, and policy related to economic and industrial development. May not be repeated for credit. Graded on a pass/fail basis. **Prerequisite:** Completion of course work for degree.
- SOC 899 SPECIAL PROJECTS
1-3 cr. (1-3 and 0)
Only three hours of credit in this course may be counted toward the nonthesis master's degree. Graded on a pass/fail basis.

ENGLISH

C. Harold Woodell, Program Coordinator, 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 English courses beyond the sophomore level; for the M.Ed. degree in secondary education with emphasis in English, an applicant must present at least nine. Entrance credits should include one course each above the sophomore level in Shakespeare and in English and American literature; students deficient in these may seek provisional admission.

M.A. students complete 25 semester credits of approved graduate courses and write a thesis, which may be developed with the approval of the Graduate Committee, from any interest area covered by the M.A. program. The nonthesis option requires 37 credits. All English M.A. students must demonstrate a reading knowledge of an approved foreign language.

At the core of the M.A. program is a 10-hour requirement, including ENGL 800 and one course from each of the following groups:

- I. British literature — ENGL 805, 808, 811, 814 or an appropriate 831;
- II. American literature — ENGL 820, 823 or an appropriate 831;
- III. Language and composition — ENGL 685 (required of graduate teaching assistants), 801, 802, 832, 835, 837 or an appropriate 831.

M.Ed. students in secondary education with emphasis in English complete a total of 37 graduate credits, including ENGL 685 and 800.

Candidates for the M.A. and M.Ed. degrees also must demonstrate proficiency in composition and pass a comprehensive oral examination.

ENGLISH

- ENGL 600 THE ENGLISH LANGUAGE
3 cr. (3 and 0)
- ENGL 601 GRAMMAR SURVEY
3 cr. (3 and 0)
- ENGL 602 SYNTAX
3 cr. (3 and 0)
- ENGL 603 THE CLASSICS IN TRANSLATION
3 cr. (3 and 0)
- ENGL 604 CLASSICAL DRAMA
3 cr. (3 and 0)
- ENGL 605 STUDIES IN ENGLISH LITERATURE TO 1700
3 cr. (3 and 0)
- ENGL 606 STUDIES IN ENGLISH LITERATURE SINCE 1700
3 cr. (3 and 0)
- ENGL 607 THE MEDIEVAL PERIOD
3 cr. (3 and 0)
- ENGL 608 CHAUCER
3 cr. (3 and 0)
- ENGL 609 THE EARLIER ENGLISH RENAISSANCE
3 cr. (3 and 0)
- ENGL 610 DRAMA OF ENGLISH RENAISSANCE
3 cr. (3 and 0)
- ENGL 611 SHAKESPEARE
3 cr. (3 and 0)
- ENGL 612 STUDIES IN SHAKESPEARE
3 cr. (3 and 0)
- ENGL 613 THE LATER ENGLISH RENAISSANCE
3 cr. (3 and 0)
- ENGL 614 MILTON
3 cr. (3 and 0)
- ENGL 615 THE RESTORATION AND EIGHTEENTH CENTURY
3 cr. (3 and 0)
- ENGL 616 THE ROMANTIC PERIOD
3 cr. (3 and 0)
- ENGL 617 THE VICTORIAN PERIOD
3 cr. (3 and 0)
- ENGL 618 THE ENGLISH NOVEL
3 cr. (3 and 0)

- ENGL 622 STUDIES IN AMERICAN LITERATURE I
3 cr. (3 and 0)
- ENGL 623 STUDIES IN AMERICAN LITERATURE II
3 cr. (3 and 0)
- ENGL 624 STUDIES IN AMERICAN LITERATURE III
3 cr. (3 and 0)
- ENGL 625 THE AMERICAN NOVEL
3 cr. (3 and 0)
- ENGL 626 SOUTHERN LITERATURE
3 cr. (3 and 0)
- ENGL 630 MODERN DRAMA
3 cr. (3 and 0)
- ENGL 631 MODERN POETRY
3 cr. (3 and 0)
- ENGL 632 MODERN FICTION
3 cr. (3 and 0)
- ENGL 635 LITERARY CRITICISM
3 cr. (3 and 0)
- ENGL 636 FEMINIST LITERARY CRITICISM
3 cr. (3 and 0)
- ENGL 637 DIRECTED STUDIES
1-3 cr. (1-3 and 0)
- ENGL 645 FICTION WORKSHOP
3 cr. (3 and 0)
- ENGL 646 POETRY WORKSHOP
3 cr. (3 and 0)
- ENGL 647 PLAYWRITING WORKSHOP
3 cr. (3 and 0)
- ENGL 655 AMERICAN HUMOR
3 cr. (3 and 0)
- ENGL 685 COMPOSITION FOR TEACHERS
3 cr. (3 and 0)
- ENGL 690 ADVANCED TECHNICAL AND BUSINESS WRITING
3 cr. (3 and 0)
- ENGL 691 CLASSICAL RHETORIC
3 cr. (3 and 0)
- ENGL 692 MODERN RHETORIC
3 cr. (3 and 0)

ENGLISH

- ENGL 700 CHILDREN'S LITERATURE FOR TEACHERS
3 cr. (3 and 0)
Literature for grades preschool through junior high.
- ENGL 701 LITERATURE FOR TEACHERS
3 cr. (3 and 0)
Literary studies of special interest to secondary school teachers.
- ENGL 702 WRITING PROJECTS
3 cr. (3 and 0)
Exchange and development of methods for teaching writing that have a firm theoretical foundation.
- ENGL 800 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 and Master of Education degree with a concentration in secondary education, English.
- ENGL 801 TOPICS IN COMPOSITION
3 cr. (3 and 0)
Principal theories and practices in modern grammar, stylistics and semantics related to teaching composition.
- ENGL 802 TOPICS IN LITERARY GENRES
3 cr. (3 and 0)
Principal literary genres.
- ENGL 803 TOPICS IN RHETORICAL THEORY
3 cr. (3 and 0)
Major rhetorical theories, figures and historical movements.
- ENGL 805 TOPICS IN MEDIEVAL LITERATURE
3 cr. (3 and 0)
Principal works in verse and prose from c. 1100-1500.
- ENGL 808 TOPICS IN RENAISSANCE AND RESTORATION LITERATURE
3 cr. (3 and 0)
Principal works in verse and prose from c. 1500-1700.
- ENGL 811 TOPICS IN NEOCLASSIC AND ROMANTIC LITERATURE
3 cr. (3 and 0)
Principal works in verse and prose from c. 1700-1832.
- ENGL 814 TOPICS IN VICTORIAN AND MODERN BRITISH LITERATURE
3 cr. (3 and 0)
Principal works in verse and prose from c. 1832 to present.
- ENGL 820 TOPICS IN AMERICAN LITERATURE TO 1865
3 cr. (3 and 0)
Significant authors; works in poetry and prose; literary-intellectual movements such as puritanism, the enlightenment, romanticism and transcendentalism from c. 1607-1865.

- ENGL 823 TOPICS IN AMERICAN LITERATURE SINCE 1865
3 cr. (3 and 0)
Significant authors; works in poetry and prose; literary-intellectual movements such as realism, naturalism, modernism and post-modernism from 1865 to the present.
- ENGL 831 SPECIAL TOPICS
3 cr. (3 and 0)
Topics not covered in other courses.
- ENGL 832 TOPICS IN SCIENTIFIC, TECHNICAL AND BUSINESS WRITING
3 cr. (3 and 0)
Seminar courses in areas such as professional editing and publishing, writing for government and industry, teaching technical writing, and writing for journals, magazines and newspapers.
- ENGL 835 TOPICS IN LITERARY CRITICISM
3 cr. (3 and 0)
Principal statements of literary critics from the classical era to the present.
- ENGL 837 TOPICS IN LINGUISTICS
3 cr. (3 and 0)
Concepts of traditional and modern grammarians; development of English language.
- ENGL 840 DIRECTED STUDIES
3 cr. (3 and 0)
Tutorial work in linguistics or American, British or European literature not offered in other courses. **Prerequisite:** Permission of director of graduate studies.
- ENGL 850 RESEARCH AND STUDIES IN SCIENTIFIC, BUSINESS AND TECHNICAL WRITING
3 cr. (3 and 0)
Theories of professional communication and methods of inquiry; readings and research into the ways that the writing of professionals create new knowledge and affect the daily life of others; research methods emphasize humanistic inquiry. **Prerequisite:** Graduate standing.
- ENGL 851 SEMINAR IN PROFESSIONAL WRITING
3 cr. (3 and 0)
Advanced seminar in the principles and practice of writing and editing documents for government, industry and the sciences; students produce projects suitable for publication, typically chosen from document design, scientific or technical journalism, and public policy writing. **Prerequisite:** Graduate standing.
- ENGL 853 VISUAL COMMUNICATIONS
3 cr. (3 and 0)
Understanding the language of images used in textual and extra-textual communication; theories of perception, methods of visual persuasion, gender analysis, and cognitive and aesthetic philosophies of visual rhetoric. **Prerequisite:** Graduate standing.

ENGLISH

- ENGL 854 TEACHING PROFESSIONAL WRITING
3 cr. (3 and 0)
Teaching professional writing and examining theories and practices of written, graphic and oral communication; students prepare course descriptions, rationales and syllabi for teaching various forms of business, scientific and technical writing. **Prerequisite:** Graduate standing.
- ENGL 855 LINGUISTICS FOR PROFESSIONAL COMMUNICATION
3 cr. (3 and 0)
Theoretical and applied linguistics with emphasis on developing linguistically sound strategies for effective professional communication. **Prerequisite:** Graduate standing.
- ENGL 885 COMPOSITION THEORY
3 cr. (3 and 0)
Teaching college-level courses, stressing contemporary composition theory, research and practice. **Prerequisite:** Graduate standing.
- ENGL 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- SPCH 664 ADVANCED ORGANIZATIONAL COMMUNICATION
3 cr. (3 and 0)

HISTORY

Donald G. Nieman, Program Director, Department of History

Major
History

Degree
M.A.

The M.A. in history requires 30 credits in courses numbered 600 or above that 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 in graduate courses selected with the approval of the director of the graduate program in history; (3) a minimum of six 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 assistantships terminated.

With departmental consent, any 600-level course in history may be repeated one time for credit.

- HIST 600 STUDIES IN UNITED STATES HISTORY
3 cr. (3 and 0)
- HIST 638 PROBLEMS IN AFRICAN HISTORIOGRAPHY AND
METHODOLOGY
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 697 STUDIES IN THE HISTORY OF SCIENCE AND TECHNOLOGY
3 cr. (3 and 0)
- HIST 700 UNITED STATES THROUGH THE CIVIL WAR
3 cr. (3 and 0)
Problems in United States history through 1865 with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 710 UNITED STATES SINCE 1865
3 cr. (3 and 0)
Problems in United States history since 1865 with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 720 SOUTHERN HISTORY
3 cr. (3 and 0)
Problems in Southern history with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 760 BRITISH HISTORY
3 cr. (3 and 0)
Problems in the history of Great Britain and the British Empire with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.

HISTORY

- HIST 770 EUROPE TO THE 18TH CENTURY
3 cr. (3 and 0)
Problems in European history to 1700 with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 775 EUROPE SINCE THE 18TH CENTURY
3 cr. (3 and 0)
Problems in European history since 1700 with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 790 HISTORICAL AREA STUDIES
3 cr. (3 and 0)
Problems in the history of Africa, Asia, Latin America or the Middle East with attention given to bibliography and teaching methods. Primarily for Master of Education candidates, but open to all graduate students. May be repeated with permission of graduate program director.
- HIST 800 SEMINAR IN UNITED STATES HISTORY
3 cr. (3 and 0)
Training in historical research and writing. May be repeated for credit with approval of graduate program director.
- HIST 830 SEMINAR IN ASIAN HISTORY
3 cr. (3 and 0)
Training in historical research and writing with focus on Asian history. May be repeated for credit with approval of graduate program director.
- HIST 840 SEMINAR IN LATIN AMERICAN HISTORY
3 cr. (3 and 0)
Training in historical research and writing with focus on Latin American history. May be repeated for credit with approval of graduate program director.
- HIST 860 SEMINAR IN BRITISH HISTORY
3 cr. (3 and 0)
Training in historical research and writing. May be repeated for credit with approval of graduate program director.
- HIST 870 SEMINAR IN EUROPEAN HISTORY
3 cr. (3 and 0)
Training in historical research and writing. May be repeated for credit with approval of graduate program director.
- HIST 880 SPECIAL TOPICS IN HISTORY
3 cr. (3 and 0)
Training in historical research and writing. May be repeated for credit with approval of graduate program director.

- HIST 885 INDEPENDENT STUDY
3 cr. (3 and 0)
Critical study of a historical topic, selected according to needs of student and with approval of graduate program director.
- HIST 887 ARCHIVAL MANAGEMENT: AN INTRODUCTION
3 cr. (3 and 0)
Introduction to basic concepts of archival theory and management.
- HIST 888 HISTORICAL AND TEXTUAL EDITING
3 cr. (3 and 0)
Practical, intensive course introduces techniques for handling archival materials and preparing scholarly editions.
- HIST 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- HIST 893 PRACTICUM IN ARCHIVAL MANAGEMENT
3 cr. (0 and 9)
Hands-on experience in the operations of an archival program, including acquisitions, arrangements, descriptions, conservation and reference service. **Prerequisite:** HIST 887 or permission of instructor.
- HIST 894 PRACTICUM IN HISTORICAL EDITING
3 cr. (3 and 0)
Practicum for applying methodologies learned in introductory editing course to a specific body of original sources such as family correspondence, diaries or journals in order to become a historical editor. **Prerequisite:** HIST 888.
- GEOG 601 STUDIES IN REGIONAL GEOGRAPHY
3 cr. (3 and 0)
- GEOG 610 GEOGRAPHY OF THE AMERICAN SOUTH
3 cr. (3 and 0)
- GEOG 620 HISTORICAL GEOGRAPHY OF THE UNITED STATES
3 cr. (3 and 0)
- GEOG 700 TOPICS IN GEOGRAPHY
3 cr. (3 and 0)
Intensive study of a topic in geography such as world regions, American minorities, the historical geography of the United States or the geography of South Carolina. Restricted to elementary and secondary school teachers. May be repeated for credit with departmental permission. **Prerequisite:** Permission of department.
- GEOG 710 GEOGRAPHY FOR TEACHERS
3 cr. (3 and 0)
Methods and materials for teaching geography presented within a framework of basic geographic concepts and real world information.

LANGUAGES

LANGUAGES

Judith M. Melton, Head, Department of Languages

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

- FR 699 SELECTED TOPICS IN FRENCH LITERATURE
3 cr. (3 and 0)
- GER 698 INDEPENDENT STUDY
1-3 cr. (1-3 and 0)
- SPAN 699 SPANISH LITERATURE, LANGUAGE AND CULTURE
3 cr. (3 and 0)

Two special courses are offered in French and German for graduate students preparing for the language examination.

- FR 151 FRENCH FOR GRADUATE STUDENTS
3 cr. (3 and 0)
- GER 151 GERMAN FOR GRADUATE STUDENTS
3 cr. (3 and 0)

PHILOSOPHY AND RELIGION

Stuart Silvers, Head, Department of Philosophy and Religion

Advanced degrees are not awarded in philosophy and religion. Courses are offered to provide electives for students in other areas.

- PHIL 601 STUDIES IN THE HISTORY OF PHILOSOPHY
3 cr. (3 and 0)
- PHIL 602 TOPICS IN PHILOSOPHY
3 cr. (3 and 0)
- REL 601 STUDIES IN BIBLICAL LITERATURE AND RELIGION
3 cr. (3 and 0)
- REL 602 STUDIES IN RELIGION
3 cr. (3 and 0)

POLITICAL SCIENCE

Charles 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 GOVERNMENT POLICY AND POLITICAL ECONOMY
3 cr. (3 and 0)
- POL SC 623 URBAN POLITICS
3 cr. (3 and 0)
- POL SC 625 MONEY, BUDGETS AND GRANTSMANSHIP
3 cr. (3 and 0)
- POL SC 627 PUBLIC PERSONNEL MANAGEMENT
3 cr. (3 and 0)
- POL SC 628 NATIONAL SECURITY POLICY
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 ELECTIONS
3 cr. (3 and 0)
- POL SC 657 POLITICAL TERRORISM
3 cr. (3 and 0)
- POL SC 662 PEACE AND ORDER IN INTERNATIONAL RELATIONS
3 cr. (3 and 0)

COLLEGE OF NURSING

NURSING

COLLEGE OF NURSING

Opal S. Hipps, Dean

Major
Nursing

Degree
M.S.

The objectives of the Master of Science degree program with a major in nursing are to provide graduates with the ability to:

1. integrate advanced knowledge from nursing and related disciplines into a specialized area of nursing practice and a functional role;
2. evaluate theories from nursing and related disciplines as a basis for advanced nursing practice;
3. demonstrate competence in a selected functional role of educator, administrator or clinical specialist;
4. participate in the development of nursing knowledge by identifying researchable nursing problems, conducting research and selectively integrating research findings in advanced nursing practice;
5. utilize leadership, management, and teaching knowledge and competency to influence nursing practice;
6. participate as a leader to influence health policy and improve the health care delivery system; and
7. contribute to the advancement of the nursing profession.

Admission Requirements

In addition to meeting University admission requirements, applicants 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 applicants must also be licensed to practice professional nursing in the state(s) in which they do their clinical practice and carry nurse's liability insurance. Opportunity to do clinical practice in sites outside the Clemson area and/or South Carolina is subject to availability of appropriate faculty.

The Program*

The Master of Science degree program with a major in nursing is designed to build upon the first professional degree. The student acquires advanced knowledge and skills in both a nursing practice specialty and in a role area. Areas of practice specialization are adult health, child health, gerontology, maternal-infant and rehabilitative nursing. Role areas include education, management and clinical specialization. Upon graduation, students will be prepared for advanced practice in a designated area of nursing. Health assessment is a prerequisite to enrollment in the graduate program. A thesis or nonthesis option is available. Normally, 37 semester credit hours are required for awarding the Master of Science degree. Each student's advisory committee, formed during the first semester of the program, determines the curriculum required of the student.

The master's program articulates with the baccalaureate program in the continued acquisition of advanced nursing knowledge and skills of the specialist. Using pervasive and progressive concepts and subconcepts, this specialization builds toward advanced nursing practice in selected clinical and role areas. Theory, research and role development are emphasized to enable the graduate to participate in the development of nursing knowledge and contribute to the advancement of the nursing profession.

* The college reserves the right to limit enrollment of students in any course and not to offer a clinical option if enrollment is insufficient. This curriculum is subject to change.

- NURS 801 FAMILY HEALTH NURSING
4 cr. (3 and 3)
Application of humanistic nursing process and family theories to care of families; biophysical, psychosocial, cultural, intellectual, and spiritual nature of health and illness; dynamics of family health in various stages of family development; helping relationships; crisis intervention; emerging systems of health maintenance; analysis of the care of selected families and clinical areas.
- NURS 802 ADVANCED LEADERSHIP AND ROLE
3 cr. (3 and 0)
Introduction to the advanced roles of educator, administrator and clinical specialist in nursing; leadership theory/models and practices; leadership functions of program planning and evaluation, and health policy formation.
- NURS 804 NURSING THEORY
3 cr. (3 and 0)
Definition of theory and processes used to develop theory; selected models of nursing are presented and evaluated to determine if they classify as theories and their relevance to family health nursing.
- NURS 807 CLINICAL NURSING RESEARCH
3 cr. (3 and 0)
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 808 NURSING RESEARCH ANALYSIS
3 cr. (3 and 0)
Use of quantitative methods for the development of nursing knowledge. Topics include basic elements of the research process utilizing descriptive and inferential methodology. Computer use will be integrated to emphasize application to nursing. **Prerequisite:** Undergraduate statistics course.
- 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 825 THEORIES AND MODELS OF NURSING ADMINISTRATION
3 cr. (3 and 0)
Identification, analysis and synthesis of theories, models and issues related to nursing management and leadership; organization, attitudes, and practices applicable to the middle and executive levels of nursing administration. **Prerequisite:** NURS 835, 837, 840 or 861.
- NURS 826 ADMINISTRATION OF NURSING SERVICES
3 cr. (2 and 3)
Application of theories and models to specific nursing administration issues and problems; practicum in nursing administration at the middle or executive level permits specific use and evaluation of a conceptual model of nursing administration. **Prerequisite:** NURS 825. **Corequisite:** NURS 836, 838, 841 or 862.

NURSING

- NURS 827 FOUNDATIONS OF NURSING EDUCATION
3 cr. (3 and 0)
Exploration of the foundations of nursing education with emphasis on curriculum development in nursing; current issues and research which influence nursing education. **Prerequisite:** NURS 835, 837, 840 or 861.
- NURS 828 THE NURSE EDUCATOR
3 cr. (2 and 3)
Continuation of NURS 827; major focus on teaching in nursing education programs; course development and selection of learning experiences; current issues and research in classroom and clinical teaching; a teaching practicum is required. **Prerequisite:** NURS 827. **Corequisite:** NURS 836, 838, 841 or 862.
- NURS 829 THEORIES AND MODELS OF CLINICAL SPECIALIZATION
2 cr. (2 and 0)
The caregiver, researcher, manager, teacher and consultant roles of the clinical nurse specialist in a variety of settings; theories, models and health care issues underlying the role of clinical nurse specialist. **Prerequisite:** NURS 835, 837, 840 or 861.
- NURS 830 CLINICAL SPECIALTY PRACTICUM IN NURSING
4 cr. (1 and 9)
Advanced practice in a selected clinical specialty area in nursing that emphasizes application of the clinical specialist role. **Prerequisite:** NURS 829. **Corequisite:** NURS 836, 838, 841 or 862.
- NURS 833 REHABILITATIVE NURSING I
6 cr. (3 and 9)
Advanced concepts, principles and theories basic to humanistic practice of professional rehabilitative nursing; repatterning as an integral part of the human development process; clinical laboratory practice selected from rehabilitation, ambulatory and community settings. **Prerequisites:** NURS 801, 804, 807 and 812.
- NURS 834 REHABILITATIVE NURSING II
6 cr. (3 and 9)
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; clinical laboratory experience selected from rehabilitation, ambulatory and community settings. **Prerequisite:** NURS 833.
- NURS 835 ADVANCED NURSING OF DEVELOPING CHILDREN
5 cr. (3 and 6)
Analysis of physiological, psychological, sociocultural, developmental and family theories, issues and research that form the basis for nursing practice with families who have healthy children within the developmental levels of birth through adolescence; interventions related to achieving and maintaining optimal health, growth and development incorporated into advanced clinical practice. **Prerequisites or Corequisites:** NURS 802, 804 and 807.

- NURS 836 **ADVANCED NURSING OF CHILDREN WITH HEALTH DEFICITS**
5 cr. (3 and 6)
Effects of health deficits, separation and hospitalization on children and their families; nursing concerns, issues, management and research related to ill or disabled children; adjudication of expanding nursing roles incorporated into advanced clinical practice. **Prerequisite:** NURS 835.
- NURS 837 **ADVANCED NURSING OF CHILDBEARING FAMILIES**
5 cr. (3 and 6)
Theories and advanced concepts related to nursing management in the care of healthy childbearing families; major physiological, psychological and sociological changes related to antepartum, intrapartum, postpartum and neonate, incorporated into advanced clinical practice; related nursing issues and current research. **Prerequisites or Corequisites:** NURS 802, 804 and 807.
- NURS 838 **ADVANCED NURSING OF CHILDBEARING FAMILIES AT RISK**
5 cr. (3 and 6)
Care of childbearing families at risk for complications in physical, socioenvironmental and psychological development; nursing concerns, issues, management and research related to care of the high-risk childbearing family, incorporated into advanced clinical practice. **Prerequisite:** NURS 837.
- NURS 840 **ADVANCED GERONTOLOGICAL NURSING I**
5 cr. (3 and 6)
Critical, comprehensive overview of research, knowledge, concepts and issues basic to the advanced practice of nursing care of older adults; phenomenon of human aging as reflected by changes in elders' patterns of living; clinical experiences scheduled from a variety of settings that provide health care for older adults. **Prerequisites or Corequisites:** NURS 802, 804 and 807.
- NURS 841 **ADVANCED GERONTOLOGICAL NURSING II**
5 cr. (3 and 6)
Continuation of NURS 840; builds on the review of research on the phenomenon of aging; continues the investigation of theories relevant to nursing care of the older adult; clinical experiences scheduled from a variety of settings that provide health care for older adults. **Prerequisite:** NURS 840.
- NURS 861 **ADVANCED ADULT NURSING I**
5 cr. (3 and 6)
Theories and research related to physiological, psychological and sociocultural concepts that form the basis of advanced adult nursing practice; emphasis is on human responses to selected phenomena which influence the health status of adults; current issues and research influencing the practice of adult nursing. **Prerequisites or Corequisites:** NURS 802, 804 and 807.
- NURS 862 **ADVANCED ADULT NURSING II**
5 cr. (3 and 6)
Continuation of the study of theories, research and concepts that form the basis of adult nursing practice; emphasis is on factors influencing wellness and illness in the care of adults; related issues and current research. **Prerequisite:** NURS 861.

NURSING

- NURS 879 SPECIAL TOPICS IN NURSING
1-3 cr. (1-3 and 0-9)
In-depth seminar of selected topics, such as therapeutic communication, legal and ethical issues in nursing, and health care and political process in health. **Prerequisite:** Permission of instructor.
- NURS 881 GRADUATE PROJECT
Credit to be arranged.
Scholarly experience enhancing the student's professional goals with significance for nursing practice, education or administration; the project nature is flexible and is negotiated between the student and graduate committee. Minimum of three credit hours required for students selecting the nonthesis option. **Prerequisite:** Negotiated between student and committee.
- NURS 889 SPECIAL PROBLEMS IN NURSING
1-6 cr. (1-6 and 0)
Problems selected to meet special and individualized interests of students. Up to six hours of NURS 889 may be taken as elective credit. **Prerequisites:** NURS 801, 804, 807 and permission of instructor.
- NURS 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
Research activities related to thesis; minimum of six hours required. **Prerequisites:** NURS 802, 804 and 807.
- HLTH 600 SPECIAL TOPICS IN HEALTH
1-6 cr. (1-6 and 0)
- HLTH 601 HEALTH CARE CONSUMERISM
3 cr. (3 and 0)
- HLTH 602 HEALTH CARE IN EMERGENCIES
3 cr. (3 and 0)
- HLTH 610 CONCEPTS OF CHILD HEALTH
3 cr. (3 and 0)
- HLTH 630 HEALTH PROMOTION OF THE AGED
3 cr. (3 and 0)
- HLTH 698 CONTEMPORARY HEALTH PROBLEMS
3 cr. (3 and 0)

COLLEGE OF SCIENCES

BIOCHEMISTRY
BIOLOGICAL SCIENCES
BIOLOGY
BOTANY
CHEMISTRY
COMPUTER SCIENCE
GEOLOGY
MATHEMATICAL SCIENCES
MICROBIOLOGY
PHYSICS
ZOOLOGY

COLLEGE OF SCIENCES

Bobby G. Wixson, Dean

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

Biochemistry	Mathematical Sciences
Botany	Microbiology
Chemistry	Physics
Computer Science	Zoology
Geology	

Degrees offered are: the Master of Science degree in biochemistry, botany, chemistry, computer science, geology, mathematical sciences, microbiology, physics and zoology; and the Doctor of Philosophy degree in biochemistry, chemistry, computer science, mathematical sciences, microbiology, physics and zoology.

A graduate program leading to the Ph.D. with major emphasis in botany is available through an interdepartmental plant physiology program. In addition, the Ph.D. in management science is awarded jointly with the departments of Management and Mathematical Sciences. Graduate courses in biology and astronomy provide electives for students in other areas.

All graduate programs offered in this college emphasize a broad academic foundation in the disciplinary area with intensive study and research in a specific area that culminates 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 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

Gary L. Powell, Program Coordinator, Department of Biological Sciences

Major	Degrees
Biochemistry	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.

Attendance and participation in departmental seminars are mandatory for all graduate students.

Biochemistry 631, 632, 633 and 634 (10 total credit hours) constitute the core of the biochemistry program. All students are expected to complete these courses if they have not had their equivalents 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. At least eight of these 800-level credits (including BIOCH 851) must be in biochemistry courses. Two of the following four courses are required: BIOCH 815, 820, 822 and 831. A minimum of six semester hours of M.S. research (BIOCH 891), culminating in a thesis, is required.

The Ph.D. degree requires, in addition to the core courses, three of the four courses: BIOCH 815, 820, 822 and 831. Successful completion of written and oral

comprehensive examinations (before six 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 623 PRINCIPLES OF BIOCHEMISTRY
3 cr. (3 and 0)
- BIOCH 631 A PHYSICAL APPROACH TO BIOCHEMISTRY
3 cr. (3 and 0)
- BIOCH 632 BIOCHEMISTRY OF METABOLISM
3 cr. (3 and 0)
- BIOCH 633 GENERAL BIOCHEMISTRY LABORATORY I
2 cr. (0 and 4)
- BIOCH 634 GENERAL BIOCHEMISTRY LABORATORY II
2 cr. (0 and 4)
- BIOCH 641 MOLECULAR BIOLOGY
3 cr. (3 and 0)
- 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 431/631 and 433/633; or 423/623 and 433/633; 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. **Prerequisite:** BIOCH 432/632 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; endocrinopathies of hormone imbalance. **Prerequisite:** BIOCH 432/632 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 is covered in lectures, discussions and guided reading of original, current and classical literature. **Prerequisite:** BIOCH 432/632 or permission of instructor.

BIOCHEMISTRY

- 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. **Prerequisite:** BIOCH 432/632 or 441/641 or permission of instructor.
- BIOCH 821 PROTEINS
3 cr. (3 and 0)
Isolation, composition, structure and properties of proteins; methods of isolation, analysis and characterization; properties of "unusual" protein systems. **Prerequisite:** BIOCH 431/631 or 423/623 or permission of instructor.
- BIOCH 822 ENZYMES
3 cr. (3 and 0)
Kinetics, mechanisms of action, inhibitions and general properties of enzymes. **Prerequisite:** BIOCH 431/631 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 432/632.
- 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 431/631 or 423/623, and one semester of physical chemistry or 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.

BIOLOGICAL SCIENCES

Jack Lilien, Head, Department of Biological Sciences

Advanced degrees are not awarded in biological sciences as a major. These courses are taught by faculty in the Department of Biological Sciences to supplement courses and graduate degrees awarded in botany, zoology and biochemistry.

- BIO SC 616 MOLECULAR GENETICS
(GEN 616) 3 cr. (3 and 0)
- BIO SC 618 BIOTECHNOLOGY I: NUCLEIC ACIDS TECHNIQUES
(MICRO 618) 4 cr. (2 and 4)
(GEN 618)
- BIO SC 630 BIOENERGETICS FOR ENGINEERS
(AG E 630) 4 cr. (3 and 3)
- BIO SC 635 PRINCIPLES OF EVOLUTION
4 cr. (4 and 0)
- BIO SC 640 DEVELOPMENTAL ANIMAL BIOLOGY
4 cr. (3 and 3)
- BIO SC 641 ECOLOGY
4 cr. (3 and 3)
- BIO SC 642 BIOGEOGRAPHY
3 cr. (3 and 0)
- BIO SC 643 AQUATIC ECOLOGY
4 cr. (3 and 3)
- BIO SC 652 ANATOMY AND MORPHOLOGY OF VASCULAR PLANTS
4 cr. (3 and 3)
- BIO SC 658 CELL PHYSIOLOGY
(AG E 658) 3 cr. (3 and 0)
- BIO SC 661 CELL BIOLOGY
4 cr. (3 and 3)
- BIO SC 683 REGULATORY BIOLOGY I
4 cr. (3 and 3)
- BIO SC 684 REGULATORY BIOLOGY II
4 cr. (3 and 3)
- BIO SC 685 BIOLOGICAL ASSESSMENT OF AQUATIC ENVIRONMENTS
4 cr. (3 and 3)
- BIO SC 801 ELECTRON MICROSCOPY OF BIOLOGICAL SPECIMENS
(AN PH 801) 3 cr. (1 and 6) F, S
See AN PH 801 for description.

BIOLOGY

William M. Surver, Acting Director, Biology Program

Advanced degrees are not awarded in biology as a major. These courses are taught by faculty in the life sciences and are offered for elementary and secondary education majors.

- BIOL 700 CLASSICAL GENETICS
1 cr.
Classical principles of genetics including Mendelian genetics, chromosomal theory of inheritance, gene interactions and population genetics. Restricted to elementary and secondary school teachers.
- BIOL 701 THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM I
1 cr.
Introduction to theory and practice of instructional uses of microcomputers and computer terminals in the biology classroom; use and construction of programs designed to teach biology through drill and practice, tutorial, simulation and gaming techniques. Restricted to elementary and secondary school teachers.
- BIOL 702 ECOLOGY
1 cr.
Theories, principles and examples describing interactions of individuals, populations and communities with their environment; emphasis and examples come from human situations. Restricted to elementary and secondary school teachers.
- BIOL 703 SURVEY OF THE KINGDOMS MONERA, PROTISTA AND FUNGI
1 cr. SS
Distribution, classification, morphology and economic importance of bacteria, blue-green algae, eucaryotic algae, protozoans, fungi, lichens and viruses. Laboratory investigations applicable for use in classroom. Restricted to elementary and secondary school teachers.
- BIOL 704 ANALYTICAL THINKING IN BIOLOGY
1 cr.
Role of analysis and critical thinking in biology as a science; rationale and theories which provide a basis for this teaching approach; learning experiences, with modification, applicable at high school level. Restricted to elementary and secondary school teachers.
- BIOL 705 PUBLIC HEALTH MICROBIOLOGY
1 cr.
Microbiologist's role in maintenance of public health, including food inspection, sewage and water treatment, vaccination programs, air quality control and epidemiology at state and federal levels. Restricted to elementary and secondary school teachers.
- BIOL 706 BASIC METHODS OF PRESERVING VERTEBRATES FOR TEACHING COLLECTIONS
1 cr. (1 and 0)
Principles of collection management and specimen preparation; includes preservation in liquids and preparation of standard study skins and skeletons. Restricted to elementary and secondary school teachers.

- BIOL 707 PREPARATION OF PLANTS FOR PERMANENT TEACHING COLLECTIONS
1 cr. (1 and 0)
History and principles of herbarium collections (vascular plants, bryophytes, fungi, lichens, algae, fruit and seeds); includes methods used by major herbaria for preserving various plant collections and inexpensive methods for small teaching collections. Restricted to elementary and secondary school teachers.
- BIOL 708 FOOD MICROBIOLOGY
1 cr. (1 and 0)
Factors that influence the survival and growth of microbes in foods, methods of enumeration, food fermentations; food spoilage and food-borne illness; microbiological specifications for foods and aspects of control of product quality and safety are also discussed. Restricted to elementary and secondary school teachers.
- BIOL 709 BIOLOGICAL MICROSCOPY AND MICROTECHNIQUES
1 cr.
Principles and practical applications of light microscopy and microtechnique; basic histology, staining and repair of the light microscope with limited instruction in the techniques of transmission and scanning electron microscopy; laboratory provides experience in the use of materials and equipment necessary for light microscopy.
- BIOL 710 SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN BIOLOGY
1-6 cr. (0-6 and 0-18)
Study of one or more topics organized according to institute needs; lecture and laboratory emphasize the incorporation of new or updated subject matter into classroom instruction. Restricted to elementary and secondary school teachers.
- BIOL 711 CONCEPTUAL THEMES IN BIOLOGY
3 cr. (2 and 2)
Overview of the current structure of the biological sciences from a constructionist viewpoint; major conceptual themes of biology are identified and evaluated as well as the significance of more recent discoveries. Recommended for secondary school teachers of biological sciences. **Prerequisite:** Secondary biology certification or undergraduate degree in a life science.
- BIOL 731 THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM II
1 cr.
Intermediate-level continuation of BIOL 701. Restricted to elementary and secondary school teachers. **Prerequisite:** BIOL 701.
- BIOL 732 MICROECOSYSTEMS IN THE CLASSROOM
1 cr.
Theory and techniques for establishing and maintaining freshwater aquaria, saltwater aquaria, earthworm microecosystems, research aquatic microecosystems and terraria in the laboratory; microecosystems used to illustrate ecological principles in the laboratory. Restricted to elementary and secondary school teachers. **Prerequisite:** BIOL 702 or permission of instructor.

BIOLOGY

- BIOL 733 THE BRAIN, NERVOUS SYSTEM AND SENSE ORGANS
1 cr.
Structural and functional approach to the nervous system and sense organs, mainly of vertebrates; understanding sought at molecular, cellular, tissue and gross anatomy levels; laboratory practice includes dissection, physiological and histological studies, and exercises using students as experimental subjects. Restricted to elementary and secondary school teachers.
- BIOL 734 THE PHYSIOLOGY OF RESPIRATION
1 cr.
Human respiration including anatomy, mechanics, gas transport and control of respiration; recent advances in high altitude and underwater breathing, artificial blood substitutes and liquid breathing. Restricted to elementary and secondary school teachers.
- BIOL 761 THE MICROCOMPUTER IN THE BIOLOGY CURRICULUM III
1 cr.
Advanced-level continuation of BIOL 731. Restricted to elementary and secondary school teachers. **Prerequisite:** BIOL 731.
- BIOL 762 HUMAN GENETICS
1 cr.
Genetic principles as they relate to human inheritance, emphasizing patterns of human inheritance and their implication in society; student project required. Restricted to elementary and secondary school teachers. **Prerequisite:** Permission of instructor.
- BIOL 763 FUNDAMENTAL IMMUNOLOGY AND SEROLOGY IN PUBLIC HEALTH
1 cr.
Antigens and antigenicity, production and characterization of antibody, antigen-antibody reactions, cell-mediated immune response. Restricted to elementary and secondary school teachers.
- BIOL 764 MODERN MOLECULAR GENETICS
1 cr.
Survey of molecular genetics and its recent advances. Topics include nucleic acid structure and function, transcription, translation, replication, processing, regulation and recombinant DNA.

BOTANY

Thomas M. McInnis, Program Coordinator, Department of Biological Sciences

Major	Degrees
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. 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 generally are 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 INTRODUCTION MYCOLOGY
4 cr. (3 and 3) F (even numbered years)
- BOT 613 PHYCOLOGY
4 cr. (3 and 3) S (even numbered years)
- BOT 621 PLANT PHYSIOLOGY
4 cr. (3 and 3)
- BOT 631 INTRODUCTION PLANT TAXONOMY
4 cr. (3 and 3) F, SS
- BOT 656 PLANT MICROTECHNIQUE
2 cr. (0 and 6) 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; nonvascular 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.

BOTANY

- BOT 815** **PHYCOLOGY COLLOQUIUM**
1-3 cr. (1-3 and 0) F (even numbered years)
Phenomena associated with algae; discussion topics, taken from current scientific literature, present to students a forum for criticizing research, conceiving new ideas for research, developing research outlines and proposals, and 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 and nutrient relations; permeability; uptake and translocation; transpiration; 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 621 and BIOCH 623, or permission of instructor.
- BOT 823** **PLANT GROWTH AND 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; morphogenesis. **Prerequisite:** BOT 421/621, or 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 831** **ADVANCED PLANT TAXONOMY**
4 cr. (3 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 431/631 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 431/631 or permission of instructor.
- BOT 835** **PLANT SPECIATION**
3 cr. (3 and 0) F (even numbered years)
Examination of species concepts and factors affecting the formation of species. **Prerequisite:** BOT 431/631 or permission of instructor.

- BOT 837** **EVOLUTION OF ANGIOSPERMS**
 3 cr. (3 and 0)
 An advanced study of the phylogeny of the angiosperms. Topics include the current hypothesis of angiosperm origin, the probable nature of the earliest angiosperms, evolutionary trends in morphological specialization, the origin of monocots, adaptations for pollination and the coevolution of plants and animals. **Prerequisite:** BOT 431/631 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. **Prerequisite:** BOT 431/631, ZOOL 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, plant nutrient relations, plant water relations, and reproduction and establishment of plants. **Prerequisites:** BOT 421/621 and BIO SC 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:** 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; other topics and advances in plant ecology. Applicable for all graduate students in ecology. May be repeated for credit. **Prerequisite:** BIO SC 441/641 or permission of instructor.
- BOT 846** **PLANT ECOLOGY**
 4 cr. (3 and 3) F
 Detailed study of the effects of environmental factors upon plants and the influence of plants upon the environment; identification and analysis of interrelated biotic and physical factors that affect the structure, distribution and dynamics of individual plants, plant populations and ecosystems. **Prerequisite:** BIO SC 441/641 or permission of instructor.
- BOT 850** **PLANT TISSUE AND CELL CULTURE**
 3 cr. (2 and 3) F (odd numbered years)
 Consideration of methods and principles of plant tissue and cell culture: cloning, embryogenesis, protoplast fusion, plant regeneration, potential of plant genetic engineering. **Prerequisite:** Introductory plant physiology or permission of instructor.

BOTANY

- BOT 851 PLANT ANATOMY**
3 cr. (2 and 3) F
Study of the origin, development and comparative structures of tissues, systems and organs of higher plants. **Prerequisite:** BIO SC 452/652 or permission of instructor.
- BOT 861 PLANT CELL BIOLOGY**
3 cr. (3 and 0) F (odd 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 permission of instructor.
- BOT 891 MASTER'S THESIS RESEARCH**
Credit to be arranged.
- BOT 921 PLANT PHYSIOLOGY COLLOQUIUM**
(HORT 921) 1 cr. (1 and 0)
Topics from current plant physiology literature provide a forum for criticizing research, conceiving new research ideas, developing research outlines and proposals, and integrating knowledge from various subdisciplines of plant physiology. May be repeated for credit. **Prerequisite:** BOT 421/621 or permission of instructor.
- BOT 991 DOCTORAL DISSERTATION RESEARCH**
Credit to be arranged.

CHEMISTRY

John D. Petersen, Head, Department of Chemistry

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 School of Textiles.

Students in either degree program must present satisfactory research seminars and must complete, or have completed, a computer science course equivalent to Clemson University's CP SC 110. In some instances, the computer science course requirement may be waived for candidates for the M.S. degree who have satisfactorily completed undergraduate courses in French, German or Russian. Students in the Ph.D. program must 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 a satisfactory thesis.

The primary requirement for the Ph.D. degree is the performance of original research leading to a dissertation. 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 a faculty 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 ATOMIC 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. **Prerequisite:** Permission of instructor for graduate students in secondary education.
- 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.

CHEMISTRY

- 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 804 FUNDAMENTAL PRINCIPLES OF INORGANIC CHEMISTRY
3 cr. (3 and 0)
Fundamental principles of modern inorganic chemistry showing their relationship to other areas of chemistry.
- CH 805 THEORETICAL INORGANIC CHEMISTRY
3 cr. (3 and 0)
Application of group theory to structure and properties of inorganic molecules. **Prerequisites:** CH 435/635 and 804 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. **Prerequisite:** CH 804 or permission of instructor.
- CH 807 CHEMISTRY OF THE TRANSITION ELEMENTS
3 cr. (3 and 0)
Structure, spectroscopy and reactivity of transition metals and their compounds. **Prerequisite:** CH 804 or permission of instructor.
- CH 808 CHEMISTRY OF THE NONMETALLIC ELEMENTS
3 cr. (3 and 0)
Development and application of a bonding model for descriptive inorganic chemistry of boron, carbon, silicon, nitrogen, phosphorus, oxygen and sulfur. **Prerequisite:** CH 804 or permission of instructor.
- CH 809 CHEMICAL APPLICATIONS OF X-RAY CRYSTALLOGRAPHY
3 cr. (2 and 2)
Topics include a physical description of the crystalline state, symmetry in crystals, X-ray diffraction, modern methods of structure determination and chemical interpretation of structural results. **Prerequisite:** CH 331, 332 or permission of instructor.
- CH 811 ANALYTICAL CHEMISTRY
3 cr. (3 and 0)
Graduate-level review of modern analytical chemistry; literature, sampling, quality control/assurance, chemometrics and the use of modern analytical methods are stressed; team taught by the analytical faculty.
- 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 816 SEPARATION SCIENCE
3 cr. (3 and 0)
Fundamental thermodynamic and kinetic concepts of separation and practical aspects of current separation techniques used in analytical chemistry.
- CH 821 ORGANIC CHEMISTRY I
3 cr. (3 and 0)
Theoretical concepts of organic chemistry, stereochemistry and mechanisms of organic reactions. **Prerequisite:** CH 421/621 or satisfactory performance on the organic chemistry placement examination.
- 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. **Prerequisite:** Permission of instructor.
- 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 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.

CHEMISTRY

- 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; homogeneous and heterogeneous catalysis; experimental methods; chain reactions; diffusion; 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 Schroedinger equation and application of this method to chemical problems.
- CH 840 TECHNIQUES OF EXPERIMENTAL CHEMISTRY
3 cr. (1 and 6)
Theory and practice in 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)
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)
New techniques and their applications in analytical chemistry; laser methods; data acquisition processing; electronics, instrument/computer interfacing; field methods of sampling and analysis. Topics vary with interests of students. May be repeated 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 and special topics in statistical mechanics. Topics vary with interests of students. May be taken for additional credit.
- CH 991 **DOCTORAL DISSERTATION RESEARCH**
Credit to be arranged.

COMPUTER SCIENCE

A. Joe Turner, Jr., Head, Department of Computer Science

Major	Degrees
Computer Science	M.S., Ph.D.

The following are required for unconditional admission to graduate study in computer science:

1. intermediate-level undergraduate computer science, including computer organization and data representation, machine and assembly language programming, data structures, file organization and processing, programming systems, theory of computation and software methodology; and
2. basic mathematics, including calculus, probability and statistics, and discrete mathematics.

An applicant with minimal deficiencies may be admitted provisionally, while one with several deficiencies may be required to satisfactorily complete prerequisite work as a postbaccalaureate student prior to admission as a graduate student.

A candidate for the M.S. degree must satisfactorily complete an approved program of at least 30 graduate hours. There are three plans available to the student to satisfy the degree requirements. Plan A requires a thesis; Plan B requires a research paper; and Plan C requires course work only. Students may take up to six hours of approved courses in areas outside the department.

Although there are no formal course requirements for the Ph.D. degree, a typical program requires two to four years of effort beyond the M.S. degree. Each candidate is required to pass a qualifying examination, a comprehensive examination, a dissertation proposal and a defense of the dissertation.

- CP SC 605 **INTRODUCTION TO GRAPHICAL SYSTEMS DESIGN**
3 cr. (3 and 0)
- CP SC 622 **INTRODUCTION TO OPERATING SYSTEMS**
3 cr. (3 and 0)
- CP SC 623 **IMPLEMENTATION OF OPERATING SYSTEMS**
3 cr. (2 and 2)

COMPUTER SCIENCE

- 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 DATA BASE MANAGEMENT SYSTEMS
3 cr. (3 and 0)
- CP SC 663 ON-LINE SYSTEMS
3 cr. (3 and 0)
- CP SC 664 INTRODUCTION TO COMPUTER ARCHITECTURE
3 cr. (3 and 0)
- CP SC 672 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 740 COMPUTER SCIENCE FOR HIGH SCHOOL TEACHERS I
3 cr. (2 and 2)
Introduction to modern problem-solving and programming methods for high school teachers. Topics include algorithm development, software life cycle concepts, system hardware and software components, and an introduction to programming in PASCAL. Restricted to graduate students and in-service teachers in secondary education. **Prerequisite:** Introductory computer programming.
- CP SC 741 COMPUTER SCIENCE FOR HIGH SCHOOL TEACHERS II
3 cr. (2 and 2)
Continuation of CP SC 740; problem-solving and programming techniques are considered in greater depth; elementary data structures are introduced. Restricted to graduate students and in-service teachers in secondary education. **Prerequisite:** CP SC 740 or equivalent.
- CP SC 810 INTRODUCTION TO ARTIFICIAL INTELLIGENCE
3 cr. (3 and 0)
Problem solving and game playing; knowledge representation; expert systems; natural language; perception and learning. **Prerequisite:** Permission of instructor.

- CP SC 820 PARALLEL ARCHITECTURE
3 cr. (3 and 0)
Parallel processing issues; vector and pipeline processors; arrays of processing elements; associative processor; data flow computers; networks of processors; survey of parallel programming languages; design and implementation of parallel algorithms; future trends. **Prerequisite:** CP SC 664.
- 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 401/601 and CP SC 423/623.
- CP SC 824 ADVANCED OPERATING SYSTEMS
3 cr. (3 and 0)
Recent trends in system design and implementation; operating system structures to support reliable secure systems; verification techniques; fault tolerant systems; operating system considerations for closely coupled multiprocessor systems; network operating systems. **Prerequisite:** CP SC 623 or permission of instructor.
- CP SC 825 SOFTWARE SYSTEMS FOR DATA COMMUNICATIONS
3 cr. (3 and 0)
Structure of software systems supporting communications among computing devices having diverse processing and communication capabilities; characterization of data communications software in terms of unified network architectures consisting of several functional layers; evaluation of several network architectures. **Prerequisite:** CP SC 622 or permission of instructor.
- CP SC 827 INTRODUCTION TO FORMAL LANGUAGES
3 cr. (3 and 0)
Review of the Chomsky hierarchy of languages and their machine equivalents; context-free languages; context-sensitive languages; type-0 languages and recursive functions; abstract families of languages; regulated rewriting systems; array grammars; complexity considerations. **Prerequisite:** CP SC 650 or equivalent.
- 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. **Prerequisites:** CP SC 429/629 and 450/650.
- CP SC 830 SYSTEMS MODELING
3 cr. (3 and 0)
Fundamental concepts and techniques used in the stochastic modeling of computer and computer-based communication systems; applications include hardware configuration design, software performance evaluation and reliability estimation of fault-tolerant systems. **Prerequisites:** CP SC 630 and MTH SC 400 or MTH SC 800, or permission of instructor.

- CP SC 838 **ADVANCED DATA STRUCTURES**
3 cr. (3 and 0)
Search trees; data structures for sets; index structures for data bases; data abstraction and automation implementation; implicit data structures; storage compaction of lists; data structures for decision trees; data structures in areas such as computer graphics, artificial intelligence, picture processing and simulation. **Prerequisite:** Permission of instructor.
- 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; inherently difficult problems. **Prerequisite:** MTH SC 419/619 or E&CE 352 or equivalent.
- CP SC 841 **COMPUTATIONAL COMPLEXITY**
3 cr. (3 and 0)
Deterministic and nondeterministic polynomial-time algorithms; NP-complete problems and Cook's Theorem; techniques for establishing NP-completeness; oracle machines; polynomial-time hierarchy; polynomial space; probabilistic algorithms and complexity classes; parallel complexity; provable intractability results. **Prerequisite:** CP SC 650 or 840.
- CP SC 850 **RECURSIVE FUNCTION THEORY**
3 cr. (3 and 0)
Turing machines; partially computable functions; r.e. sets; reducibilities; complete sets; recursion theorem; arithmetic hierarchy; Post's Theorem; priority methods; Turing degrees. **Prerequisite:** CP SC 650.
- CP SC 862 **DATA BASE 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. **Prerequisite:** CP SC 462.
- CP SC 864 **COMPUTER ARCHITECTURE**
3 cr. (3 and 0)
Computer architecture and structures from the classical Von Neumann machines to state-of-the-art computer organizations; nonconventional architectures such as array, pipeline, associative, data flow, reduction and tree machines. **Prerequisite:** CP SC 664.
- CP SC 872 **SOFTWARE SPECIFICATION AND DESIGN TECHNIQUES**
3 cr. (3 and 0)
Techniques, tools, environments and formal methods for software specification and design; verification of design correctness. **Prerequisite:** CP SC 672 or equivalent.

- CP SC 873 SOFTWARE VERIFICATION, VALIDATION AND MEASUREMENT
3 cr. (3 and 0)
Proofs of correctness; test planning; static dynamic testing; symbolic execution; automated testing; verification and validation over the software life cycle; software metrics; software maintenance. **Prerequisite:** CP SC 672 or equivalent.
- 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 888 DIRECTED PROJECTS IN COMPUTER SCIENCE
1-6 cr.
Directed individual project supervised by department faculty. Graded on a pass/fail basis.
- CP SC 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- CP SC 981 SEMINAR IN COMPUTER SCIENCE
1-3 cr. (1-3 and 0)
Topics of current research interest. May be repeated for credit.
- CP SC 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

GEOLOGY

Villard S. Griffin, Jr., Acting Head, Department of Earth Sciences

Major
Geology

Degree
M.S.

Candidates for the Master of Science degree in geology should have a baccalaureate degree in the geosciences. However, students having a strong undergraduate background in chemistry, physics or biology, or in civil, environmental or agricultural engineering, may be admitted but will be required to correct deficiencies in their geologic education during the first year. Specifically, GEOL 306 (Mineralogy) and GEOL 309 (Petrology), or their equivalents, are required. Credit toward the M.S. degree will not be allowed for 400/600-level courses which are listed in the *Clemson University Undergraduate Announcements* as required courses for the B.S. or B.A. degrees in geology.

Two options are offered for the M.S. degree. The nonthesis option requires 30 semester hours of course work and a final written examination. The thesis option requires 24 semester hours of course work and 6 hours of thesis research. Candidates must write a thesis based on original research and defend it at an oral examination.

All candidates must take at least six of the following core courses: CE 623 and 865, ESE/CE 682, ESE 685, GEOL 605, 608, 800, 801, 802 and 804. Three of these must be 800-level geology courses. Students may also select a number of recommended elective courses in engineering and geology from an approved list available in the department.

GEOLOGY

- GEOL 600 ENVIRONMENTAL GEOLOGY
3 cr. (3 and 0)
- GEOL 601 APPLIED GEOPHYSICS
3 cr. (2 and 2)
- 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 607 QUATERNARY GEOLOGY
3 cr. (2 and 2)
- GEOL 608 GEOHYDROLOGY
3 cr. (3 and 0)
- GEOL 610 OPTICAL MINERALOGY
3 cr. (1 and 5)
- GEOL 611 RESEARCH PROBLEMS
1-3 cr. (0 and 3-9)
- GEOL 612 GEOCHEMICAL ANALYTICAL TECHNIQUES
3 cr. (1 and 4)
- GEOL 613 STRATIGRAPHY AND SEDIMENTATION
3 cr. (2 and 2)
- GEOL 651 SPECIAL TOPICS IN HYDROGEOLOGY
1-4 cr. (1-3 and 0-3)
- GEOL 700 EARTH SCIENCE I: GEOLOGY FOR SCIENCE TEACHERS
3 cr. (2 and 3)
Geology for elementary and secondary school teachers of earth science and physical sciences; geologic methods; origin of the earth, rocks and minerals; processes and changes through time of the crust and surface; field trips provide practical examples.
- GEOL 711 EARTH SCIENCE II: SPECIAL TOPICS IN GEOLOGY FOR SCIENCE TEACHERS
1 cr. (0 and 2)
Earth science topics suitable for elementary and secondary school programs in a teaching laboratory format; grade is based on final oral and/or written report. May be repeated for credit. **Corequisite:** GEOL 101, 700 or permission of instructor.

- GEOL 740 EARTH/SPACE SCIENCE FOR ELEMENTARY SCHOOL TEACHERS
3 cr. (2 and 3)
Comprehension and application of earth/space science concepts suitable for classroom use at the elementary school level; earth science concepts will be related to South Carolina geological features.
- GEOL 790 SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN EARTH SCIENCES
1-6 cr. (0-6 and 0-18)
A study of one or more topics organized according to institute requirements; incorporates new or updated subject matter into classroom instruction through lecture and laboratory. Restricted to elementary and secondary school teachers.
- GEOL 800 GROUNDWATER GEOCHEMISTRY
3 cr. (2 and 3)
Lectures and project-oriented field work focusing on processes controlling natural impurities in groundwater and the occurrence of inorganic, organic and radioactive contaminants. Topics include solution equilibria, chemical weathering, oxidation-reduction, utilization of radioactive isotopes as tracers and studies of contamination plumes. **Prerequisites:** CH 101 and 102 or equivalent.
- GEOL 801 GROUNDWATER GEOPHYSICAL TECHNIQUES
3 cr. (1 and 4)
Lectures and project-oriented field work focusing on the utilization of geophysical instruments to detect groundwater-bearing fracture zones, to determine the depth to the water table, and to map contamination plumes. **Prerequisite:** PHYS 221 or permission of instructor.
- GEOL 802 ADVANCED STRUCTURAL GEOLOGY
3 cr. (2 and 2)
Rock mechanics; fabric analysis of tectonites; statistical structural field methods; preparation of structural contour maps and cross sections; tectonic setting of sedimentary basins; emphasis on the kinematics of deformed rock systems at all scales. **Prerequisite:** GEOL 402/602.
- GEOL 804 WATER WELL EXPLORATION, DRILLING AND MONITORING
3 cr. (2 and 2)
Locating sites for high yield water wells by means of satellite imagery, aerial photographs, topographic maps, subsurface and surface geological maps; drilling and coring techniques; installation of monitor wells and interpretation of data from monitor wells. **Prerequisite:** GEOL 408/608 or its equivalent.
- GEOL 851 GEOLOGY SEMINAR
1 cr. (1 and 0)
Students review current topics in geology and make oral presentations. May be taken twice for credit.
- GEOL 891 MASTER'S THESIS RESEARCH
Credit to be arranged.

MATHEMATICAL SCIENCES

Richard D. Ringeisen, Head, Department of Mathematical Sciences

Major	Degrees
Mathematical Sciences	M.S., Ph.D.

Entering students are expected to have a background in linear algebra, differential equations, a computer language and statistics.

For the master's program, both thesis and nonthesis options are available. The curriculum for both options includes foundation courses (advanced calculus, modern algebra, probability and discrete computing—courses often taken prior to entering the master's program); a breadth requirement (a course from each of algebra, analysis, computing, operations research and statistics plus one additional course in operations research or statistics); and a concentration area (six courses selected to define an identifiable specialty area). Every student's program is required to include at least one course, possibly chosen from outside the Department of Mathematical Sciences, which emphasizes mathematical modeling. A minimum of 36 graduate hours is required for the master's degree. In addition, students in the nonthesis option are required to complete a one-credit-hour project course.

Students in the doctoral program are expected to satisfy the master's program requirements prior to receiving their doctorate. Including master's study, a doctoral program must include two courses from each of the major areas of the mathematical sciences (algebra, analysis, computing, operations research and probability/statistics) and generally consists of 60 hours of graduate course work. Students are admitted to candidacy for the Ph.D. degree upon successful completion of a qualifying examination in three areas chosen from algebra, analysis, computing, operations research, statistics and stochastic processes. A student's Ph.D. program must include both a concentration area and a supporting area.

The departments of Management and Mathematical Sciences jointly offer and administer a doctoral program in management science. It is described under Management Science in the College of Commerce and Industry.

Mathematical sciences courses at the 700-level are applicable to master's degree programs in the College of Education only.

MTH SC 600	THEORY OF PROBABILITY 3 cr. (3 and 0)
MTH SC 601	STATISTICAL METHODOLOGY 3 cr. (3 and 0)
MTH SC 603	INTRODUCTION TO STATISTICAL THEORY 3 cr. (3 and 0)
MTH SC 605	STATISTICAL THEORY AND METHODS II 3 cr. (3 and 0)
MTH SC 606	SAMPLING THEORY AND METHODS 3 cr. (3 and 0)
MTH SC 607	REGRESSION AND TIME SERIES ANALYSIS 3 cr. (3 and 0)
MTH SC 608	TOPICS IN GEOMETRY 3 cr. (3 and 0)
MTH SC 612	INTRODUCTION TO MODERN ALGEBRA 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 634 ADVANCED ENGINEERING MATHEMATICS
3 cr. (3 and 0)
- MTH SC 635 COMPLEX VARIABLES
3 cr. (3 and 0)
- MTH SC 640 LINEAR PROGRAMMING
3 cr. (3 and 0)
- MTH SC 641 INTRODUCTION TO STOCHASTIC MODELS
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 700 MATHEMATICAL COMPUTER APPLICATIONS FOR ELEMENTARY TEACHERS
3 cr. (3 and 0)
Use of readily available software as tools in the elementary mathematics curriculum; LOGO language is used in a discovery approach to geometry; spreadsheets are employed to facilitate the organization and statistical processing of classroom data; word processing is integrated with spreadsheets applied to mathematics problem sets, examinations and parental reports.
- MTH SC 701 NUMBER SYSTEMS FOR THE ELEMENTARY GRADES
3 cr. (3 and 0)
Sets and cardinal numbers; development of base 10 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. Restricted to graduate students in elementary and secondary education.
- MTH SC 705 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL TEACHERS—ALGEBRA, PROBABILITY AND STATISTICS
3 cr. (3 and 0)
Fundamentals of elementary algebra, elementary probability and descriptive statistics. Restricted to graduate students in elementary and secondary education.
- MTH SC 707 MATHEMATICS FOR MIDDLE SCHOOL TEACHERS— ALGEBRA
3 cr. (3 and 0)
Algebraic concepts in middle-school mathematics: elementary number theory; the rational, real and complex number systems; polynomials and rational expressions; equations and inequalities. Restricted to graduate students in elementary and secondary education.
- MTH SC 709 MATHEMATICS FOR MIDDLE SCHOOL TEACHERS— GEOMETRY
3 cr. (3 and 0)
Geometric concepts in middle-school mathematics: lines and planes, angles and triangles, congruence and similarity, circles and spheres, area and volume. Restricted to graduate students in elementary and secondary education.
- MTH SC 710 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT I
3 cr. (3 and 0)
Origins of calculus; limits; derivative; maxima and minima; continuity; area and other applications of the integral. Restricted to graduate students in elementary and secondary education. **Prerequisite:** MTH SC 108 or its equivalent.
- MTH SC 711 ELEMENTARY CALCULUS FROM AN ADVANCED VIEWPOINT II
3 cr. (3 and 0)
Techniques of integration, logarithmic and exponent functions; applications of integrals; sequences and series. Restricted to graduate students in elementary and secondary education. **Prerequisite:** MTH SC 710 or permission of instructor.

- MTH SC 712 MODERN ALGEBRAIC CONCEPTS
3 cr. (3 and 0)
Development of axioms and fundamental concepts of some modern algebraic structures such as groups, rings and fields; applications to the familiar number systems. Restricted to graduate students in secondary education.
- MTH SC 715 ORDINARY DIFFERENTIAL EQUATIONS WITH APPLICATIONS
3 cr. (3 and 0)
Introduction to the study of ordinary differential equations and their application to physical, biological and social science problems. Topics include first and second order differential equations and their applications. **Prerequisite:** Knowledge of elementary calculus or permission of instructor.
- MTH SC 719 DISCRETE MATHEMATICS
3 cr. (3 and 0)
A survey of discrete mathematics emphasizing applications to computer science; propositions and logic; Boolean Algebra and switching circuits; recursion and induction; relations and partially ordered sets, graphs and trees.
- MTH SC 721 MATRIX ALGEBRA I
3 cr. (3 and 0)
Matrices and systems of equations; determinants; vector spaces and linear transformations; eigenvalues. 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 723 APPLICATIONS OF LINEAR AND MODERN ALGEBRA
3 cr. (3 and 0)
Various applied problems whose solutions rely on techniques and results of linear and modern algebra; problems selected from such areas as economics, forest management, genetics, population growth, transportation networks, cryptography, satellite communications, electronic switching circuits, chemistry, physics, sociology and others. **Prerequisite:** MTH SC 712, MTH SC 721 or equivalent, or permission of instructor.
- 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 727 ANALYSIS CONCEPTS FOR TEACHERS I
3 cr. (3 and 0)
Elementary functions, differential calculus and integral calculus; enrichment material and a theoretical perspective of calculus. Re-

stricted to teachers who hold a current teaching certificate in secondary mathematics. Completion of this course satisfies the special certification requirements for AB-calculus teachers in South Carolina.

- MTH SC 728 ANALYSIS CONCEPTS FOR TEACHERS II
3 cr. (3 and 0)
Continuation of MTH SC 727; enrichment material and a theoretical perspective on vector functions, sequences, series and elementary differential equations. Restricted to teachers who hold a current teaching certificate in secondary mathematics. Completion of this course satisfies certification for BC-calculus teachers in South Carolina.
- 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 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 761 PROBABILITY AND STATISTICS FOR TEACHERS
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 SCHOOL 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 the 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 SCHOOL MATHEMATICS II
3 cr. (3 and 0)
Computational mathematical topics are covered and implemented on a microcomputer: series approximation; area under a curve; Monte Carlo simulation; zeros of a function; Euclidean algorithm; amortization and compound interest; mean and standard deviation. Restricted to graduate students in secondary education. **Prerequisite:** MTH SC 771 or permission of instructor.
- 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 800 PROBABILITY
3 cr. (3 and 0)
Basic probability theory with emphasis on results and techniques useful in operations research and statistics. Topics include axiomatic probability, advanced combinatorial probability, conditional informative expectation, functions of random variables, moment generating functions, distribution theory and limit theorems. **Prerequisite:** MTH SC 206.
- 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 311.

MATHEMATICAL SCIENCES

- 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; operations research. **Prerequisite:** MTH SC 400/600 or 800.
- MTH SC 804 STOCHASTIC PROCESSES II
3 cr. (3 and 0)
Continuation of MTH SC 803: renewal theory, branching processes, Brownian motion, 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 and 400/600, or MTH SC 401/601 and 800.
- 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 600 or 800.
- 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; principle components analysis; factor analysis; analytic rotations; canonical correlations. **Prerequisites:** MTH SC 403/603 and 805 or permission of instructor.
- MTH SC 808 RELIABILITY AND LIFE TESTING
3 cr. (3 and 0)
Probability models and statistical methods relevant to parametric and nonparametric analysis of reliability and life testing data. **Prerequisites:** MTH SC 400/600 and 401/601 or equivalent.
- 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 600 and 605, or MTH SC 800 and 605, or equivalent.

- MTH SC 810 **MATHEMATICAL PROGRAMMING**
 3 cr. (3 and 0)
 Formulation and solution of linear programming models; mathematical development of the simplex method; revised simplex method; duality; sensitivity analysis; parametric programming, implementation, software packages. **Prerequisite:** MTH SC 311.
- 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; gradient methods. **Prerequisites:** MTH SC 440 and 454.
- MTH SC 812 **DISCRETE OPTIMIZATION**
 3 cr. (3 and 0)
 Principal methods used in integer programming and discrete optimization. Topics include branch and bound, implicit enumeration, cutting planes, group knapsack, Lagrangian relaxation, surrogate constraints, heuristics (performance analysis), separation/branching strategies and polynomial time algorithms for specific problems on special structures. **Prerequisite:** MTH SC 810 or equivalent.
- 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; nonlinear representations and other methods such as ellipsoid and Karmarkan. **Prerequisite:** MTH SC 440/640, 810 or equivalent.
- MTH SC 814 **NETWORK FLOWS**
 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); implementation and computational considerations. **Prerequisite:** MTH SC 440/640, 810 or equivalent.
- MTH SC 815 **DATA STRUCTURES**
 3 cr. (3 and 0)
 Representation and transformation of information; formal description 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 816 **GRAPH ALGORITHMS**
 3 cr. (3 and 0)
 Design, analysis and implementation of algorithms and data structures associated with the solution of problems formulated as networks and graphs; applications to graph theory, combinatorial optimization and network programming. **Corequisite:** MTH SC 640, 810, 863, 854 or 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. **Prerequisite:** MTH SC 803.
- 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 multicomponent structures. **Prerequisite:** MTH SC 817.
- MTH SC 819 MULTICRITERIA OPTIMIZATION
 3 cr. (3 and 0)
 Theory and methodology of optimization problems with vector-valued objective functions; preference orders and domination structures; generating "efficient" solutions; solving multicriteria decision-making problems, noninteractive and interactive methods with applications. **Prerequisite:** MTH SC 810 or equivalent.
- MTH SC 821 LINEAR ANALYSIS
 3 cr. (3 and 0)
 Normed spaces; Hilbert spaces, Banach spaces, linear functionals, linear operators, orthogonal systems. **Prerequisites:** MTH SC 454/654 or MTH SC 453 and 853.
- MTH SC 822 MEASURE AND INTEGRATION
 3 cr. (3 and 0)
 Rings and algebras of sets, inner and outer measures; measurability and additivity, examples on the line and in space, Lebesgue integration, types of convergence, Lebesgue spaces; integration and differentiation, product measure, Fubini theorem. **Prerequisite:** MTH SC 454/654.
- 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 nonengineering 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 INTRODUCTION TO DYNAMICAL SYSTEMS THEORY
3 cr. (3 and 0)
Techniques of analysis of dynamical systems. Topics include sensitivity analysis, linear systems, stability and control; the theory of differential and difference equations is emphasized. **Prerequisites:** MTH SC 454/654 and 311, or MTH SC 453 and 853.
- MTH SC 826 PARTIAL DIFFERENTIAL EQUATIONS
3 cr. (3 and 0)
First-order equations: elliptic, hyperbolic and parabolic; second-order equations: existence and uniqueness results, maximum principles, finite difference and Hilbert Space methods. **Prerequisite:** MTH SC 821 or permission of instructor.
- 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 837 CALCULUS OF VARIATIONS AND OPTIMAL CONTROL
3 cr. (3 and 0)
Fundamental theory of the calculus of variations; variable end points; the parametric problem; the isoperimetric problem; constraint inequalities; introduction to the theory of optimal control; connections with the calculus of variations; geometric concepts. **Prerequisite:** MTH SC 453/653 or 463/663.
- MTH SC 841 APPLIED MATHEMATICS I
3 cr. (3 and 0)
Derivation of equations from conservation laws, dimensional analysis, scaling and simplification; methods such as steepest descent, stationary phase, perturbation series, boundary layer theory, WKB theory, multiple-scale analysis and ray theory applied to problems in diffusion processes, wave propagation, fluid dynamics and mechanics. **Prerequisites:** MTH SC 208 and 453/653 or MTH SC 463/663.
- 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)
Survey of some basic algebraic structures: groups, rings and fields. Topics include permutation groups, Sylow theorems, finite abelian groups, polynomial domains, factorization theory and elementary field theory.

MATHEMATICAL SCIENCES

- MTH SC 852 ABSTRACT ALGEBRA II
3 cr. (3 and 0)
A continuation of MTH SC 851 including selected topics from ring theory and field theory.
- MTH SC 853 MATRIX ANALYSIS
3 cr. (3 and 0)
Topics in matrix analysis that support an applied curriculum: similarity and eigenvalues; Hermitian and normal matrices; canonical forms; norms; eigenvalue localizations; singular value decompositions; definite matrices. **Prerequisite:** MTH SC 311, 453 or 463.
- 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)
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 geometries; Latin rectangles; orthogonal arrays; block designs; error detecting and error correcting codes. **Prerequisite:** MTH SC 311.
- 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; 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 453 and 460.
- 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 311, 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 NAS AS/XL-V60; 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 110 and MTH SC 311 or 419.
- MTH SC 868 AN INTRODUCTION TO SCIENTIFIC COMPUTING
3 cr. (3 and 0)
Floating point models, conditioning and numerical stability, numerical linear algebra, integration, systems of ordinary differential equations and zero finding; emphasis is placed on the use of existing scientific software. **Prerequisites:** MTH SC 208, 311 and CP SC 110.
- MTH SC 881 MATHEMATICAL STATISTICS
3 cr. (3 and 0)
Fundamental concepts of sufficiency, hypothesis testing and estimation; robust estimation; resampling (jackknife, bootstrap, etc.) methods; asymptotic theory; two-stage and sequential sampling problems; ranking and selection procedures. **Prerequisite:** MTH SC 403/603 or equivalent.
- MTH SC 882 MONTE CARLO METHODS
3 cr. (3 and 0)
Random number generators, discrete and continuous random variate generation and approximations, random vector generation, Monte Carlo integration, variance reduction techniques. **Prerequisites:** MTH SC 800 and 603.
- MTH SC 885 ADVANCED DATA ANALYSIS
3 cr. (3 and 0)
Continuation of MTH SC 805, covering alternatives to ordinary least squares, influence and diagnostic considerations, robustness, special statistical computation methods. **Prerequisites:** MTH SC 800, 603 and 805.
- MTH SC 891 MASTER'S THESIS RESEARCH
Credit to be arranged.
- MTH SC 892 MASTER'S PROJECT COURSE
1 cr. (0 and 1)
For students in the nonthesis option of the Master of Science degree program in the mathematical sciences. Successful completion includes a presentation of the master's project to the student's advisory committee and acceptance of the paper by the committee.
- 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; models of convergence; weak and strong laws of large numbers. **Prerequisites:** MTH SC 400/600 and 822, or MTH SC 800 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 $L^1(\mathbb{R})$ and ideals in L^1 . **Prerequisites:** MTH SC 822 and 824.
- MTH SC 927 **FUNCTIONAL ANALYSIS I**
 3 cr. (3 and 0)
 Linear operators on specific spaces, spectral theory, semigroups of operators and the Hille-Yosida theorem, applications of linear spaces and operators, convexity. **Prerequisite:** MTH SC 821.
- MTH SC 928 **FUNCTIONAL ANALYSIS II**
 3 cr. (3 and 0)
 Continuation of MTH SC 927.
- MTH SC 954 **ADVANCED GRAPH THEORY**
 3 cr. (3 and 0)
 Continuation of MTH SC 854; covers topics not covered in 854, including the four-color theorem, domination numbers, Ramsey theory, graph isomorphism, embeddings, algebraic graph theory and tournaments; research papers are also examined. **Prerequisite:** MTH SC 854 or permission of instructor.
- 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 983 **SPECIAL TOPICS IN COMPUTATIONAL ANALYSIS**
 3 cr. (3 and 0)
 Advanced topics in computational mathematics and numerical analysis 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

Malcolm 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; genetic engineering; 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

MICROBIOLOGY

- MICRO 603 MARINE MICROBIOLOGY
3 cr. (2 and 3)
- MICRO 605 GENERAL MICROBIOLOGY
4 cr. (3 and 3)
- 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) F
- MICRO 616 INTRODUCTORY VIROLOGY
3 cr. (3 and 0) S
- MICRO 617 MOLECULAR MECHANISMS OF CARCINOGENESIS AND AGING
3 cr. (3 and 0)
- MICRO 618 BIOTECHNOLOGY I: NUCLEIC ACIDS TECHNIQUES
(BIO SC 618) 4 cr. (2 and 4)
(GEN 618)
- 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 a 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 subcellular levels with emphasis on bacterial and viral infections in man. **Prerequisite:** MICRO 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 twice for credit.
- 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 302 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. **Prerequisite:** MICRO 305/605; BIOCH 423/623; 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. **Prerequisite:** MICRO 305/605; BIOCH 423/623; MTH SC 206; or permission of instructor.
- MICRO 815 ADVANCED MICROBIAL GENETICS
3 cr. (3 and 0)
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; physicochemical 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

Peter J. McNulty, Head, Department of Physics and Astronomy

Major
Physics**Degrees**
M.S., Ph.D.

Graduate studies in physics and astronomy may be pursued by well-prepared students in the physical and mathematical sciences or engineering. As the basic physical science, physics offers intellectual opportunities of an unparalleled nature. Theoretical, experimental or computer-simulated studies of the physical universe, ranging from the macroscopic studies of cosmology to the microscopic world of quanta, are available.

All graduate student progress will be evaluated each spring semester by the Graduate Student Evaluation Committee. This committee will report its recommendations to the faculty, who, in turn, will advise the department head concerning students' performances. The recommendation of the faculty may be: (1) continuing satisfactory progress toward Ph.D. candidacy; (2) satisfactory progress toward the master's degree; (3) unsatisfactory progress toward any graduate degree. The department head will consider continuance of the student based, in part, on these recommendations.

Students beginning graduate studies in physics and astronomy usually enter the M.S. program. After two semesters, well-prepared students will be ready to begin a research program. This program most often culminates in a thesis, although a nonthesis option is available. A final oral examination on the general area of study and thesis defense is required for those electing the thesis option. In the nonthesis option, 36 credit hours are required, including six credit hours of Physics 890, Directed Activities in Applied Physics. A written report must be submitted on the directed studies. A final oral examination on the general area and directed activities completes the requirements for the nonthesis option. A program leading to the M.S. degree in physics with a concentration in health physics is available. Six credits of health physics or biophysics and nine credits of courses in biology, biochemistry or chemistry are required in this option.

Study for the Ph.D. degree begins with the general qualifying examination. A sufficiently high score on this examination may make it possible for a student to bypass the master's degree. An oral examination on the general research area is given within six months after completion of the written qualifying examination. At least three weeks prior to the convocation at which the student expects to receive the Ph.D. degree, a final oral examination on the dissertation must be completed.

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
3 cr. (1 and 4)

- PHYS 626 EXPERIMENTAL PHYSICS II
3 cr. (1 and 4)
- PHYS 627 INSTRUMENTATION IN EXPERIMENTAL PHYSICS
3 cr. (2 and 2)
- PHYS 632 OPTICS
3 cr. (3 and 0)
- PHYS 642 ELECTROMAGNETIC THEORY
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 673 X-RAY CRYSTALLOGRAPHY
3 cr. (2 and 3)
- PHYS 675 SPECIAL TOPICS IN PHYSICS
1-3 cr. (0-3 and 0-9)
- PHYS 703 MODERN PHYSICS FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0)
Rutherford model of the atom; molecular description of matter; nuclear forces; radioactivity; special relativity. Restricted to students in elementary and secondary education.
- PHYS 710 SPECIAL INSTITUTE COURSE: SELECTED TOPICS IN PHYSICS
1-6 cr. (0-6 and 0-18)
One or more topics organized according to institute needs; lecture and laboratory emphasize the incorporation of new or updated subject matter into classroom instruction. Restricted to elementary and secondary school teachers. **Prerequisite:** Permission of instructor.

PHYSICS

- 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 elementary and 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 suitable for classroom demonstration broaden the concepts of physics. Restricted to students in elementary and secondary education.
- PHYS 720 EARTH SCIENCE III: METEOROLOGY AND OCEANOGRAPHY FOR SCIENCE TEACHERS
3 cr. (3 and 0)
Physical processes governing the motions of the earth's atmosphere and oceans. Special topics include descriptions of experiments well suited for classroom use at the junior and senior high school level.
- PHYS 721 EARTH SCIENCE IV: SPECIAL TOPICS IN METEOROLOGY FOR SCIENCE TEACHERS
1 cr. (0 and 2)
Approved topics in meteorology in a field or laboratory environment; topics normally not covered in a formal course but may be an extension of a course. **Corequisite:** PHYS 720, 723 or permission of instructor.
- PHYS 723 WEATHER SCIENCE FOR SCIENCE TEACHERS
3 cr. (3 and 0)
Meteorological phenomena emphasizing nonmathematical 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 elementary and secondary education.
- PHYS 731 PHYSICS FOR AP TEACHERS
3 cr. (2 and 2)
Prepares teachers to develop and teach advanced placement physics; problem-solving skills and related instructional strategies are emphasized; lecture and problem-solving session format is used. **Prerequisite:** Permission of instructor.
- PHYS 775 TOPICS IN PHYSICS FOR TEACHERS
1-3 cr. (0-3 and 0-6)
Topics in mechanics, electricity and magnetism or modern physics, determined by the educational needs of the students. May be taken for a maximum of nine credits. Restricted to students in elementary and secondary education. **Prerequisite:** Permission of instructor.
- 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 solutions of physical problems.
- PHYS 815 STATISTICAL THERMODYNAMICS I
(ME 815) 3 cr. (3 and 0)
Fundamental principles of kinetic theory and quantum statistical mechanics; Boltzmann statistics, Fermi-Dirac statistics and Bose-Einstein statistics. **Prerequisite:** A course in thermodynamics or permission of instructor.
- PHYS 816 STATISTICAL THERMODYNAMICS II
3 cr. (3 and 0)
Generalized ensemble theory and fluctuations; applications to solids, liquids, gases and blackbody radiation. **Prerequisite:** PHYS 815.
- PHYS 817 ADVANCED STATISTICAL MECHANICS
3 cr. (3 and 0)
Current topics in statistical mechanics; phase transitions and critical phenomena. **Prerequisite:** PHYS 816.
- 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; wave guides; diffraction phenomenon; 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.

PHYSICS

- 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 852 RADIATION PHYSICS
 3 cr. (3 and 0)
 The interactions and basic mechanisms involved in the natural radiation environments of space, which include a variety of energetic, charged particles with sufficient energy to penetrate heavily shielded spacecraft and pose potential hazards to astronauts and electronic systems. **Prerequisite:** Undergraduate degree in physics or electrical engineering or permission of instructor.
- 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 department 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; 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 relativ-

istic effects are important; advanced scattering theory; quantization of relativistic field theories; development of covariant forms of perturbation theory; 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 re-normalization 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. degree 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)
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 elementary and secondary education.
- ASTR 711 **STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS**
3 cr. (3 and 0)
Lecture and observation course covering stellar and galactic astronomy, energy sources and other topics of current interest; planetarium programs and observing sessions are included. Restricted to students in elementary and secondary education.
- ASTR 730 **EARTH SCIENCE V: ASTRONOMY FOR SCIENCE TEACHERS**
3 cr. (3 and 0)
Astronomy with emphasis on the solar system and related phenomena. Topics include the major planets, the sun, comets and meteor showers, evolution of the solar system, celestial motions, time, constellations, structure of the Milky Way and elementary cosmology. Restricted to students in elementary and secondary education.

PHYSICS

- ASTR 731 EARTH SCIENCE VI: SPECIAL TOPICS IN ASTRONOMY
1 cr. (0 and 2)
Approved topics in astronomy to supplement the lecture course ASTR 730; primarily a laboratory/observation course. Restricted to students in elementary and secondary education. **Corequisite:** ASTR 730 or permission of instructor.
- ASTR 732 ASTRONOMY FOR EARTH SCIENCE TEACHERS
3 cr. (3 and 0)
Extra-solar system astronomy including motions of stars, stellar classification, the Hertzsprung-Russell diagram, evolution of stars, extragalactic astronomy and cosmology. Restricted to students in elementary and 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

James M. Colacino, Program Coordinator, Department of Biological Sciences

Major
Zoology

Degrees
M.S., Ph.D.

Students seeking the master's degree may select either a thesis or nonthesis option. Requirements for the thesis option 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 nonthesis option include 36 semester hours of course work and satisfactory performance in a final comprehensive examination.

Requirements for the Ph.D. degree include written and oral comprehensive examinations, research, a dissertation and satisfactory performance in a final oral defense. Although there is no required 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. (3 and 0) S
- ZOOL 604 PROTOZOOLOGY LABORATORY
1 cr. (0 and 3)
- ZOOL 605 ANIMAL HISTOLOGY
4 cr. (3 and 3)
- ZOOL 609 MODERN BIOLOGICAL INSTRUMENTATION
3 cr. (2 and 3)
- ZOOL 610 LIMNOLOGY
4 cr. (3 and 3) F
- ZOOL 615 INTRODUCTION TO MATHEMATICAL ECOLOGY
3 cr. (3 and 0)
- ZOOL 621 SEMINAR IN INVERTEBRATE ZOOLOGY
4 cr. (3 and 3)

- ZOOL 630 INTRODUCTION TO POPULATION GENETICS
3 cr. (3 and 0)
- ZOOL 650 COMPARATIVE VERTEBRATE EMBRYOLOGY
4 cr. (3 and 3)
- ZOOL 656 MEDICAL AND VETERINARY PARASITOLOGY
4 cr. (3 and 3) F
- ZOOL 657 COMPARATIVE PHYSIOLOGY
4 cr. (3 and 3)
- ZOOL 659 SYSTEMS PHYSIOLOGY
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
4 cr. (3 and 3)
- 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 topics in 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.

ZOOLOGY

- 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:** BIO SC 441/641 and ZOOL 470/670 or permission of instructor.
- ZOOL 812 SEMINAR
 1 cr. (1 and 0)
 Current literature on zoology.
- 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 students with natural macro- and microenvironments of individual species; field measurements of parameters of the environment are undertaken, and laboratory studies furnish detailed knowledge of various physiological adaptations to these parameters.
- ZOOL 816 ADVANCED ECOSYSTEM ANALYSIS 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 605; BIO SC 641 or BOT 846; ZOOL 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 605, BIO SC 641 or BOT 846; 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 are stressed. **Prerequisite:** AN PH 801/BIO SC 801 or ZOOL 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 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.
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; 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 involve a variety of developmental systems; various techniques used to study development and critical interpretation of results. **Prerequisites:** ZOOL 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.

ZOOLOGY

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 29634

University Switchboard

(803) 656-3311

Affirmative Action

Office of Human Resources, E-103 Martin Hall, telephone (803) 656-3181, zip: 29634-5004

Assistantships

Address the head of the department of proposed major.

Financial Aid

Financial Aid Office, G-01 Sikes Hall, telephone (803) 656-2280, zip: 29634-4023

Graduate Study

Dean of Graduate School, E-106 Martin Hall, telephone (803) 656-3195, zip: 29634-5120

Housing

Housing Office, 200 Mell Hall, telephone (803) 656-2295, zip: 29634-4075

International Programs and Services

Office of International Programs and Services, E-208 Martin Hall, telephone (803) 656-2457, zip: 29634-5120

Public School Teachers Information

Agricultural Education, telephone (803) 656-3300, zip: 29634-0356
Elementary and Secondary Education, telephone (803) 656-3482, zip: 29634-0709

Industrial Education, telephone (803) 656-3447, zip: 29634-0711

Off-Campus Courses—Office of Extension and Public Relations, telephone (803) 656-2497, zip: 29634-0713

Registration and Class Schedules

Registrar, 102 Sikes Hall, telephone (803) 656-2171, zip: 29634-4019

Telecampus

Director, E-205 Martin Hall, telephone (803) 656-4227 or 1-800-922-8316, zip: 29634-5121

Transcripts

Registrar, 104 Sikes Hall, telephone (803) 656-2173, zip: 29634-4019

Vice President for Research

Vice President for Research, 107 Tillman Hall, telephone (803) 656-4538, zip: 29634-5701

Veterans Affairs

Registrar, 102 Sikes Hall, telephone (803) 656-2171, zip: 29634-4019

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 29634

