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Clemson Graduate School Catalog, 1977-1978

Clemson University

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THE GRADUATE SCHOOL ANNOUNCEMENTS

1977-78

CLEMSON UNIVERSITY

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.

The requirements for each curriculum shall be the catalog requirements in effect on the date of enrollment in that curriculum. If a student withdraws from the University and subsequently returns, the catalog requirements in effect at the time of return will control.

STUDENT RESPONSIBILITY

All colleges and departments establish certain academic requirements which must be met before a degree is granted. Advisors, department heads, and deans are available to help the student understand and arrange to meet these requirements, but the student is responsible for fulfilling them. At the end of a student's course of study, if 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 in timely manner.

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

EQUAL OPPORTUNITY IN PROGRAMS AND ACTIVITIES

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

Title VI of the Civil Rights Act of 1964

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

Title IX of the Education Amendments of 1972

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

Section 504 of the Rehabilitation Act of 1973

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

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

Inquiries concerning the above may be addressed to:

President
Clemson University   or
Clemson, South Carolina 29631

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

CLEMSON
UNIVERSITY

THE GRADUATE SCHOOL ANNOUNCEMENTS

1977-78

DEADLINES DATES

For those who expect to receive a graduate degree:

	August 6, 1977
Last day for:	
Filing GS4, Admission to Candidacy for a degree and diploma order	June 3, 1977
Oral and/or written examination	July 15, 1977
(Optional)	
Preliminary review of completed (signed) theses, prior to printing, by the Graduate School Office	July 22, 1977
Final submission of theses and dissertations to the Graduate School Office	July 29, 1977

CHECK LIST ON GRADUATE SCHOOL PROCEDURES

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

1. Select in consultation with the appropriate department head a major advisor and advisory committee. (See page 26)

2. Submit Graduate Degree Curriculum (GS Form 2). (See page 27)

3. Satisfy any prescribed language requirement and qualifying examination prerequisite to admission to candidacy. (See pages 33, 36, 37)

4. Apply for admission to candidacy for a degree and order diploma (GS Form 4) after completing at least half the prescribed course work. (See page 27)

5. Submit completed thesis (if required) or dissertation to advisory committee chairman and arrange for final examination by the advisory committee. (See pages 30, 31, 33, 38)

6. Pay binding fee to the bursar and submit approved copies of thesis to the Graduate School. Doctoral candidates pay for abstract publication in Dissertation Abstracts. (See page 31)

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

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EXPLANATION OF COURSE DESCRIPTIONS

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

Courses listed in this catalog in the 600 series are described in the undergraduate catalog, *Announcements 1977–78*, as 300- and 400-level courses. A copy of the general catalog may be obtained from the director of admissions. Graduate credit can be earned only for courses numbered 600 or above.

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

Master's thesis and doctoral dissertation research (891 and 991 courses respectively) may be taken more than one semester.

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GRADUATE PROGRAMS AND COURSE OFFERINGS

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

CLEMSON UNIVERSITY CALENDAR
SUMMER 1977–SUMMER 1978

SUMMER SESSIONS 1977

(Classes meet Monday–Friday except as indicated.)

First Session

May 16	Monday—Registration
May 17	Tuesday—Classes begin
June 22–23	Wednesday–Thursday—Examinations

Second Session

June 27	Monday—Orientation, new students
June 28	Tuesday—Registration
June 29	Wednesday—Classes begin
July 4	Monday—Classes suspended
July 9	Saturday—Classes meet
July 30	Saturday—Classes meet
August 3–4	Wednesday–Thursday—Examinations
August 6	Saturday—Graduation

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FALL SEMESTER 1977

August 22–23	Monday–Tuesday—Orientation, new students
August 24	Wednesday—Registration, all students
August 25	Thursday—Late registration
August 26	Friday—Late registration fee applies
August 26	Friday—Classes begin regular schedule
September 1	Thursday—Last day for registration
September 1	Thursday—Last day to add a subject
September 15	Thursday—Last day to order diploma for mid-year graduation
September 22	Thursday—Last day to drop a subject without record
October 17	Monday—Preliminary reports due
November 2	Wednesday—Last day to drop a subject or withdraw from the University without receiving final grades
November 14–18	Monday–Friday—Preregistration
November 23	Wednesday—Thanksgiving holidays begin after last class
November 28	Monday—Classes resume
December 12	Monday—Examinations begin
December 22	Thursday—Mid-year graduation

SPRING SEMESTER 1978

January 9	Monday—Orientation, new students
January 10	Tuesday—Registration, all students
January 11	Wednesday—Late registration
January 12	Thursday—Late registration fee applies
January 12	Thursday—Classes begin regular schedule
January 18	Wednesday—Last day for registration
January 18	Wednesday—Last day to add a subject
February 1	Wednesday—Last day to order diploma for May graduation
February 8	Wednesday—Last day to drop a subject without record
March 6	Monday—Preliminary reports due
March 17	Friday—Last day to drop a subject or withdraw from the University without receiving final grades
March 17	Friday—Spring holidays begin after last class
March 27	Monday—Classes resume
April 12	Wednesday—Honors and Awards Day; classes suspended at noon
April 17–21	Monday–Friday—Preregistration
May 1	Monday—Examinations begin
May 12	Friday—Commencement

SUMMER SESSIONS 1978

(Classes meet Monday–Friday except as indicated.)

First Session

May 22	Monday—Registration
May 23	Tuesday—Classes begin
June 28–29	Wednesday–Thursday—Examinations

Second Session

July 5	Wednesday—Orientation, new students
July 5	Wednesday—Registration
July 6	Thursday—Classes begin
July 8	Saturday—Classes meet
August 5	Saturday—Classes meet
August 9–10	Wednesday–Thursday—Examinations
August 12	Saturday—Graduation

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THE UNIVERSITY

INTRODUCTION

Clemson University is a coeducational land-grant university offering 76 fields of study in nine undergraduate colleges and 55 areas of graduate study. The academic units are the Colleges of Agricultural Sciences, Engineering, Architecture, Education, Forest and Recreation Resources, Industrial Management and Textile Science, Liberal Arts, Nursing, and Sciences. Fully accredited by the Southern Association of Colleges and Schools, the graduate curriculums form a background of education for the hundreds of occupations which Clemson graduates enter.

Present on-campus enrollment totals approximately 11,000 students, which includes about 1,900 graduate students. The 600-acre campus is located in the northwestern part of South Carolina approximately two and one-half hours' driving time from both Atlanta, Georgia, and Charlotte, North Carolina.

UNIVERSITY GOVERNMENT AND ADMINISTRATION

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

Academic deans are responsible for programs and personnel in their individual colleges and report directly to the dean of the university. At the direction of the dean of the university, the academic deans coordinate undergraduate programs, graduate programs and research, and extension programs respectively with the deans of undergraduate studies, graduate studies and university research, and university extension.

The dean of graduate studies and university research coordinates all graduate programs and university research. He advises the dean of the university on policies and regulations pertaining to graduate study and research. Matters concerning graduate admissions policies, graduate student programs, and the granting of graduate degrees are coordinated through his office. He chairs the Graduate Council and the University Research Council and is administratively responsible for the Computer Center, the Division of Administrative Programming Services, and the Division of Information Systems Development.

Board of Trustees

Life Members

Paul W. McAlister, Chairman .... Laurens, S.C.
Robert R. Coker .... Hartsville, S.C.
William Green DesChamps, Jr. .... Bishopville, S.C.
Thomas B. McTeer, Jr. .... Columbia, S.C.
Buck Mickel .... Greenville, S.C.
James C. Self .... Greenwood, S.C.
James M. Waddell, Jr. .... Beaufort, S.C.

Term Expires 1978

Lewis F. Holmes, Jr. .... Trenton, S.C.
E. Oswald Lightsey .... Hampton, S.C.
D. Leslie Tindall .... Pinewood, S.C.

Term Expires 1980

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

Joseph B. McDevitt, Secretary .... Clemson, S.C.

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Executive Officers and Deans

Robert Cook Edwards, B.S., LL.D. .... President
Victor Hurst, Ph.D. .... Vice-President for Academic Affairs
and Dean of the University
Stanley Gosanko Nicholas, B.S.M.E. ... Vice-President for Development
Joseph Bryan McDevitt, J.D. .... Vice-President for Executive
Affairs and University Counsel
Walter Thompson Cox, B.S. .... Vice-President for Student Affairs
Melvin Eugene Barnette, M.S. . Vice-President for Business and Finance
Claud Bethune Green, Ph.D. .... Dean of Undergraduate Studies
Arnold Edward Schwartz, Ph.D. .... Dean of Graduate Studies
and University Research
Samuel Marsh Willis, Ph.D. .... Dean of University Extension
Luther Perdee Anderson, Ph.D. ...Dean, College of Agricultural Sciences
Harlan Ewart McClure, M.Arch. .... Dean, College of Architecture

Harold Fochone Landrith, Ed.D. . . . . Dean, College of Education
Lyle Chester Wilcox, Ph.D. . . . . Dean, College of Engineering
William Henry Davis McGregor, Ph.D. . . . . Dean, College of Forest
and Recreation Resources
Wallace Dabney Trevillian, Ph.D. . . . . Dean, College of Industrial
Management and Textile Science
Headley Morris Cox, Ph.D. . . . . Dean, College of Liberal Arts
Geraldine Labecki, Ed.D. . . . . Dean, College of Nursing
Henry Elliott Vogel, Ph.D. . . . . Dean, College of Sciences

Members of the Graduate Council

Arnold E. Schwartz, Ph.D., Professor of Civil Engineering and Dean of
Graduate Studies and University Research, Chairman, ex-officio.

Term Expires 1980

I. Carolyn Briscoe, Ed.D. . . . . Associate Professor of Education
Johannes P. Holschneider, Dr. Ing. . . . . Professor of Architecture
Thomas E. Skelton, Ph.D. . . . . .Associate Professor of Entomology
and Economic Zoology

Term Expires 1979

Richard J. Calhoun, Ph.D. . . . . Alumni Professor of English
Lawrence A. Dyck, Ph.D. . . . . Associate Professor of Botany
Lawrence E. Nix, Ph.D. . . . . Assistant Professor of Forestry

Term Expires 1978

Marvin W. Dixon, Ph.D. . Associate Professor of Mechanical Engineering
Warren W. Menke, Ph.D. . Associate Professor of Industrial Management
Gloria A. Tanner, Ed.D. . . . . Assistant Professor of Nursing

One Year Term

Faculty Senate Representative:
O. John Jacobus, Ph.D. . . . . Professor of Chemistry
Student Representatives:
Michael J. Ellerbrock, M.R.P.A.
Sarah F. Newsome, B.S.

GRADUATE SCHOOL

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

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

Graduate Council

This council consists of the dean of graduate studies and university research, ex-officio, one member of the Faculty Senate, one faculty member from each college, one officially designated alternate from each college who will attend and vote in the regular council member's absence, and two graduate students. The faculty senator is nominated by the Faculty Senate and appointed by the dean of the university for one year. The faculty members are nominated by the dean of the college and appointed by the dean of the university for a term of three years. The graduate students are nominated by the Graduate Student Association, and appointed by the dean of the university for a term of one year.

All policies and regulations affecting graduate curricula and requirements leading to graduate credits, certification, and degrees are approved by this council and recommended to the dean of the university.

The Graduate Council also serves as an appeal board for decisions regarding admission and/or degree requirements or other policy decisions affecting the welfare of graduate students. The appeal must be presented in writing to the graduate dean or to any member of the Graduate Council. Graduate students and faculty members who are not members of the council may be invited to attend its meetings.

ROBERT MULDROW COOPER LIBRARY

The Robert Muldrow Cooper Library is essentially a consolidation of special libraries pertaining to agricultural and biological sciences, science and technology, and carefully selected collections in the social sciences and the humanities. The collection consists of 618,000 volumes of books, periodicals and government publications. Sixty-nine newspapers and 11,300 serial titles—periodicals, reports, bulletins and the like—are received regularly. Microfilm and microcard readers are provided for consulting material in microtext.

The library building, which was occupied in 1966, is modern in every respect and was designed for quiet reading, convenient reference service and easy access to research materials. It is the permanent home of papers

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and souvenirs of the late State Senator Edgar A. Brown, as well as valuable collections of papers and letters of John C. Calhoun, the late James F. Byrnes, and other famous South Carolina statesmen.

In addition to the main library, there are departmental libraries in the colleges of Industrial Management and Textile Science, Architecture, Engineering, and Sciences.

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

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

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

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

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

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

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

COMPUTER CENTER

The Clemson University Computer Center operates an IBM System 370/Model 165-II with four megabytes of core storage, which is available to graduate students for course work and research. The Center supports FORTRAN, COBOL, PL/I, ALGOL, BASIC, ASSEMBLER, and a number of simulation and special-purpose languages. A large library of statistical and mathematical routines is available to users.

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

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

The main Computer Center in the basement of the R. F. Poole Agricultural Center is open from 7:45 a.m.–11 p.m. Monday–Friday; 8 a.m.–6 p.m. Saturday; and 2–11 p.m. Sunday. Remote centers are located in Martin, Riggs, and Sirrine Halls. The Martin center is open Monday–Friday 7:45 a.m.–11:30 p.m.; Saturday 8 a.m.–6 p.m.; Sunday 2–11:30 p.m. The Riggs center is open Monday–Friday 9 a.m.–5 p.m. and 7–10 p.m. The Sirrine center is open Monday–Friday 8 a.m.–noon and 1–4:30 p.m.

STUDENT SERVICES

HOUSING

Residence Halls

Residence halls are located on the main campus and provide excellent accommodations at economical rates for graduate and undergraduate students. All rooms are air conditioned and equipped with clothes lockers, study desks, chairs, and single or convertible bunk beds with inner spring mattresses. Two students are assigned to a room.

Graduate students interested in residence hall accommodations should write directly to the Housing Office, Mell Hall, Clemson University, Clemson, South Carolina 29631, to obtain information regarding assignments. This should be accomplished promptly for there is a critical shortage of on-campus housing. To request a space, applicants should contact the Housing Office at least three to six months prior to the date scheduled for enrollment.

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

Semester room fees are as follows:

Johnstone (Sections E, F) (Men)	$250.00
Johnstone (Sections A, B, C, D) (Men)	$265.00
Bowen, Bradley, Donaldson, Johnstone (Annexes A, F), Norris, Wannamaker (Men)	$275.00
Benet, Cope, Geer, Sanders, Young (Women)	$275.00
Lever, Mauldin (Men)	$290.00
Barnett, Byrnes, Manning, Smith (Women)	$290.00

Clemson House (Women)
Room (two occupants) $290.00
Apartment with kitchenette
(three or four occupants) $310.00

Married Student Housing

The University provides comfortable and economical housing for its married students. There are three housing areas consisting of 100 single Prefab units, 100 East Campus apartments contained in 50 duplex buildings, and 50 Littlejohn apartments in 11 buildings.

All units have two bedrooms, living room, kitchen and bath. East Campus apartments are the newest and are equipped with stove and refrigerator. Residents of Littlejohn apartments and Prefabs must furnish these items.

Applications and booklets describing these facilities are available upon request from the Housing Office of the University. Monthly rental fees are: Prefabs, $51; Littlejohn, $72 for end units, $69 for interior units; East Campus, $90. A $25 refundable reservation fee must accompany the application at time of submission.

Graduate assistants and graduate fellows only are given priority over undergraduate students in assignments to married student housing. To qualify for this priority their applications must be received at the Housing Office before April 20 for first semester housing, before November 1 for second semester housing, and before March 1 for summer housing.

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Off-Campus Housing

Commerical housing in the surrounding community accommodates the majority of graduate students, both married and single. A listing of realty companies and other contacts has been compiled by the Graduate Student Association and is available at no cost from the Graduate School upon request.

Housing for International Students

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

FOOD SERVICE

The two University dining halls, operated by ARA Food Services, offer two board plans and also provide meals on an individual basis.

1. 5-Day Board Plan—15 meals, Monday through Friday, excluding holidays, $265 per semester.

2. 7-Day Board Plan—21 meals, Monday through Sunday, excluding holidays, $320 per semester.

3. Students not on a board plan may purchase individual meals at prevailing prices.

Both the five-day and seven-day board plans begin immediately after a student obtains a meal ticket and terminate on the day scheduled for graduation. Five-day board plan tickets will not be issued on Saturdays or Sundays. Summer school fees for either plan are on a prorated basis. Á la carte service will be offered in student dining halls only on special occasions.

HEALTH SERVICE

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

The $45 per semester medical fee (summer session fees are on a prorated basis) covers the services of the University physicians and health service staff and medication for most illnesses and injuries. Items not covered by the fee, however, include physical examinations for employment or transfer to another school, outside physicians called in for consultation, medical or surgical services performed away from campus, and ambulance service. Dental care is not offered by the health service but can be obtained locally at the student's expense.

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

The health service is housed in Redfern Health Center and is complete with an outpatient department and a 34-bed hospital. The outpatient clinic is open 8:30–11:30 a.m. and 2–4:30 p.m. weekdays, and 8:30–11:30 a.m. Saturdays. The nursing staff is available to treat minor ailments after hours, and one physician is on call at night for emergencies whenever school is in session. The health service does not operate between semesters.

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

INTERNATIONAL STUDENTS AND EXCHANGE VISITORS

The International Services Office assists foreign students in academic, social, financial, and personal matters. It serves as a liaison

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office between Clemson University and the U.S. Immigration Service. All foreign students should report immediately to this office upon arrival at Clemson.

International students coming from abroad or transferring from another school are required to have sufficient funds deposited with Clemson University to cover costs for one academic year. Students receiving an assistantship must deposit $1,000 and students without an assistantship must deposit $3,000. These deposits must be made prior to the issuing of a certificate of eligibility for entering the United States. Should a student not enroll at Clemson, the deposit will be refunded.

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

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

GRADUATE EXPENSES AND FINANCIAL AID

EXPENSES, 1977-1978

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Tuition and Fees

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

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

Tuition	$ 75.00*
University Fee	290.00*
Matriculation Fee (non-refundable)	5.00
Medical Fee	45.00
Semester Total (excluding room and board)	$415.00*

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

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

Tuition (per semester hour)	$6.00*
University Fee (per semester hour)	22.00*
Matriculation Fee (non-refundable)	5.00
Medical Fee (optional for non-dormitory domestic students)	45.00
Fike Recreation Center Fee (optional)	15.00

*Subject to change.

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

Auditing

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

Tuition (per semester hour) $3.00*
University Fee (per semester hour) 11.00*

Graduate Assistants and University Staff

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

Tuition (per semester hour) $3.00*
University Fee (per semester hour) 11.00*
Matriculation Fee (non-refundable) 5.00

Use of Fike Recreation Center facilities by graduate assistants during the regular fall and spring semesters is at no additional cost while the summer fee is $7.50 per session for all students. Graduate assistants utilizing the student health service must pay the medical fee of $45.00 per semester. Season athletic tickets may be purchased at the faculty-employee rates.

A graduate assistant is defined as a student with at least a baccalaureate degree from an approved institution who is enrolled in a degree program and devotes a minimum of 10 hours of service per week to the University for the entire semester.

Graduation Fees

Fees for thesis binding, diploma, rental of cap and gown, and publication of dissertation abstract are not included in the above charges.

Athletic Contests and University Concerts

All graduate students are eligible to pay the full fee schedule of $415 with the same restrictions and privileges as apply to undergraduate students. Students enrolled for less than 12 hours and electing not to pay the full fee are eligible to apply for the purchase of season tickets as follows:

1. Graduate assistants and full-time equivalent students will be eligible to purchase season tickets at the faculty-employee rates.

2. Other graduate students may purchase at regular season and individual ticket rates.

*Subject to change.

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

Settlement of University Fees

The entire amount of the expense for each semester or summer session is due and payable at the beginning of each semester or summer session, and no student is officially enrolled until all expenses are satisfied. In special cases the University will accept, at the beginning of a semester, a non-interest bearing promissory note for a portion of the semester residence hall fee and semester-plan board fee. In such cases, the note for the first semester charges will be due October 10, and the note for the second semester charges will be due March 1. International graduate students are not eligible for deferred payments. No deferred payments are permitted for summer sessions for any graduate student.

Upon certification and recommendation of the department head and approval by the dean of graduate studies and university research, deferred payment of academic fees may be granted to students employed as graduate assistants, except international graduate students. The total amount deferred shall not exceed fifty percent of the sum of the student's assistantship for the first five consecutive pay periods for the semester.

A $75 advance payment is required in reserving a room in University residence halls. This payment is made to the Housing Office in accordance with room reservation instructions provided upon request by that office.

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

Past Due Student Accounts

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

Establishment of University Fees

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

FINANCIAL AID FOR GRADUATE STUDY

All graduate students, with the exception of full-time employees must enroll as full-time equivalent students in order to qualify for any financial aid from the University. The University reserves the right to withdraw financial aid at any time due to failure to meet this requirement.

Research and Teaching Assistantships

Research and teaching assistantships are available to outstanding graduate students. Teaching assistantships are normally awarded for the academic year* while research assistantships may be granted for longer periods. Stipends range from $2,000 to $5,400 and fees are reduced. Application forms can be obtained from the Graduate School or from department heads and should be completed and filed early in the academic year before the student expects to enroll. Recipients of assistantships are selected by the respective academic departments and will be notified by the department.

Graduate Fellowships

Graduate Fellowships are also available. All fellowship awards are made by the heads of departments concerned.

Other Funds

Limited assistance may also be available from the Clemson Foundation, Clemson Student Loan Funds, and National Defense Student Loan Programs. Contact the Student Financial Aid Office prior to June 1 for further information.

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ADMISSION REQUIREMENTS AND PROCEDURES

GENERAL REQUIREMENTS

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

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*Teaching assistants may be awarded stipends during the summer months for performance of departmental duties provided they continue to work towards their degree.

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

There is no fee for Graduate School applications.

New Applicants

For enrollment in the University's graduate programs, a student must hold at least a bachelor's degree from an institution whose scholastic rating is satisfactory to the University and must have the approval of the head of the department in which the major work is planned. A satisfactory score on the aptitude portion of the Graduate Record Examination (GRE) also is required for admission to all M.A., M.S., and Ph.D. degree programs and some advanced professional programs. This examination is required of all international students prior to admission regardless of the program they plan to enter. A satisfactory score on the Test of English as a Foreign Language (TOEFL) is also required of international students, but this requirement *may* be waived if the applicant has earned a four-year bachelor's degree in the United States. The Graduate School also 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.

Admission in all programs is restricted to those students whose academic records clearly indicate they are prepared to benefit from graduate study. Neither an academic record exceeding minimum requirements nor satisfactory scores on standardized tests alone will assure a student's admission. Rather, the total record must indicate the likelihood of successful graduate study.

Conditional Acceptance

Notice of conditional acceptance may be given to highly qualified applicants prior to receipt of the degree they are presently pursuing; however, all requirements for this degree must be completed prior to enrolling in the proposed graduate program at Clemson University.

Clemson University seniors lacking less than a full semester of work to complete the requirements for their baccalaureate degree may apply for admission to a graduate program and, if admitted, be allowed to enroll in courses for graduate credit. Refer to "Clemson University Seniors" on page 24.

Applicants Presently Enrolled in the Graduate School

Students enrolled in a master's degree program at Clemson University who wish to continue their studies in a doctoral program may apply by submitting the normal application. This application must be supported by the student's advisory committee for the master's degree or other faculty

designated by the graduate dean who are associated with the applicant's present or proposed program.

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

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 an M.A. or M.S. degree in a given field, received at another institution, become a candidate for a different master's degree in the same field at Clemson.

MEDICAL REQUIREMENT

Submission of a medical history is required of all students who subscribe to the health service and in particular of all full-time graduate students entering Clemson University for the first time. Prior to or during the registration period, the student will receive a medical questionnaire which is to be completed and returned for data processing to the service agency who will forward the information to the director of student health services. The cost for this service is $7.00 payable to the agency, and the entire procedure is in lieu of a medical examination.

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

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

ADMISSION CLASSIFICATIONS

All applicants to advanced degree programs are expected to have completed an undergraduate curriculum appropriate to their field of graduate study. Those potentially acceptable applicants who already hold the bachelor's degree but who have a significant number of undergraduate deficiencies will not be admitted to the Graduate School in any classification. Such applicants who choose to enroll in undergraduate courses at Clemson University in order to remove the deficiencies may be admitted as a postgraduate student by the Undergraduate Admissions Office and may reapply to the Graduate School subsequent to the completion of a sufficient number of undergraduate courses as may be required by the department head. Postgraduate students are not eligible to enroll in any

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graduate level courses or to receive graduate assistantships or fellowships until they are accepted by the Graduate School in a degree program (see pages 21 and 25).

Admission to a Degree Program

This is the normal classification of qualified students who become candidates for an advanced degree from Clemson University. In addition to the minimum requirements for degree programs listed under "Degree Requirements" (page 31), the student must also meet any special departmental requirements.

Admission as a Non-Degree Student

Admission in this category is restricted primarily to public school teachers who are required to complete graduate courses for certification or re-certification and to other applicants whose profession may require additional study at the graduate level. Non-degree students are not eligible to become candidates for advanced degrees while in this status. Should the student subsequently be admitted to a degree program, a maximum of 12 semester hours of graduate credit taken at any campus (non-degree and/or transfer) can be applied toward the degree. In all cases the non-degree student must receive permission from the head of the department before enrolling in courses. This classification is not open to international students.

ENROLLMENT IN GRADUATE COURSES

Clemson University Seniors

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

Seniors with a cumulative grade-point ratio of 3.0 or higher may enroll in 700- and/or 800-level courses and may choose to use these courses to meet requirements for the bachelor's degree. However, courses used for this purpose may not be counted later toward an advanced degree. Alternatively, students who take such courses in excess of the requirements for their undergraduate degrees may request that these courses be included as a part of their graduate program if they are subsequently admitted to the Graduate School at Clemson.

A Clemson senior with a cumulative grade point ratio less than 3.0 may

apply to the Graduate School and be given conditional acceptance as described on page 22. If accepted, the student may enroll in graduate courses subject to approval of GS Form 6.

Transient Graduate Students

A student who has been admitted to a degree program at another institution and who wishes to take courses for transfer to that institution may be permitted to enroll in graduate courses on receipt of the Certification of Transient Graduate Admission (GS Form 8) which may be obtained from the Graduate School at Clemson University. This form and a completed application form must be presented 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 concerned 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 29.

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Teacher Certification

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

Restrictions

Enrollment in any graduate course is subject to approval by the department offering the course and requires permission of the instructor whether or not such is specifically stated in the course description. In order to enroll in or receive credit for any courses of the 600 series or above, the student (with exception of certain Clemson University seniors) must have been officially accepted by the Graduate School in one of the classifications listed under "Admission Classifications" on page 23.

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

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

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

PROCEDURES TO FOLLOW IN PURSUING A DEGREE

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

The Major Advisor

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

The Advisory Committee

An advisory committee will approve the student's graduate degree curriculum, supervise the graduate program, administer the preliminary and/or final comprehensive examination, and initiate the recommendation for the awarding of the degree. One member of the committee will be designated as chairman and normally will direct the student's dissertation or thesis, if required. This committee is selected by the department head and student. Concurrently with submission of the graduate degree curriculum, the department head will forward recommendations to the dean of the college, who will, if he or she approves, then transmit the recommendation to the graduate dean. A minimum of three faculty members shall be selected for a student seeking a master's degree, and a minimum of four faculty members shall be selected for a student seeking a Ph.D. degree. Qualifications of faculty for membership on the advisory committee should be discussed with the college dean. The student and faculty members are notified of the committee appointments by the graduate dean.

Filing of a Graduate Degree Curriculum

A graduate degree curriculum (GS Form 2) must be filed with the Graduate School by those students who are in degree programs. Since fixed curriculums normally do not exist for graduate degrees, this planned program represents the formulation of an individual student's curriculum as recommended by the advisory committee. It must adhere to departmental as well as Graduate School policies. Courses taken in excess of those required by the advisory committee for the degree should not be listed on the curriculum. Graduate credit is received only for courses numbered 600 or above, and no student shall receive both undergraduate and graduate credit for the same course. Transfer credit appearing in the curriculum must adhere to the stipulations described under "Acceptance of Transfer Credit" on page 30.

Candidates for master's degrees should submit the curriculum by the middle of their second semester* and Ph.D. 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 college dean for approval and is forwarded to the graduate dean for approval and appropriate distribution of copies.

Admission to Candidacy for a Degree

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

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

Application for a Diploma

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

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

ACADEMIC REGULATIONS

Academic Standards

Graduate students are graded on the same A-B-C-D-F scale as undergraduates. Nonetheless, a graduate student is expected to do superior work, and the only satisfactory grades for graduate students are A and B. Thesis and dissertation research grades are graded on a "pass-fail" basis only and are not included in the academic average; however, they are recorded on the student's permanent record. Only credit hours for which a grade of pass is achieved will apply toward the number of research credit hours required for the degree.

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

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

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

Incomplete Graduate Course Work

The grade of I may be given for incomplete work for any graduate course in which work remains undone and the student is unable to fulfill all requirements because of circumstances beyond his or her control. This grade is *not* given in lieu of unsatisfactory or failing grades received for completed courses for the opportunity of improving the grade later.

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

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

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A graduate student will not be permitted to repeat any portion or re-register for any course 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 time the deadlines described in the previous paragraph expire, 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 "incomplete" 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.

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

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Credit Loads

University upper limits on graduate student loads per semester are (in credit hours):

	Semester	6 Weeks Session	3 Weeks Session*
Persons employed full time	6	3	1
Graduate assistants (half-time)	12	4	2
Graduate assistants (quarter-time)	15	6	3
Full-time students	18	6	3

A person employed full time is defined as anyone employed five full working days per week regardless of the employer(s). Half-time and quarter-time graduate assistants are defined as those who contribute 20 and 10 clock hours per week, respectively, or the equivalent of service to the University. Graduate students employed less than 10 hours per week by the University are not classified as graduate assistants.

Auditing by Graduate Students

Audited courses do not carry credit, and the fact that a course has been audited is not noted on the graduate student's official record. Audited

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

courses do not count against allowable credit-hour loads.

Graduate auditors are not required to stand tests or examinations. However, the instructor, at his or her own discretion, may demand or deny the auditor's participation in class to whatever extent deemed desirable.

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

Acceptance of Transfer Credit

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

In all cases, the use of transfer credits must be recommended by the student's advisory committee and be approved by the Graduate School. Transfer credit will not be awarded for research or for courses in which a grade lower than B, or its equivalent, has been received. Quality points for courses taken at institutions other than Clemson University will not be included in the student's academic average.

Credits may be transferred for work completed at off-campus centers of accredited institutions provided such courses are acceptable, without reservation, in degree programs at those institutions. No credit will be given for correspondence, extension, in-service, or field courses.

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

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

Theses and Dissertations

A candidate for an advanced degree in each curriculum requiring a thesis or dissertation must prepare this document under the direction of a major advisor. Six hours of credit are required for research leading to the Master of Science or Master of Arts thesis when required. Fifteen hours of credit are required for theses in the Master of Architecture and Master of Fine Arts degrees while nine hours of credit are required for the Master of City and Regional Planning degree. Eighteen hours of research credit are required for the Doctor of Philosophy degree.

Three copies of the thesis must be presented to the chairman of the student's advisory committee in sufficient time for the chairman to arrange for a final examination to be held at least three weeks prior to the date on which the degree is expected. A doctoral dissertation must be completed and delivered to the student's advisory committee at least two weeks prior to the final examination. Three copies of the master's thesis and four copies of the doctoral dissertation must be submitted to the Graduate School by the deadline for the date on which the degree is conferred (see pages 2 and 3). A binding fee of $18.00 must be paid to the bursar and the bursar's receipt submitted to the Graduate School Office at the time the thesis or dissertation is submitted. If the student desires, additional copies may be bound at the cost of $6.00 a copy. The responsibility for placing the thesis or dissertation in proper final form rests with the student and the chairman of the advisory committee. A guide for the preparation of theses and dissertations at Clemson University may be obtained from the Graduate School.

Candidates for the Doctor of Philosophy degree will prepare an additional copy of the abstract and title sheet to be submitted to the Graduate School. Ordinarily this abstract should not exceed 500 words in length. It should be written and edited in such a way that it will be suitable for publication.

Doctoral students are required to pay a fee of $25.00 to the bursar for publication of the *Dissertation Abstract*. An additional fee of $15.00 is required if copyright is desired.

Restriction on Use of Theses and Dissertations

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

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 Master of Agriculture, Master of Agricultural Education, Master of Architecture, Master of City and Regional Planning, Master of Education, Master of Engineering, Master of Fine Arts, Master of Forestry, Master of Industrial Education, Master of Nutritional Sciences, and Master of Recreation and Park Administration. The Master of Business Administration degree is offered jointly by Furman University and Clemson University.

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MASTER'S DEGREE

Residence Requirements

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

Time Limit

All course work which is to be credited toward any of the master's degrees must have been completed not more than six calendar years prior to the date on which the degree is to be awarded. When approved by the student's department head and the dean of graduate studies and university research, 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

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

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

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

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

Language Requirement

A reading knowledge of one approved foreign language is a departmental requirement for all Master of Arts degrees and certain Master of Science degrees. The required reading knowledge is equivalent to that provided by two years of study of the language at the college level. The procedures for satisfying this language requirement are identical to those for the Ph.D. degree as listed on page 36.

Study in Absentia

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

Final Examination

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

DOCTOR OF PHILOSOPHY DEGREE

Work leading to the Doctor of Philosophy degree is planned in such a way as to give the student a comprehensive knowledge of his or her fields of specialization and a mastery of the methods of research. The degree is not awarded solely on the basis of course work completed, residence or other routine requirements. The final basis for granting the degree will be the student's grasp of the subject matter of a broad field of study, 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. Within the entire program of required course work, at least half must consist of courses numbered 800 or above. Work in the minor field or fields, if required, normally should consist of from 12 to 24 hours in courses carrying graduate credit. A minimum of 18 hours of doctoral research is required. Should the direction of study or research interest change, the student may request the appointment of a new advisor.

Residency Requirements

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

1. In direct personal association with members of the faculty of the University.

2. Under direct tutelage and advisement of a research advisor and advisory committee in the department or program of the major.

3. Participating in other normal activities pertinent to graduate education such as seminars and close association with other student researchers.

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

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

Off-Campus Research

Under special circumstances, it may appear desirable that doctoral research be conducted away from the Clemson University campus. If

such research is to be performed *under the immediate direction of a Clemson University faculty member acting as dissertation advisor and supervisor*, then in order to accommodate the student as well as to exercise proper and necessary control over this most important phase of doctoral study, the following additional requirements will be made:

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

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

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

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

5. An employee, having an earned Ph.D. and engaged in the general subject area of the student's research, must be designated by an officer of the organization to supervise the student's research work and must be recommended for appointment as an adjunct professor of Clemson University. A resume of the research supervisor must be submitted to the stu-

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dent's full advisory committee for their review and recommendation to the graduate dean.

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

Time Limit

All work for a Doctor of Philosophy degree must be completed within a period of seven years. If a student begins the doctoral program after receiving the master's degree, all work above the master's level must be completed within a six-year period.

Language Requirement

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

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

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

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

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

3. The student may elect to enroll on a pass-fail basis in French 151 or 152, or German 151 or 152. This sequence is designed to prepare graduate students to read technical material in their particular academic discipline. To receive a grade of pass (P), the student must present a satisfactory score as determined by the Language Department from either the College Entrance Examinations Board test (CEEB), the GSFLT (see option 1), or a locally prepared translation exam similar to the GSFLT; otherwise, a grade

of incomplete (I) will be reported. A passing score achieved at the end of 152 will automatically eradicate an incomplete in 151, but university procedures, appropriate for undergraduate courses, must be followed in order to change the incomplete to pass.

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

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

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

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

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

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

Qualifying Examinations Before Admission to Candidacy

The student must undertake such preliminary or qualifying examinations as may be prescribed by the department before applying for admission to candidacy for the degree. These examinations may be written, oral, or a combination of both. The function of the examinations is to obtain objective evidence of an adequate intellectual mastery of the areas of major and minor specialization.

Immediately after the examination, the examining committee will notify the Graduate School of its findings on GS Form 5. The student's performance on these examinations will determine whether the committee recommends acceptance of the application for admission to candidacy.

Should the student fail to pass the preliminary examinations, he or she may be given the opportunity to undergo the examinations a second time. A second failure shall result in the student being declared ineligible for the Doctor of Philosophy degree at Clemson University.

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Some departments have both qualifying and comprehensive examinations. Information about these examinations may be obtained from the individual departments.

Final Doctoral Oral Examination

The candidate for the Doctor of Philosophy degree must pass a final oral examination at least three weeks prior to the time of the convocation 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.

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

COLLEGE OF AGRICULTURAL SCIENCES

COLLEGE OF AGRICULTURAL SCIENCES

L. P. Anderson, Dean

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

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

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

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

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

AGRICULTURAL ECONOMICS

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

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

Graduate work in agricultural economics is of increasing importance since it enables the student to attain a higher degree of specialized professional competence and to secure a greater mastery of techniques for

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*Jointly administered by the College of Agricultural Sciences and the College of Education. The Master of Agricultural Education degree is awarded by the College of Education.

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

applying quantitative economic analysis to agricultural firm and industry problems. Industry, government and universities offer challenging opportunities in research, development, education, management and other related areas for persons with advanced training.

In addition to applicants with baccalaureate degrees in agricultural economics and related programs, the department encourages applications from students who have a sound background in general economics. In many cases, such students may be admitted to full graduate status without prerequisites other than those required of all graduate students.

Special emphasis in the graduate program is placed on the economics of agricultural production and marketing, economic development, analysis of programs and policies affecting agriculture, and statistical techniques used in solving economic problems of the agricultural industry.

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

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

AG EC 651   AGRICULTURAL COOPERATION
2 cr. (2 and 0) S

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

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

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

AG EC 701   AGRIBUSINESS MANAGEMENT PRINCIPLES
3 cr. (3 and 0) F
Concepts and principles of agribusiness firm management; decision theory, information systems, systems analysis and organization theory applied to the organization, administration, and management of agriculturally-related businesses.

AG EC 791   SELECTED TOPICS IN AGRICULTURAL ECONOMICS
1–3 cr. (1–3 and 0)
Students working toward Master of Agriculture degree in Department of Agricultural Economics and Rural Sociology study selected topics under guidance of major professor. Course may be repeated for maximum of six credits.

AG EC 802   PRODUCTION ECONOMICS
3 cr. (3 and 0)
Production economics theory in a quantitative framework. Technical and economic factor-product, factor-factor, and product-product relationships in single and multi-product firms under conditions of perfect and imperfect competition

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in both factor and product markets. **Prerequisite:** AG EC 808 or permission of instructor.

AG EC 804   WATER RESOURCE POLICIES
              3 cr. (3 and 0) F
Economic, social and legal aspects of the control, use, development and management of water resources and related public policies.

AG EC 805   SEMINAR IN MARINE RESOURCES MANAGEMENT AND POLICY
              3 cr. (3 and 0)
Economic, institutional and legal aspects of the control and management of common-property marine resources. Management systems for coastal zone and continental shelf resources.

AG EC 806   ECONOMIC DEVELOPMENT IN AGRICULTURAL AREAS
              3 cr. (3 and 0) S
Theories of economic growth and development and their application to areas or regions. Methods of regional economic analysis emphasizing macro- and microeconomic aspects.

AG EC 807   MARKET STRUCTURE IN AGRICULTURAL INDUSTRIES
              3 cr. (3 and 0) S
Market structure and other approaches related to agricultural marketing. Individual assignments in the student's field of interest required. **Prerequisite:** Permission of instructor.

AG EC 808   APPLIED QUANTIFICATIONS IN AGRICULTURAL ECONOMICS
              3 cr. (3 and 0) F
Mathematical tools needed for concise description of agricultural economic principles. Microeconomic theory under assumptions of perfect competition. Relations among agricultural demand, supply, cost, revenue, and productivity. **Prerequisite:** Permission of instructor.

AG EC 809   ADVANCED NATURAL RESOURCE ECONOMICS
              3 cr. (3 and 0)
Applications of economic theory to problems of natural resource management. Epistemological considerations, rent theory, public and private investment criteria, benefit-cost analysis and general equilibrium management models. **Prerequisite:** AG EC 802 or permission of instructor.

AG EC 814   CONTEMPORARY PUBLIC POLICY
              3 cr. (3 and 0) F
Contemporary public policy, including price and resource policy, affecting rural areas. Public policy, or the lack thereof, related to programs designed to implement public policy.

AG EC 851   SEMINAR IN RESEARCH METHODOLOGY
              1 cr. (1 and 0)
Logic and the scientific method; formulation, initiation and carrying out of research problems in economics and business; methods and problems of obtaining and analyzing economic data; role of electronic computers and data processing

systems; and group discussions of proposed thesis problems of individual students. (Required of all graduate students who have not already had a comparable course.)

AG EC 881   INTERNSHIP IN COMMUNITY AND RESOURCE DEVELOPMENT
1–6 cr.
Supervised employment in an agency dealing with socio-economic aspects, community development and/or natural resource management. Monthly reports covering student's experience required. **Prerequisite:** 18 semester hours graduate credit.

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

AG EC 904   SEMINAR IN RESOURCE ECONOMICS
3 cr. (3 and 0)
Special problems and recent periodical literature relating to the control, management, development and use of land and water resources in the United States and in other parts of the world. **Prerequisite:** AG EC 403/603 or 804.

AG EC 906   SEMINAR IN AREA ECONOMIC DEVELOPMENT
3 cr. (3 and 0)
Recent research developments in economic development. Review of research publications, journal articles, and other literature. Objectives, analytical techniques, and procedures used in area or regional development efforts. **Prerequisite:** AG EC 806.

AG EC 907   AGRICULTURAL MARKETING PROBLEMS
3 cr. (3 and 0)
Theory and research related to consumer behavior. Economic consequences of individuals' and firms' decisions upon supply and demand. General interdependency among economic variables. **Prerequisite:** AG EC 807.

AG EC 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

CRD 611   REGIONAL IMPACT ANALYSIS
3 cr. (2 and 3)

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

AGRICULTURAL MECHANIZATION

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

Courses are offered leading to the Master of Agriculture degree.

This program prepares individuals with agricultural and related backgrounds for positions of leadership in technical services, mechanized production and other businesses serving modern agriculture. Students with undergraduate backgrounds in agricultural mechanization, other ag-

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ricultural curriculums or related curriculums from non-agricultural colleges and universities may apply.

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

AGM 605   ADVANCED INTEGRATED SHOP
3 cr. (2 and 3)

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

AGM 652   FARM POWER
3 cr. (2 and 3)

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

AGM 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.

AGM 733   ANALYSIS OF AGRISTRUCTURES
3 cr. (3 and 0)
Materials and their function in farm buildings, aesthetic values and rational selection of individual components; farmstead planning, space and environmental considerations, crop processing, materials handling, and waste disposal.

AGM 771   SELECTED TOPICS IN AGRICULTURAL MECHANIZATION
1–3 cr. (1–3 and 0)
Selected topics not covered in other course offerings. Performance measured by oral or written reports or examinations; may be repeated for maximum of six credits.

AGM 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.

AGM 851   SIMULATION OF AGRICULTURAL SYSTEMS
3 cr. (3 and 0)
Synthesis and analysis of agricultural systems via computer simulation; continuous and discrete systems; philosophy of system simulation and optimization. Models will be used to teach working techniques and each student will build a model of a system; computer background not required. **Prerequisite:** MATH 106 or permission of instructor.

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AGRONOMY

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

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

Applicants with baccalaureate degrees in chemistry, biology, plant science, physics, geology, general science or soils may pursue graduate work in agronomy. Programs include courses in soil chemistry, soil physics, soil genesis, soil fertility, cytogenetics, plant breeding and genetics, as well as fundamental research problems relating to these subjects.

AGRON 601   FERTILIZERS
            3 cr. (3 and 0) F

AGRON 602   LAND POLLUTION CONTROL
            3 cr. (3 and 0) S (odd numbered years)

AGRON 603   SOIL GENESIS AND CLASSIFICATION
            2 cr. (1 and 3) F

AGRON 604   SOILS AND LAND USE
            2 cr. (1 and 3) F

AGRON 605   PLANT BREEDING
            3 cr. (2 and 2) S

AGRON 607   PRINCIPLES OF WEED CONTROL
            3 cr. (2 and 2) F

AGRON 621   FIELD CROPS—MONOCOTS AND SPECIALTY CROPS
            3 cr. (3 and 0) F

AGRON 622   FIELD CROPS—DICOTS
            3 cr. (3 and 0) S

AGRON 623   FIELD CROPS—FORAGES
            3 cr. (3 and 0) S

AGRON 624   ADVANCED FIELD CROPS LABORATORY
            1 cr. (0 and 2) S

AGRON 652   SOIL FERTILITY AND MANAGEMENT
            2 cr. (2 and 0) S

AGRON 653   SOIL FERTILITY LABORATORY
            1 cr. (0 and 3) S

AGRON 655   SEMINAR
            1 cr. (1 and 0)

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AGRON 656   SEMINAR
1 cr. (1 and 0)

AGRON 675   SOIL PHYSICS AND CHEMISTRY
3 cr. (2 and 3) S

AGRON 801   CROP PHYSIOLOGY AND NUTRITION
3 cr. (3 and 0) F (odd numbered years)
Basic concepts and physiologic aspects of growth and culture applied to crop management practices.

AGRON 802   PEDOLOGY AND SOIL CLASSIFICATION
3 cr. (2 and 3) F (odd numbered years)
Soil genesis, soil morphology, and soil classification; soil formation including parent material, topography, climate and organisms; classification of Southeastern soils.

AGRON 804   THEORY AND METHODS OF PLANT BREEDING
3 cr. (3 and 0) F (even numbered years)
Concepts and principles of plant breeding and genetics as applied to development and maintenance of improved crop varieties; theoretical considerations of various breeding methods.

AGRON 805   SOIL FERTILITY
3 cr. (3 and 0) S (even numbered years)
Essential nutrients in the soil-plant system and mechanisms of retention and transport; supplies and availability; reactions and interactions; deficiency diagnosis and remedies; concepts and techniques for evaluating soil fertility problems.

AGRON 806   SPECIAL PROBLEMS
1–3 cr. (0 and 3–9)
Research not related to a thesis.

AGRON 807   SOIL PHYSICS
4 cr. (3 and 3) F (even numbered years)
Principles and applications of transport of water and solutes in soils emphasizing unsaturated flow phenomenon. **Prerequisite:** MATH 108 or equivalent.

AGRON 808   SOIL CHEMISTRY
3 cr. (2 and 3) F (odd numbered years)
Principles and theories concerning the structure and chemical properties of soil colloids, ionic exchange and membrane phenomena, chemical equilibria, soil acidity, oxidation-reduction relations, soil chemistry of plant nutrients.

AGRON 812   CROP ECOLOGY AND LAND USE
3 cr. (3 and 0) F (even numbered years)
Concepts and factors affecting adaptation and distribution of crop plants; microclimate and crop response to environmental factors with modifications of microclimate by agricultural operations; interactions among crop plants and between weeds and crop plants under field conditions.

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AGRON 820   PESTICIDE RESIDUES IN THE ENVIRONMENT
3 cr. (3 and 0) S (odd numbered years)

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

AGRON 825   SEMINAR
1 cr. (1 and 0) F, S

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

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

AGRON 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

ANIMAL AND FOOD INDUSTRIES

R. F. Wheeler, Head, Department of Animal Science

Courses are offered leading to the Master of Science degree.

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

ANIMAL PHYSIOLOGY

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

Courses are offered leading to the Doctor of Philosophy degree.

The graduate program in animal physiology uses the facilities of the Departments of Animal Science, Dairy Science, Entomology and Economic Zoology, Poultry Science, and Zoology. It includes faculty from these departments plus the Departments of Food Science, Electrical and Computer Engineering, Bioengineering, and Psychology.

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

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

AN PH 801   ELECTRON MICROSCOPY OF ANIMAL AND PLANT TISSUES
3 cr. (1 and 6) S, F

Theory of and practice in preparing animal, plant and microbial specimens

for electron microscope observations; thin-sectioning; section staining; operating the electron microscope; photographing, developing and printing micrographs; interpreting electron micrographs. Student selects a tissue, studies it with the electron microscope, prepares and interprets electron micrographs.

AN PH 802   DIGESTIVE AND EXCRETORY PHYSIOLOGY
3 cr. (2 and 3) F

Physiology of food intake, gastrointestinal secretions, digestion, absorption and excretion in ruminant and monogastric animals; basal metabolism and temperature regulation.

AN PH 803   CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY
4 cr. (3 and 3) F (odd numbered years)

Physiology of blood cell formation, clotting mechanism, immune response, homeostasis, cardio-vascular relationships, acid-base balance, lymphatic and interstitial fluid dynamics, fluid excretion, and respiration and gaseous exchange in mammals and birds; effects of environmental stress on respiration and circulation.

AN PH 804   MUSCLE AND NERVE PHYSIOLOGY
4 cr. (3 and 3) S (even numbered years)

Physiology of muscles (striated, smooth and cardiac), nerve responses (transmitting, processing and receiving signals), hearing, seeing, tasting, smelling and feeling; functions of skin and bones.

AN PH 805   PHARMACOLOGY
3 cr. (2 and 3) S (odd numbered years)

Action of drugs on the various biological systems of the mammal; classes of drugs, methods of action, uses, general dosage levels, and toxicity. Classroom and student experimentation will demonstrate actions of drugs on mammalian systems.

AN PH 806   EXPERIMENTAL ANIMAL PHYSIOLOGY
3 cr. (1 and 6) F (odd numbered years)

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

AN PH 807   SPECIAL PROBLEMS IN ANIMAL PHYSIOLOGY
1–3 cr. (1–3 and 0) F, S, SS

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

AN PH 808   MAMMALIAN AND AVIAN ENDOCRINOLOGY
3 cr. (3 and 0) S (odd numbered years)

Interrelationships of the nervous and endocrine systems as they influence growth and development, body metabolism, body regulatory mechanisms, behavior, and reproduction in mammals and birds, and lactation in mammals; integrating actions of hormones as they affect production; theoretical and practical aspects of exogenous administration of hormones (natural and synthetic) on body functions.

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

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

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

Continuation of AN PH 851.

AN PH 991   DOCTORAL DISSERTATION RESEARCH
              Credit to be arranged.

Descriptions for the following 800-level courses are listed under the respective department headings.

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

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

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

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

DY SC 653   ANIMAL REPRODUCTION
              3 cr. (3 and 0)

DY SC 655   REPRODUCTIVE MANAGEMENT
              1 cr. (0 and 3)

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

ENT 670   INSECT PHYSIOLOGY
              3 cr. (2 and 3)

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

MICRO 811   BACTERIAL CYTOLOGY AND PHYSIOLOGY
              4 cr. (4 and 0)

ZOOL 605   ANIMAL HISTOLOGY AND HISTOLOGY TECHNIQUES
              4 cr. (2 and 6)

ZOOL 657   COMPARATIVE PHYSIOLOGY
              4 cr. (3 and 3)

ZOOL 658   CELL PHYSIOLOGY
              4 cr. (3 and 3)

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ZOOL 659	SYSTEMIC PHYSIOLOGY	
	4 cr. (3 and 3)	
ZOOL 670	ANIMAL BEHAVIOR	
	3 cr. (3 and 0)	
ZOOL 671	ANIMAL BEHAVIOR LAB	
	1 cr. (0 and 3)	
ZOOL 674	INVERTEBRATE ENDOCRINOLOGY	
	3 cr. (2 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 681	METHODS IN DEVELOPMENTAL BIOLOGY	
	2 cr. (0 and 6)	

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ANIMAL SCIENCE

R. F. Wheeler, Head, Department of Animal Science

Courses are offered leading to the Master of Agriculture degree (animal science). The department also participates in four inter-departmental programs providing opportunities for specialization in animal science. These include the Master of Science degree with majors in animal and food industries and in nutrition, as well as the Doctor of Philosophy degree with majors in animal physiology and in nutrition.

AN SC 601	BEEF PRODUCTION	
	3 cr. (3 and 0)	
AN SC 603	BEEF PRODUCTION LABORATORY	
	1 cr. (0 and 3)	
AN SC 608	PORK PRODUCTION	
	3 cr. (3 and 0)	
AN SC 610	PORK PRODUCTION LABORATORY	
	1 cr. (0 and 3)	
AN SC 652	ANIMAL BREEDING	
	3 cr. (3 and 0)	

AN SC 802   TOPICAL PROBLEMS
1–3 cr. (1–3 and 0)
Animal science experiments and interpretation of their results.

AN SC 803   MEAT TECHNOLOGY
3 cr. (3 and 0)
Biochemistry, histology and microbiology of fresh, frozen, cured, smoked and processed meats; quality of meats and meat products, processing methods, nutritive value, and research techniques. **Prerequisites:** AN SC 353 and 355.

AN SC 804   METHODS IN ANIMAL BREEDING
3 cr. (3 and 0)
Gene and zygotic frequency; systems of mating; heritabilities; genetic consequences of selection; and criteria for evaluating improvement in beef cattle, swine, and sheep. **Prerequisite:** AN SC 452/652.

AN SC 805   NUTRITION OF MEAT ANIMALS
3 cr. (3 and 0)
Metabolism of carbohydrates, lipids, proteins, inorganic elements, and vitamins in the nutrition of beef cattle, swine and sheep; nutritional requirements of meat animals; properties and functions of nutrients in relation to practical production situations; common nutritional aberrations. **Prerequisite:** NUTR 401/601 or equivalent.

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

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DAIRY SCIENCE
W. A. King, Head, Department of Dairy Science

Courses are offered leading to the Master of Agriculture degree (dairy science). The department also participates in four interdepartmental programs providing opportunities for specialization in dairy science. These include the Master of Science degree with majors in animal and food industries and in nutrition, as well as the Doctor of Philosophy degree with majors in animal physiology and in nutrition.

DY SC 602   DAIRY MANUFACTURERS
3 cr. (2 and 3)

DY SC 604   PLANT MANAGEMENT
3 cr. (2 and 3)

DY SC 606   DAIRY TECHNOLOGY
3 cr. (2 and 3)

DY SC 607   MARKET MILK
3 cr. (2 and 3)

DY SC 652   DAIRY CATTLE FEEDING AND MANAGEMENT
3 cr. (2 and 3)

DY SC 653   ANIMAL REPRODUCTION
3 cr. (3 and 0)

DY SC 655   REPRODUCTIVE MANAGEMENT
1 cr. (0 and 3)

DY SC 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)
Effects of hormones on gametogenesis, fertilization, embryological development, pregnancy and lactation; comparative anatomy of mammary glands and physiology of lactation in various species. Students will evaluate most recent scientific literature in these areas for content, experimental methods, and authors' conclusions, and will select a problem, review related literature and write a research proposal for solving the problem.

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 891   MASTER'S THESIS RESEARCH
Credit to be arranged.

ENTOMOLOGY

S. B. Hays, Head, Department of Entomology and Economic Zoology

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

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

An optional program is available in pest management.

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

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

ENT 603   FIELD CROP INSECTS
        3 cr. (2 and 3)

ENT 604   STRUCTURAL, INDUSTRIAL AND HOUSEHOLD INSECTS
        3 cr. (2 and 3)

ENT 605   INSECT MORPHOLOGY
        4 cr. (3 and 3)

ENT 610   INSECT TAXONOMY
        3 cr. (1 and 6)

ENT 612   FIELD AND MUSEUM ENTOMOLOGY
        3 cr. (0 and 9)

ENT 620   TOXICOLOGY OF INSECTICIDES
        3 cr. (2 and 3)

ENT 655   MEDICAL AND VETERINARY ENTOMOLOGY
        3 cr. (2 and 3)

ENT 668   INTRODUCTION TO RESEARCH
        2 cr. (1 and 3)

ENT 669   AQUATIC INSECTS
        3 cr. (2 and 3)

ENT 670   INSECT PHYSIOLOGY
        3 cr. (2 and 3)

ENT 680   INSECT PATHOLOGY
        3 cr. (2 and 3)

ENT 808   TAXONOMY OF IMMATURE INSECTS
        3 cr. (1 and 6)
    Identification of immature insects emphasizing the Holometabola. Identified collection required.

ENT 809   RECENT ADVANCES IN ENTOMOLOGY
        1 cr. (1 and 0)
    Current literature in entomology; needs and changes in future research.

ENT 812   ENTOMOLOGICAL HISTORY AND LITERATURE
        1 cr. (1 and 0)
    Literature related to development of the science of entomology. Reading in the available journals, indexing and abstracting journals required.

ENT 840   INSECT ECOLOGY
        3 cr. (2 and 3)
    Principles of insect ecology, population dynamics and natural regulating

mechanisms of insect populations; effect of environment on distribution and abundance of insects.

ENT 853   PRINCIPLES OF CLASSIFICATION
3 cr. (2 and 3)
Zoological information storage and retrieval system, methods of ordering species in a hierarchical classification of taxa and necessary devices for its operations; biological aspects of systematics, modern descriptive, organizational, cataloging and identification techniques. **Prerequisite:** A taxonomic course in entomology or zoology and permission of instructor.

ENT 856   MEDICAL ENTOMOLOGY
3 cr. (2 and 3)
Disease vectors of animals emphasizing insects and related Arthropod disease carriers. **Prerequisite:** ENT 301 or permission of instructor.

ENT 860   INSECT PEST MANAGEMENT
3 cr. (3 and 0)
Application of ecological principles to the management or control of insect populations; major factors influencing insect population fluctuations; integrated systems including biological, cultural, physical, chemical and other techniques forming a unified multi-faceted approach based on applied ecology.

ENT 861   INSECT TOXICOLOGY
3 cr. (2 and 3)
History, development, application, chemical nature and mode of action of insecticides. **Prerequisite:** organic chemistry.

ENT 863   SPECIAL PROBLEMS IN ENTOMOLOGY
3–6 cr. (3–6 and 0)
Insect toxicology, insect physiology, medical entomology and biological control of insects through research not related to a thesis.

ENT 870   ADVANCED INSECT PHYSIOLOGY
3 cr. (2 and 3)
Metabolism, excretion, regulatory mechanisms, endocrine system, pheromones, nervous system, insect immunity, defensive secretions, and chemicals controlling insect behavior.

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

ENT 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

ENVIRONMENTAL SCIENCE

R. F. Borgman, Program Coordinator

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

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

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

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

EXPERIMENTAL STATISTICS

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

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

Courses to be used to satisfy the minor should be approved at the beginning of the student's program.

Students who elect a minor at the doctoral level must demonstrate competence in the theoretical basis as well as the application of statistics.

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

EX ST 801   STATISTICAL METHODS
           4 cr. (3 and 3) F, S, SS
Role and application of statistics in research; estimation, test of significance, analysis of variance, multiple comparison techniques, basic designs, mean square expectations, variance components analysis, simple and multiple linear regression and correlation, and non-parametric procedures. **Prerequisite:** Permission of instructor.

EX ST 803   REGRESSION AND LEAST SQUARES ANALYSIS
           3 cr. (3 and 0) F
Regression analysis; simple and multiple linear, curvilinear and multiple curvilinear; curve fitting; least squares and computer techniques for fitting of constants and analysis of planned experiments. **Prerequisite:** EX ST 801.

EX ST 804   SAMPLING
           3 cr. (3 and 0) F
Principles of scientific sampling; finite population sampling; simple random, stratified, multistage, and systematic sampling; optimum allocation; methods of obtaining, processing and reporting survey information. Sampling as related to the environment, natural resources, and social and economic problems. **Prerequisite:** EX ST 801.

EX ST 805   DESIGN AND ANALYSIS OF EXPERIMENTS
           3 cr. (3 and 0) S
Review of the basic designs and analysis; data transformations; single degree of freedom, orthogonality and responses in ANOVA; covariance; response

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surfaces; incomplete blocks; introduction to least squares analysis of experiments; uses of standard computer programs for selected analyses. **Prerequisite:** EX ST 801.

FOOD SCIENCE

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

The department participates in the inter-departmental degree program, animal and food industries, leading to the Master of Science degree with specialization in food science. In addition, students may pursue the following degree programs: Master of Nutritional Sciences, Master of Science in nutrition and Doctor of Philosophy in animal physiology and in nutrition.

FD SC 601   FOOD CHEMISTRY I
4 cr. (3 and 3)

FD SC 602   FOOD CHEMISTRY II
4 cr. (3 and 3)

FD SC 603   FOOD PRESERVATION AND PROCESSING I
3 cr. (3 and 0)

FD SC 604   FOOD PRESERVATION AND PROCESSING II
3 cr. (3 and 0)

FD SC 605   FOOD PRESERVATION AND PROCESSING LABORATORY I
1 cr. (0 and 3)

FD SC 606   FOOD PRESERVATION AND PROCESSING LABORATORY II
1 cr. (0 and 3)

FD SC 622   QUALITY ASSURANCE AND SENSORY EVALUATION
2 cr. (2 and 0)

FD SC 624   QUALITY ASSURANCE AND SENSORY EVALUATION LABORATORY
1 cr. (0 and 3)

FD SC 662   FOOD PACKAGING SYSTEMS
4 cr. (3 and 3)

FD SC 801   TOPICAL PROBLEMS IN FOOD SCIENCE
1–3 cr. (1–3 and 0)
Topics in food science not covered in other courses or by thesis research. Cumulative credit not to exceed three semester hours.

FD SC 802   FOOD ENZYMOLOGY
2 cr. (2 and 0)
Production, utilization and application of food enzymes in the food industry; effect of food enzymes on color, texture and flavor of foods and food products; health

and legal aspects of use of enzymes in foods; current topics in food enzymology. **Prerequisite:** FD SC 401/601 or permission of instructor.

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

GENETICS

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

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

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

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

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

GEN 701   MODERN DEVELOPMENTS IN GENETICS
                     3 cr. (3 and 0)
Contemporary developments in genetics for secondary school teachers; genetic approaches to the problems of health and behavior; methods and equipment used to illustrate principles of genetics in the theory and laboratory. **Prerequisite:** A genetics course or the equivalent in biology courses.

GEN 801   CYTOGENETICS
                     3 cr. (2 and 3) S (even numbered years)
Classical and contemporary problems of chromosome structure, behavior and transmission; recombination, interspecific hybridization, euchromatin and heterochromatin, polyploidy, mutable genetic systems; structural and numerical aberrations of chromosomes and their effects upon breeding systems of plants and animals. **Prerequisite:** GEN 302 or equivalent.

GEN 806   SPECIAL PROBLEMS IN GENETICS
                     1–3 cr. (0 and 3–9)
                     Research not related to a thesis.

HORTICULTURE

T. L. Senn, Head, Department of Horticulture

Courses are offered leading to the Master of Agriculture and Master of Science degrees. The Doctor of Philosophy is offered in plant physiology with an emphasis in horticulture.

Graduate study in horticulture is designed to acquaint the student with the important biological principles underlying the production and post-harvest physiology and handling of horticultural crops. This includes

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not only the study of the economic product prior to harvest, but also study of its harvesting, storage, marketing and processing. Scientific knowledge obtained in horticultural research, as well as that available in the related fields of botany, plant physiology, biochemistry and genetics, gives the student a broad base for future work.

HORT 605	NUT TREE CULTURE
	2 cr. (2 and 0) F (even numbered years)
HORT 606	NURSERY TECHNOLOGY
	3 cr. (2 and 3) S
HORT 607	LANDSCAPE DESIGN
	3 cr. (2 and 3) F
HORT 610	FLORICULTURE
	3 cr. (2 and 3) S
HORT 612	TURF MANAGEMENT
	3 cr. (2 and 3) F
HORT 613	ADVANCED TURFGRASS CULTURE
	3 cr. (3 and 0) S
HORT 651	SMALL FRUIT CULTURE
	3 cr. (2 and 3) S
HORT 652	COMMERICAL POMOLOGY
	3 cr. (2 and 3) F
HORT 654	SUBTROPICAL AND TROPICAL HORTICULTURE
	3 cr. (3 and 0)
HORT 656	VEGETABLE CROPS
	3 cr. (3 and 0) S (odd numbered years)
HORT 661	PROBLEMS IN LANDSCAPE DESIGN
	3 cr. (2 and 3) F
HORT 662	LANDSCAPE DESIGN IMPLEMENTATION
	3 cr. (2 and 3) S
HORT 664	POSTHARVEST HORTICULTURE
	3 cr. (2 and 2) F
HORT 670	HORTITHERAPY
	2 cr. (2 and 0)
HORT 671	INTERNSHIP
	1–6 cr. (0 and 2–12)

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HORT 673 HORTITHERAPY LAB
1 cr. (0 and 2)

HORT 801 PROBLEMS IN SMALL FRUIT PRODUCTION
3 cr. (3 and 0) F (odd numbered years)
Problems in producing blueberries, strawberries, brambles and grapes.

HORT 802 RESEARCH SYSTEMS IN HORTICULTURE
3 cr. (2 and 3) F
Current trends, developments, and techniques in horticultural research. **Prerequisites:** CH 223, 227 or CH 201 and PHYS 207, or BIOCH 210.

HORT 803 EXPERIMENTAL OLERICULTURE
3 cr. (3 and 0) F (even numbered years)
Sources of information on research developments in vegetable crops.

HORT 804 SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICULTURE
3 cr. (3 and 0) S (odd numbered years)
Research and current developments in ornamental horticulture covered in scientific periodicals.

HORT 805 PHYSIOCHEMICAL PROCEDURES FOR DETERMINING QUALITY IN HORTICULTURAL CROPS
3 cr. (2 and 3) F (even numbered years)
Titrations, organoleptic evaluations, refractory, colorimetry, and quality evaluations with succulometers and texturometers; effect of acids, sugars, salts, and other chemical constituents on quality of horticultural crops.

HORT 806 POSTHARVEST PHYSIOLOGY AND HANDLING OF HORTICULTURAL CROPS
3 cr. (3 and 0)
Principles, developments, and research findings dealing with physiological and biochemical changes and processes occurring in horticultural plant organs after harvest; biological aspects of methods and practices relating to harvesting, handling, transportation, and storage of horticultural commodities for fresh market. **Prerequisite:** BOT 421/621 or equivalent.

HORT 807 POMOLOGY
3 cr. (3 and 0) S (odd numbered years)
Growth and development of deciduous fruits emphasizing peach and apple. **Prerequisite:** HORT 352.

HORT 808 SPECIAL INVESTIGATIONS IN HORTICULTURE
2 cr. (2 and 0) S, SS
Research not related to a thesis. **Prerequisite:** HORT 802 or 805.

HORT 809 SEMINAR I
1 cr. (1 and 0) F
Current topics in horticulture prepared and presented by the student.

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HORT 810   SEMINAR II
            1 cr. (1 and 0) S
    Continuation of HORT 809.

HORT 811   QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT
            2 cr. (1 and 3) S (even numbered years)
    Principles and application of quantitative morphology and crop production analysis; techniques for visually detecting minute daily changes in plant development; graphic and statistical evaluation of the influence of specific environmental factors and their interactions on plant development; practical and theoretical applications of derived systems of observation and analysis.

HORT 870   PRACTICUM IN HORTITHERAPY
            3 cr. (1 and 4)
    Practicum in developing, evaluating and reporting on a hortitherapy project. Prerequisite: HORT 470/670 or permission of instructor.

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

HORT 991   DOCTORAL DISSERTATION RESEARCH
            Credit to be arranged.

NUTRITION

W. A. King, Head, Department of Dairy Science

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

    Nutrition is an interdisciplinary program encompassing four departments: Animal Science, Dairy Science, Food Science and Poultry Science. Applicants should have sound backgrounds in the biological and physical sciences. Students with deficiencies may be admitted if they correct their deficiencies by completing the appropriate courses. A student's program of study will include a core of basic courses in nutrition, biochemistry, and physiology. Additional course work may be taken in areas of special interest as approved by the advisory committee.

    For the M.S. and Ph.D. degrees, a student must complete an original research project and submit a thesis or dissertation respectively. The subject may deal with human, laboratory or domestic animal nutrition.

NUTR 601   FUNDAMENTALS OF NUTRITION
            3 cr. (3 and 0)
NUTR 625   NUTRITION AND DIETETICS
            3 cr. (3 and 0)
NUTR 651   HUMAN NUTRITION
            3 cr. (3 and 0)

NUTR 652   CLINICAL NUTRITION
3 cr. (3 and 0)

NUTR 701   THERAPEUTIC NUTRITION
3 cr. (3 and 0)
Interrelationship of pathological, physiological, and metabolic alterations produced by various disease states and body nutrient status; application of current practices in nutritional therapy and dietary management in treatment of diseases.

NUTR 702   PUBLIC HEALTH NUTRITION
3 cr. (3 and 0)
Improvement of dietary practices of the general population; application of nutritional principles to problems of disease and infection.

NUTR 703   NUTRITION EDUCATION
3 cr. (3 and 0)
Methods of instruction appropriate for varied age and educational levels; preparation and use of visual aids; cultural patterns in food use as related to nutrition improvement programs for various population groups.

NUTR 704   FOOD SERVICE SYSTEMS
3 cr. (3 and 0)
Volume feeding systems and their relationship to food quality, food acceptance, sanitation and materials selection; physical plant layout, management structure, food flow dynamics and computer-assisted diet formulation and accounting in various feeding systems.

NUTR 705   NUTRITION PRACTICUM
1–6 cr. (0 and 1–6)
Supervised training in outlining important aspects of practical nutrition situations and preparing plans to make improvements or changes.

NUTR 801   TOPICAL PROBLEMS IN NUTRITION
1–3 cr. (1–3 and 0)
Topics not covered in other courses or by thesis research. Credit varies with problems selected.

NUTR 808   MONOGASTRIC NUTRITION
3 cr. (3 and 0)
Basic concepts and current research related to nutrient requirement and metabolism of poultry, swine, and other monogastric species. **Prerequisite:** NUTR 401/601 or 451/651 or PS 451/651.

NUTR 809   POLYGASTRIC NUTRITION
3 cr. (3 and 0)
Microbiological, biochemical and physiological processes of digestion emphasizing synthesis of amino acids and proteins, B-vitamins, and the relation of such processes to digestion of proteins, lipids and fibrous and non-fibrous feed ingredients; properties and functions of nutrients for dairy and beef cattle, sheep, and horses; nonprotein nitrogen compounds and growth-promoting substances.

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NUTR 812   NUTRITION OF CARBOHYDRATES AND LIPIDS
3 cr. (3 and 0)

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

NUTR 813   NUTRITION TECHNIQUES WITH LARGE ANIMALS
2 cr. (1 and 3)

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

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

Nutritional techniques employing small laboratory animals; metabolism and nutrient deficiencies. To be taken concurrently with NUTR 812 or later.

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

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

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

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

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

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

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

Continuation of NUTR 851.

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

NUTR 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

Descriptions for the following 800-level courses are listed under the respective department or program headings.

AN PH 802   DIGESTIVE AND EXCRETORY PHYSIOLOGY
3 cr. (2 and 3)

AN PH 803   CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY
4 cr. (3 and 3)

AN PH 804	MUSCLE AND NERVE PHYSIOLOGY
	4 cr. (3 and 3)

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

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

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

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)

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PLANT PATHOLOGY

W. M. Epps, Head, Department of Plant Pathology and Physiology

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

Applicants for graduate work in plant pathology should have sound undergraduate training in the biological and physical sciences, especially botany and chemistry. This training may be obtained in an undergraduate curriculum in botany, microbiology, biology, chemistry, or one of the agricultural plant sciences such as agronomy, forestry, or horticulture. Undergraduate courses in plant pathology are desirable but not essential.

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

PL PA 605	FOREST PATHOLOGY
	3 cr. (2 and 3) F

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

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

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

PL PA 800   ADVANCED PLANT PATHOLOGY I
3 cr. (3 and 0) F (odd numbered years)
Economic and social importance and history of plant pathology; reproduction, genetics and variability of major groups of plant pathogens; infection process, response of host to infection, and effects of environment on disease development. **Prerequisite:** PL PA 401/601 or 405/605.

PL PA 801   ADVANCED PLANT PATHOLOGY II
3 cr. (3 and 0) S (even numbered years)
Epidemiology and control of plant diseases, including practical and theoretical coverage of chemical, physical, and biological means of plant disease control. **Prerequisites:** PL PA 401/601 or 405/605; organic chemistry.

PL PA 804   PHYSIOLOGICAL PLANT PATHOLOGY
3 cr. (3 and 0) F (even numbered years)
Interaction of pathogen and host in development of plant diseases; factors influencing infection; development of pathogen within host. **Prerequisites:** BOT 421/621; PL PA 401/601 or 405/605; organic chemistry.

PL PA 805   SPECIAL PROBLEMS IN PLANT PATHOLOGY
Credit to be arranged. F, S, SS
Research not related to a thesis. **Prerequisite:** Permission of instructor.

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PL PA 807   SEMINAR
1 cr. (1 and 0) F
Areas of plant pathology and plant physiology not covered by formal courses. Relevant literature will be reviewed and material will be organized and presented by students.

PL PA 808   TECHNIQUES AND METHODS IN PLANT PATHOLOGY I
1 cr. (0 and 3) F (even numbered years)
Research techniques and methods. **Prerequisite:** PL PA 401/601 or 405/605 or concurrent registration in PL PA 401/601 or 405/605.

PL PA 809   TECHNIQUES AND METHODS IN PLANT PATHOLOGY II
1 cr. (0 and 3) S (odd numbered years)
A continuation of PL PA 808 emphasizing more advanced methods and techniques. **Prerequisites:** Organic chemistry; PL PA 401/601 or 405/605; PL PA 808 or permission of instructor.

PL PA 811   PLANT DISEASE DIAGNOSIS I
1 cr. (0 and 3) SS (odd numbered years)
Procedures used in diagnosis of plant diseases, especially spring and early summer diseases. Students will practice diagnosing all types of diseases of cultivated and wild plants. **Prerequisite:** PL PA 401/601 or 405/605 or permission of instructor.

PL PA 812   PLANT DISEASE DIAGNOSIS II
             1 cr. (0 and 3) SS (even numbered years)
      A continuation of PL PA 811 emphasizing mid-summer diseases. **Prerequi-**
site: PL PA 401/601 or 405/605 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

W. M. Epps, Head, Department of Plant Pathology and Physiology.

Courses are offered leading to the Doctor of Philosophy degree.

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

Descriptions for the following 800-level courses are listed under the respective department headings.

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AGRON 652   SOIL FERTILITY AND MANAGEMENT
             2 cr. (2 and 0)

AGRON 653   SOIL FERTILITY LABORATORY
             1 cr. (0 and 3)

AGRON 675   SOIL PHYSICS AND CHEMISTRY
             3 cr. (2 and 3)

AGRON 801   CROP PHYSIOLOGY AND NUTRITION
             3 cr. (3 and 0)

AGRON 805   SOIL FERTILITY
             3 cr. (3 and 0)

AGRON 807   SOIL PHYSICS
             4 cr. (3 and 3)

AGRON 808   SOIL CHEMISTRY
             3 cr. (2 and 3)

AGRON 812   CROP ECOLOGY AND LAND USE
             3 cr. (3 and 0)

AGRON 820	PESTICIDE RESIDUES IN THE ENVIRONMENT 3 cr. (3 and 0)
AGRON 991	DOCTORAL DISSERTATION RESEARCH Credit to be arranged.
BOT 621	PLANT PHYSIOLOGY 4 cr. (3 and 3)
BOT 821	INORGANIC PLANT METABOLISM 4 cr. (3 and 3)
BOT 822	ORGANIC PLANT METABOLISM 3 cr. (3 and 0)
BOT 823	PLANT GROWTH & DEVELOPMENT 3 cr. (3 and 0)
BOT 824	MODE OF ACTION OF GROWTH SUBSTANCES 4 cr. (3 and 3)
BOT 826	PHYSIOLOGY OF THE FUNGI 3 cr. (3 and 0)
BOT 861	PLANT CELL BIOLOGY 3 cr. (3 and 0)
BOT 991	DOCTORAL DISSERTATION RESEARCH Credit to be arranged.
HORT 801	PROBLEMS IN SMALL FRUIT PRODUCTION 3 cr. (3 and 0)
HORT 802	RESEARCH SYSTEMS IN HORTICULTURE 3 cr. (2 and 3)
HORT 803	EXPERIMENTAL OLERICULTURE 3 cr. (3 and 0)
HORT 804	SCIENTIFIC ADVANCES IN ORNAMENTAL HORTICULTURE 3 cr. (3 and 0)
HORT 805	PHYSIOCHEMICAL PROCEDURES FOR DETERMINING QUALITY IN HORTICULTURAL CROPS 3 cr. (2 and 3)
HORT 806	POSTHARVEST PHYSIOLOGY AND HANDLING OF HORTICULTURAL CROPS 3 cr. (3 and 0)
HORT 807	POMOLOGY 3 cr. (3 and 0)

HORT 811   QUANTITATIVE EXPOSITION OF PLANT DEVELOPMENT
              2 cr. (1 and 3)

HORT 991   DOCTORAL DISSERTATION RESEARCH
              Credit to be arranged.

MICRO 612   BACTERIAL PHYSIOLOGY
              4 cr. (3 and 3)

MICRO 614   BASIC IMMUNOLOGY
              3 cr. (2 and 3)

MICRO 615   MICROBIAL GENETICS
              4 cr. (3 and 3)

MICRO 802   BACTERIOLOGICAL TECHNIC
              4 cr. (2 and 6)

MICRO 811   BACTERIAL CYTOLOGY AND PHYSIOLOGY
              4 cr. (4 and 0)

MICRO 812   BACTERIAL METABOLISM
              3 cr. (3 and 0)

MICRO 815   ADVANCED MICROBIAL GENETICS
              3 cr. (3 and 0)

MICRO 991   DOCTORAL DISSERTATION RESEARCH
              Credit to be arranged.

PL PA 804   PHYSIOLOGICAL PLANT PATHOLOGY
              3 cr. (3 and 0)

PL PA 991   DOCTORAL DISSERTATION RESEARCH
              Credit to be arranged.

POULTRY SCIENCE

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

Courses are offered leading to the Master of Agriculture degree (poultry science). The department also participates in four interdepartmental programs providing opportunities for specialization in poultry science. These include the Master of Science degree with majors in animal and food industries and in nutrition, as well as the Doctor of Philosophy degree with majors in animal physiology and in nutrition.

PS 601   ANIMAL ENVIRONMENTAL TECHNOLOGY
              2 cr. (2 and 0) F (even numbered years)

PS 603   ANIMAL ENVIRONMENTAL TECHNOLOGY LABORATORY
              1 cr. (0 and 3) F (even numbered years)

PS 605	TOPICAL PROBLEMS
	1–3 cr. (0 and 3–9)

PS 651	POULTRY NUTRITION
	2 cr. (2 and 0) S (even numbered years)

PS 654	LEAST COST FEED FORMULATION
	2 cr. (1 and 2)

PS 655	POULTRY PRODUCTS GRADING AND TECHNOLOGY
	3 cr. (2 and 3) F (odd numbered years)

PS 658	AVIAN MICROBIOLOGY AND PARASITOLOGY
	4 cr. (3 and 3) F (even numbered years)

PS 659	MANAGEMENT OF EGG, BROILER, AND TURKEY ENTERPRISES
	3 cr. (2 and 3) F (even numbered years)

PS 660	SEMINAR
	1 cr. (1 and 0)

PS 804	POULTRY PATHOLOGY
	3 cr. (1 and 6) S (odd numbered years)

Etiological agents, prophylaxis and treatment of poultry diseases. Laboratory work includes experiments in bacteriology, virology, protozoology, and immunology procedures emphasizing isolation and identification of disease producing agents. **Prerequisite:** PS 458/658 or permission of instructor.

PS 805	SEMINAR
	1 cr. (1 and 0) F

Report on special topics or original research by students, staff and visiting speakers.

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

WILDLIFE BIOLOGY

S. B. Hays, Head, Department of Entomology and Economic Zoology

Courses are offered leading to the Master of Science degree.

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

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

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WB 616   FISH CULTURE
3 cr. (2 and 3)

WB 660   BIOLOGY OF MARINE ORGANISMS
3 cr. (2 and 3)

WB 662   AQUATIC PRODUCTIVITY
3 cr. (3 and 0)

WB 809   WILDLIFE BIOLOGY SEMINAR I
1 cr. (1 and 0)
Current literature regarding problems encountered in applied wildlife biology.

WB 810   WILDLIFE BIOLOGY SEMINAR II
1 cr. (1 and 0)
Continuation of WB 809.

WB 815   PRINCIPLES OF WILDLIFE BIOLOGY
3 cr. (2 and 3) SS and alternate years
Theories and principles applicable to wildlife biology emphasizing upland game species.

WB 816   APPLIED WILDLIFE BIOLOGY
3 cr. (2 and 3)
Techniques and practices involved in management of wildlife species emphasizing upland game.

WB 818   ECOLOGY AND MANAGEMENT OF WETLAND WILDLIFE
3 cr. (2 and 3)
Identification, ecology and management of waterfowl and marshland furbearers emphasizing economically important species. Laboratory work includes demonstration and application of relevant wetland management techniques, current literature topics and field trips. **Prerequisites:** ZOOL 411/611, WB 412/612, or permission of instructor.

WB 840   IMPOUNDMENT AND STREAM MANAGEMENT
3 cr. (2 and 3)
Principles and techniques of managing ponds and streams for sport fishing and/or commercial fishing emphasizing trout streams, farm ponds, and reservoirs. Laboratory work includes demonstration and application of management techniques and field trips to observe other management practices. **Prerequisites:** ZOOL 410/610 and ZOOL 463/663 or permission of instructor.

WB 850   MARINE AQUACULTURE
3 cr. (3 and 0)
Basic aquacultural techniques applied to marine organisms and problems peculiar to marine aquaculture; past and present culture of marine organisms around the world; survey of marine aquaculture facilities of the Southeastern United States. **Prerequisite:** WB 416/616.

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WB 852   PARASITES AND DISEASES OF MARINE ANIMALS
      3 cr. (2 and 3)

  Major groups of symbionts as causative agents of disease in marine organisms; systematics, life cycles, and physiology as they contribute to the intimate host-symbiont relationship. A special problem will be completed. **Prerequisite**: ZOOL 456/656.

WB 856   DIRECTED STUDIES & FIELD WORK IN MARINE BIOLOGY
      4 cr. (2 and 6)

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

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

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

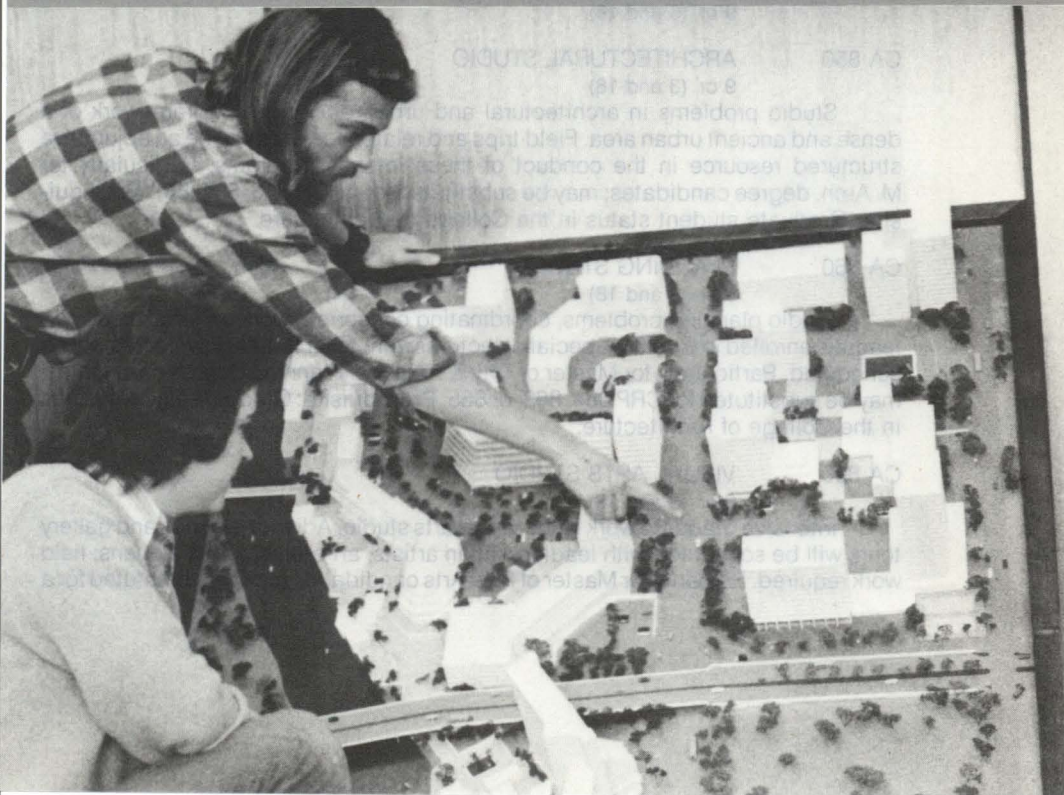WB 891   MASTER'S THESIS RESEARCH
      Credit to be arranged.

ARCHITECTURE
BUILDING SCIENCE
CITY AND REGIONAL PLANNING
VISUAL STUDIES

COLLEGE OF ARCHITECTURE

COLLEGE OF ARCHITECTURE

Harlan E. McClure, Dean

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

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

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

The following courses are included in the overseas program:

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

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

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

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

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

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

Studio planning problems, coordinating concurrent work undertaken by colleagues enrolled in CA 850. Specialist lectures from other Italian universities will be scheduled. Particularly for Master of City & Regional Planning degree candidates; may be substituted for CRP 854, 863, or 865. **Prerequisite:** Graduate student status in the College of Architecture.

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

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

graduate visual arts studio. **Prerequisite:** Graduate student status in the College of Architecture.

ARCHITECTURE

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

Courses are offered leading to the Master of Architecture degree.

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

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

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Admission Requirements:

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

1. Attainment of a pre-professional degree with a major in architecture.

2. Attainment of a satisfactory academic record in the last 60 major* credit (semester) hours.

3. Completion of a counseling review with the dean of the College of Architecture and the head of the Department of Architectural Studies, including a portfolio of previous creative efforts.

4. Letters of recommendation from three of the following: the dean of the undergraduate school, an undergraduate teacher, an employer, or a personal acquaintance.

5. Completion of the Graduate Record Examination.

Requirements for Degree Candidacy:

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

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

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

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

Requirements for Awarding of a Degree:

1. (a) 4-2 Program: A minimum of 48 semester hours of credit with a 3.0 or above average in the student's professional curriculum, excluding a thesis or a terminal project.

(b) 5-1 Program: A minimum of 27 semester hours of credit with a 3.0 or above average in the student's professional curriculum, excluding a thesis or a terminal project.

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

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

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ARCH 603   SEMINAR IN THE ANALYSIS AND CRITICISM OF ARCHITECTURAL AND TOWN BUILDING WORKS
    3 cr. (3 and 0)

ARCH 604   CURRENT DIRECTIONS IN ARCHITECTURE
    3 cr. (3 and 0)

ARCH 681   ARCHITECTURAL OFFICE PRACTICE
    3 cr. (3 and 0)

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

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

ARCH 853   ARCHITECTURAL STUDIES
    6–9 cr. (0 and 18–27)
City planning design and development of complex building structures. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program enroll for nine credit hours.

ARCH 854   ARCHITECTURAL STUDIES
    6–9 cr. (0 and 18–27)
Architectural and planning research and design of complex buildings and

urban groupings. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program enroll for nine credit hours. **Prerequisite: ARCH 853.**

ARCH 857   ARCHITECTURAL STUDIES
            9 cr. (0 and 27)
    Urban design problems, a portion of which will be undertaken as group effort and as individual problems. **Prerequisite: ARCH 854.**

ARCH 858   PRELIMINARY THESIS OR TERMINAL PROJECT
            3 cr. (1 and 6)
    Preliminary analysis of data to determine most advisable form of terminal presentation within thesis or non-thesis options for Master of Architecture degree. **Prerequisites:** ARCH 853 and ARCH 854 or CA 850 substituting for ARCH 853 or ARCH 854.

ARCH 859   TERMINAL PROJECT
            1–12 cr.
    Special project in lieu of architectural thesis. Approval of department faculty required; may be repeated for no more than 12 credits. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program enroll for nine credit hours. **Prerequisites:** ARCH 858 plus ARCH 857 and/or CA 850.

ARCH 886   HEALTH CARE FACILITIES COMPONENTS AND FUNCTIONS
            3 cr. (2 and 3)
    Components and service functions of physical and mental health care delivery systems and facilities.

ARCH 890   DIRECTED STUDIES
            1–5 cr.
    Special topics not covered in other courses emphasizing field studies, research activities, and current developments in architecture and planning. **Prerequisite:** Permission of faculty advisor, and department head or dean.

ARCH 891   ARCHITECTURAL THESIS
            1–12 cr.
    Each student will select and have approved by his major advisor an individual thesis problem of appropriate scope, and conduct his own comprehensive research. Under approved special circumstances, the thesis may be a team effort. The solution will be presented in oral, written and visual form. May be repeated for no more than 12 credits. Students in the 5-1 program will enroll for six credit hours. Those in the 4-2 program enroll for nine credit hours. **Prerequisite: ARCH 854.**

BUILDING SCIENCE

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

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

BLDSC 632   CONSTRUCTION MANAGEMENT V
            3 cr. (3 and 0)

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BLDSC 661   CONSTRUCTION ECONOMIC SEMINAR
3 cr. (3 and 0)

BLDSC 671   ARCHITECTURAL STRUCTURAL SEMINAR
3 cr. (3 and 0)

BLDSC 672   ARCHITECTURAL STRUCTURAL SEMINAR
3 cr. (3 and 0)

BLDSC 673   ARCHITECTURAL STRUCTURAL SEMINAR
3 cr. (3 and 0)

BLDSC 675   BUILDING EQUIPMENT AND SYSTEMS
3 cr. (3 and 0)

BLDSC 676   BUILDING EQUIPMENT AND SYSTEMS
3 cr. (3 and 0)

CITY AND REGIONAL PLANNING

M. A. Clark, Head, Department of City and Regional Planning

Courses are offered leading to the Master of City and Regional Planning degree.

During the first year of study in the graduate program, core subjects from within the department, and course elements from the areas of architecture, economics, computer science, operational research, philosophy, sociology, history, and transportation planning are designed to fit a candidate's particular background and provide a student with a strong rational, philosophical basis for planning. Second year involves students with clinical practice and professional experience in the conduct of a variety of research contract planning studies. Course work is a continuing feature of the program, designed to complement the "live-studies" and support individual planning theses.

Admission Requirements:

1. Attainment of a bachelor's degree from an accredited college or university.

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

3. Completion of a counseling review with the dean of the College of Architecture and the head of the Department of Planning Studies. This review is for acceptance as well as counseling in the case of applicants from outside the College of Architecture.

4. Letters of recommendation from any three of the following: the dean of

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

undergraduate school, an undergraduate teacher, an employer, or a personal acquaintance.

5. Completion of the Graduate Record Examination.

Requirements for Degree Candidacy:

1. Thirty (30) hours of study in the student's prescribed professional curriculum in the graduate studies program.

2. It is recommended that the student undertake three (3) months internship with an approved planning professional agency.

Requirements for Awarding of a Degree:

1. Thesis Option

a. A minimum of 51 hours of course work with a B average in the student's prescribed professional curriculum exluding the thesis.

b. Satisfactory completion of a nine-credit hour planning thesis while in residence as a full-time student. Only those students who have demonstrated satisfactory planning experience, as determined by both written and oral examination, will be permitted this option.

2. Non-Thesis Option

a. A minimum of 60 hours of course work with a B average in the student's prescribed professional curriculum including the four planning studio courses—CRP 853, 854, 863, and 865.

CRP 611	INTRODUCTION TO CITY AND REGIONAL PLANNING	**77**
	3 cr. (3 and 0)	
CRP 612	CITY AND REGIONAL PLANNING THEORY	
	3 cr. (3 and 0)	
CRP 621	URBAN SOCIAL STRUCTURE	
	1–3 cr. (1–3 and 0)	
CRP 641	HISTORY OF PLANNING	
	3 cr. (3 and 0)	
CRP 672	IMPLEMENTATION OF THE LOCAL PLANNING PROCESS	
	3 cr. (3 and 0)	
CRP 673	GOVERNMENT AND PLANNING LAW	
	3 cr. (3 and 0)	
CRP 683	SEMINAR ON PLANNING COMMUNICATION	
	2 cr. (2 and 0)	
CRP 821	INTERGOVERNMENTAL RELATIONS IN THE PLANNING PROCESS	
	1–3 cr. (1–3 and 0)	

Operations, structure, and review procedures between local, state, and multi-state agencies and federal government; techniques of regional delineation and areal problems in governmental planning operations. **Prerequisite:** CRP 611.

CRP 822   URBAN SYSTEMS AND DESIGN
         3 cr. (3 and 0)
     Past and present urban, social, economic, and political systems and their future applications. **Prerequisite:** Permission of instructor.

CRP 831   ECONOMICS OF LAND USE PLANNING
         3 cr. (3 and 0)
     Cost factors relating to development and redevelopment of land.

CRP 853   INTRODUCTION TO PLANNING STUDIO
         3 cr. (0 and 9)
     Laboratory work in problem solving processes encountered in comprehensive planning; steps of study design, analysis, policy advising, and preparation of alternatives for general planning problem solving emphasizing plans for physical development.

CRP 854   PLANNING STUDIO II
         3 cr. (0 and 9)
     Refinement and elaboration of planning problem solving process emphasizing concepts, policies, and applications of programming and implementation techniques within a governmental framework; more complex problems than Studio I.

CRP 863   PLANNING STUDIO III
         3–6 cr. (0 and 9–18)
     Planning studies involving small or medium-sized cities and regions; evaluation of community goals and objectives, appropriate surveys and projects, and development of comprehensive planning alternatives or suitable planning projects. Students work with available data and planning professionals and prepare a comprehensive plan, reflective and responsive to community needs.

CRP 865   PLANNING STUDIO IV
         3–9 cr. (0 and 9–27)
     Continuation of CRP 863.

CRP 871   SEMINAR ON PLANNING & MANAGEMENT OF CHANGE
         3 cr. (3 and 0)
     Potentials of planning and management approaches emphasizing new towns and the relationship and integration among various implementing techniques and instruments, importance of public-private sector partnership, and potential impact of various policies and programs. **Prerequisites:** CRP 672 and permission of instructor.

CRP 881   SEMINAR IN QUANTITATIVE METHODS I
         3 cr. (3 and 0)
     Potentials and limitations of data, statistical methods, operations research, electronic data processing and other methods used in city and regional planning. Lectures, visiting speakers, student reports and field trips included.

CRP 882   SEMINAR IN QUANTITATIVE METHODS II
          3 cr. (3 and 0)
Continuation of CRP 881.

CRP 884   PUBLIC FACILITIES AND CAPITAL IMPROVEMENT PLANNING
          3 cr. (3 and 0)
Concepts and operations of public services and facilities, budget processes, capital improvement programs, and revenue sources; federal, state, local, and private funding of community operations. **Prerequisite:** Permission of instructor.

CRP 890   DIRECTED STUDIES IN CITY AND REGIONAL PLANNING
          1–5 cr.
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 pass/fail basis. **Prerequisite:** Two semesters of city & regional planning or equivalent.

VISUAL STUDIES

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

Courses are offered leading to the Master of Fine Arts degree.

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

Admission Requirements:

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

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

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

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

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

Requirements for Degree Candidacy:

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

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

Requirements for Awarding of a Degree:

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

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

VIS 605	DRAWING	
	3 cr. (0 and 9)	
VIS 606	DRAWING	
	3 cr. (0 and 9)	
VIS 607	PAINTING	
	3 cr. (0 and 9)	
VIS 608	PAINTING	
	3 cr. (0 and 9)	
VIS 609	SCULPTURE	
	3 cr. (0 and 9)	

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

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VIS 610   SCULPTURE
3 cr. (0 and 9)

VIS 611   PRINTMAKING
3 cr. (0 and 9)

VIS 612   PRINTMAKING
3 cr. (0 and 9)

VIS 613   PHOTOGRAPHY
3 cr. (0 and 9)

VIS 614   PHOTOGRAPHY
3 cr. (0 and 9)

VIS 615   GRAPHIC DESIGN
3 cr. (0 and 9)

VIS 616   GRAPHIC DESIGN
3 cr. (0 and 9)

VIS 617   ADVANCED CERAMIC ARTS
3 cr. (0 and 9)

VIS 618   ADVANCED CERAMIC ARTS
3 cr. (0 and 9)

VIS 619   GRAPHIC DESIGN
3 cr. (0 and 9)

VIS 620   GRAPHIC DESIGN
3 cr. (0 and 9)

VIS 621   GRAPHIC DESIGN-STUDIO SEMINAR
3 cr. (0 and 9)

VIS 690   DIRECTED STUDIES
1–5 cr.

VIS 850   VISUAL ARTS STUDIO
3 cr. (0 and 9)
Concentrated and advanced work in ceramics, drawing, painting, printmaking, sculpture, photography, graphic design or multimedia. **Prerequisite:** MFA majors only.

VIS 851   VISUAL ARTS STUDIO
3–6 cr.
Continuation of VIS 850. May be repeated for maximum of six credits. **Prerequisites:** VIS 850; MFA majors only.

VIS 870   VISUAL ARTS STUDIO
6 cr. (1 and 15)
Advanced theory; directed research in art criticism; applied work in ceramic

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arts, drawing, painting, sculpture, photography, graphic design, or multimedia. **Prerequisites:** VIS 851; MFA majors only.

VIS 871 VISUAL ARTS STUDIO
     3–6 cr.
  Continuation of VIS 870. May be repeated for maximum of six credits. **Prerequisites:** VIS 870; MFA majors only.

VIS 880 VISUAL ARTS STUDIO
     3–15 cr.
  Continuation of VIS 871. May be repeated for maximum of 15 credits. **Prerequisites:** VIS 871; MFA majors only.

VIS 891 VISUAL ARTS THESIS
     3–15 cr.
  May be repeated for maximum of 15 credits. **Prerequisite:** VIS 880.

AAH 611 DIRECTED RESEARCH IN ART HISTORY
     3 cr. (3 and 0)

AAH 612 DIRECTED RESEARCH IN ART HISTORY
     3 cr. (3 and 0)

AAH 613 20th 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)

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 627 EIGHTEENTH CENTURY VISUAL ARTS
     3 cr. (3 and 0)

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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 I
               3 cr. (3 and 0)

AAH 815   HISTORY SEMINAR I
               3 cr. (3 and 0)
      Particular aspect of period of art/architectural history. **Prerequisite:** Permission of instructor.

AAH 816   HISTORY SEMINAR II
               3 cr. (3 and 0)
      Continuation of AAH 815.

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COLLEGE OF EDUCATION

COLLEGE OF EDUCATION

H. F. Landrith, Dean

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

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

All programs require a minimum of 30 semester hours, at least 15 of which must be numbered 700 or above. Additional requirements for each degree are listed by department.

AGRICULTURAL EDUCATION

E. T. Carpenter, Head, Department of Agricultural Education

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

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

Candidates for the degree are required to complete:

1. A minimum of 12 semester hours in the student's major field.

2. At least three semester hours in statistics and three semester hours in research methods.

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

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

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

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

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

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

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

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

AG ED 663   ADVANCED CONSERVATION EDUCATION
3 cr. (3 and 0)

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

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

AG ED 726   AGRICULTURAL MECHANIZATION FOR INSERVICE TEACHERS
3 cr. (3 and 0)
Development of teaching materials, course construction and curriculum design in agricultural mechanics; procedures and processes for implementing a new course in agricultural mechanics at high school level.

AG ED 727   AGRICULTURAL EDUCATION SHOP MANAGEMENT
3 cr. (1 and 6)
Basic processes and tools used in repair, maintenance and construction of farm equipment; shop management and methods of teaching technical skills; application of shop principles to design and construction of projects in agricultural mechanics.

AG ED 736   INTERNSHIP: TEACHING
3 cr. (1 and 6) S
Professional competency and program development through classroom and practical experiences in planning, conducting and evaluating educational programs.

AG ED 737   INTERNSHIP IN AGRIBUSINESS FIRMS
3 cr. (1 and 6)
Classroom and practical experiences in selected agricultural businesses and industries. Students identify and practice entry-level competencies required in selected agribusiness and natural resource management enterprises.

AG ED 803   EVALUATION OF INSTRUCTIONAL PROGRAMS
3 cr. (2 and 3) F (odd numbered years)
Measurement and evaluation in general and as applied to agricultural and vocational education; selection and/or development and use of instruments for appraising educational outcomes of student achievement and total programs.
Prerequisite: Permission of instructor.

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AG ED 804   SPECIAL PROBLEMS
3 cr. (2 and 3) F, S, SS

Planning, conducting and reporting a special problem in agricultural education appropriate to students' needs.

AG ED 805   ADMINISTRATION AND SUPERVISION IN AGRICULTURAL EDUCATION
3 cr. (3 and 0) S (even numbered years)

Developing a philosophy of education including application of administrative concepts in supervising agricultural education programs. **Prerequisite:** Experience in agricultural education.

AG ED 815   TEACHING AGRICULTURAL AND POWER MECHANICS
3 cr. (2 and 3) SS (odd numbered years)

Methods of determining course content, organizing teaching modules in logical sequence, equipping shop, teaching agricultural and power mechanics to farm and agribusiness clientele, providing individualized instruction, developing off-farm experience programs.

AG ED 820   TEACHING YOUNG FARMERS
3 cr. (3 and 0) F (even numbered years)

Principles and practices of problem solving in developing and conducting instructional programs for young farmers.

AG ED 825   SUPERVISION OF STUDENT TEACHING
3 cr. (3 and 0)

Developing philosophy of teacher education; analyzing present teacher training program in South Carolina for problem situations on which to base teacher–education programs; determining relative emphasis for each teacher to place upon solving problems in teacher–education program; projecting plans for apprentice training program; supervising apprentice training. **Prerequisite:** Experience in agricultural education and permission of instructor.

AG ED 869   SEMINAR
1–3 cr. (1–3 and 0)

Students and faculty review current topics in agricultural education.

AG ED 889   INTRODUCTION TO RESEARCH IN EDUCATION
3 cr. (3 and 0) SS, F (odd numbered years)

Problem selection, types of educational research and techniques employed, use of ERIC system, interpretation of research findings.

ELEMENTARY AND SECONDARY EDUCATION

E. J. Kozma, Head, Department of Elementary and Secondary Education

Courses are offered leading to the Master of Education degree and the Specialist in Education degree.

The Master of Education degree is offered with majors in administration and supervision, elementary education, personnel services, read-

ing, and secondary education. The department also offers the Educational Specialist degree in school administration.

Students seeking admission to the Master of Education degree programs with majors in administration and supervision, elementary education, reading, personnel services (in the areas of elementary counseling and secondary counseling), and secondary education should have a valid professional teacher's certificate on the appropriate level. Those seeking admission to the personnel services program in the areas of higher education counseling and vocational counseling must have at least six hours in psychology or educational psychology.

A major in educational administration and supervision is offered to experienced teachers who wish to prepare as elementary school administrators, elementary school supervisors, secondary school administrators, or secondary school supervisors. Courses may be selected from four areas as prescribed by the Department of Elementary and Secondary Education.

A major in elementary education is offered to teachers who hold professional elementary certificates. Courses may be selected from six areas as prescribed by the Department of Elementary and Secondary Education. Those students interested in the area of special education (emotionally handicapped, learning disabilities, or mental retardation) should enroll in the elementary education curriculum.

A major in personnel services is offered to those desiring to specialize in guidance counseling in the public schools, post-secondary schools, or the vocational counseling field. Degree candidates are required to complete:

1. A minimum of 21 hours in the area of specialization.

2. Three to six hours in field training at the level of specialization.

3. Three to six hours in statistics, research techniques or in a field related to the area of specialization.

A major in reading is offered for reading specialists, consultants and/or supervisors. The 30 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 six and not more than 12 hours in education and a minimum of 18 hours in the area of specialization.

The Educational Specialist degree program in school administration consists of 30 semester hours beyond the master's degree which must be selected from five areas as prescribed by the Department of Elementary and Secondary Education. Admission requirements include a master's degree and an administrator's certificate.

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ED 601   THE COMMUNITY COLLEGE
               3 cr. (3 and 0)

ED 605   PRINCIPLES OF GUIDANCE
          3 cr. (3 and 0)

ED 606   HISTORY AND PHILOSOPHY OF EDUCATION
          3 cr. (3 and 0)

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

ED 631   SPECIAL INSTITUTE COURSE: EARLY CHILDHOOD EDUCATION
          3 cr. (3 and 0)

ED 632   SPECIAL INSTITUTE COURSE: ELEMENTARY SCHOOL
          3 cr. (3 and 0)

ED 633   SPECIAL INSTITUTE COURSE: SECONDARY SCHOOL
          3 cr. (3 and 0)

ED 634   SPECIAL INSTITUTE COURSE: CURRENT PROBLEMS IN
          EDUCATION
          3 cr. (3 and 0)

ED 635   SPECIAL INSTITUTE COURSE: CURRICULUM
          3 cr. (3 and 0)

ED 636   SPECIAL INSTITUTE COURSE: SUPERVISION AND
          ADMINISTRATION
          3 cr. (3 and 0)

ED 659   FUNDAMENTALS OF BASIC READING
          3 cr. (3 and 0)

ED 660   CURRICULUM DEVELOPMENT IN THE ELEMENTARY SCHOOL
          3 cr. (3 and 0)

ED 661   TEACHING READING IN THE ELEMENTARY SCHOOL
          3 cr. (1 and 4)

ED 662   READING DIAGNOSIS AND REMEDIATION
          3 cr. (2 and 3)

ED 665   SECONDARY SCHOOL CURRICULUM
          3 cr. (3 and 0)

ED 669   CHARACTERISTICS OF CHILDREN WITH EMOTIONAL
          HANDICAPS
          3 cr. (3 and 0)

ED 670   CHARACTERISTICS OF CHILDREN WITH LEARNING
          DISABILITIES
          3 cr. (3 and 0)

ED 671   THE EXCEPTIONAL CHILD
            3 cr. (3 and 0)

ED 672   PSYCHOLOGY OF MENTAL RETARDATION
            3 cr. (3 and 0)

ED 673   TEACHING THE MENTALLY RETARDED
            3 cr. (3 and 0)

ED 674   EDUCATIONAL PROCEDURES FOR CHILDREN WITH
            EMOTIONAL HANDICAPS
            3 cr. (3 and 0)

ED 675   EDUCATIONAL PROCEDURES FOR CHILDREN WITH LEARNING
            DISABILITIES
            3 cr. (3 and 0)

ED 676   PRACTICUM IN INSTRUCTION FOR EXCEPTIONAL CHILDREN
            3 cr. (1 and 4)

ED 694   SCHOOL AND COMMUNITY RELATIONSHIPS
            3 cr. (3 and 0)

ED 697   AUDIO VISUAL AIDS IN EDUCATION
            3 cr. (3 and 0)

ED 698   TEACHING SECONDARY SCHOOL READING
            3 cr. (1 and 4)

ED 707   READING IN EDUCATION
            3 cr. (3 and 0)

Supervised reading, research, and independent study in area not offered in other courses. **Prerequisite:** Permission of instructor.

ED 720   SCHOOL PERSONNEL ADMINISTRATION
            3 cr. (3 and 0)

School personnel selection, practices, and problems. **Prerequisites:** One administration course and three other graduate courses in education.

ED 721   LEGAL PHASES OF SCHOOL ADMINISTRATION
            3 cr. (3 and 0)

Legal principles involved in school administration and in court actions. **Prerequisites:** One administration course and three other graduate courses in education.

ED 722   FIELD EXPERIENCES IN SCHOOL ADMINISTRATION AND
            SUPERVISION
            3 cr. (2 and 3)

Practicum with an experienced administrator or supervisor. **Prerequisites:** One administration course and three graduate courses in education.

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ED 741   INTRODUCTION TO PUPIL PERSONNEL SERVICES IN HIGHER EDUCATION
3 cr. (3 and 0)
Pupil personnel services offered by institutions of higher education.

ED 742   PSYCHOLOGY OF POST SECONDARY SCHOOL YOUTH
3 cr. (3 and 0)
Developmental aspects of young adult age group and its relationship to post secondary schools and training programs.

ED 776   COLLEGE TEACHING
3 cr. (3 and 0)
Instructional practices, curriculum, techniques of organizing and planning learning experiences, analysis of teaching strategies and systems.

ED 801   SEMINAR IN HUMAN GROWTH AND DEVELOPMENT
3 cr. (3 and 0)
Theory and research in human development. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

ED 802   HUMAN DEVELOPMENT: PSYCHOLOGY OF LEARNING
3 cr. (3 and 0)
Major theories of learning processes applied to human education. Student conducts experiments in learning theory. **Prerequisite:** Six semester hours of psychology and/or educational psychology.

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ED 803   ADVANCED METHODS OF TEACHING IN THE SECONDARY SCHOOL
3 cr. (3 and 0)
Principles and practices involved in promoting effective learning in secondary schools.

ED 804   ADVANCED METHODS OF TEACHING IN THE ELEMENTARY SCHOOL
3 cr. (3 and 0)
Principles and practices involved in promoting effective learning in elementary schools; analysis and evaluation of educational media.

ED 808   EDUCATIONAL TESTS AND MEASUREMENT
3 cr. (3 and 0) S
Construction, use and interpretation of subjective and standardized tests; measurement applications.

ED 809   ANALYSIS OF THE INDIVIDUAL
3 cr. (3 and 0)
Experience in gathering, interpreting and utilizing data as it relates to the individual. Especially significant to counselors. **Prerequisite:** ED 808.

ED 810   THEORIES AND TECHNIQUES OF COUNSELING
3 cr. (3 and 0)
Counseling theories and techniques. **Prerequisite:** ED 405/605 or permission of instructor.

ED 811   SCHOOL FINANCE
3 cr. (3 and 0)
School finance relative to programs, revenues and experience.

ED 813   EDUCATIONAL AND VOCATIONAL INFORMATIONAL SERVICE
AND PLACEMENT
3 cr. (3 and 0)
Gathering, interpreting and utilizing educational, social and occupational information; techniques used in placement, survey and follow-up.

ED 814   FIELD EXPERIENCES IN ELEMENTARY SCHOOL GUIDANCE
3 cr. (2 and 3)
Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those seeking certification on elementary school level. **Prerequisite:** ED 810 and permission of instructor.

ED 815   FIELD EXPERIENCES IN SECONDARY SCHOOL GUIDANCE
3 cr. (2 and 3)
Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those seeking certification on secondary school level. **Prerequisite:** ED 810 and permission of instructor.

ED 816   FIELD EXPERIENCES IN PERSONNEL SERVICES IN HIGHER
EDUCATION
3 cr. (2 and 3)
Practicum in developing, evaluating and reporting a project in student's field of interest. Open only to those entering field of higher education. **Prerequisite:** ED 810 and permission of instructor.

ED 817   DEVELOPMENT OF COUNSELING SKILLS
3 cr. (3 and 0)
On-campus experience to help counselors develop communication skills through role-playing activities, audio and video taping, interviewing, lecture and discussion. **Prerequisite or Co-requisite:** ED 810.

ED 818   FIELD PROBLEMS IN SCHOOL ADMINISTRATION AND
SUPERVISION OF INSTRUCTION
3 cr. (2 and 3)
Application of research techniques and practices in solution of field problems in school administration and supervision.

ED 819   PSYCHOEDUCATIONAL EVALUATION INTERNSHIP
3 cr. (0 and 6)
Internship in psychoeducational evaluation and counseling experiences with students in primary and elementary grades; consulting experiences with parents and teachers under supervision of school psychologists of Department of Elementary and Secondary Education. Open only to those seeking certification as elementary counselors or evaluators. **Prerequisite:** Permission of instructor.

ED 830   TECHNIQUES OF SUPERVISION—THE PUBLIC SCHOOLS
3 cr. (3 and 0)
Improving, coordinating and evaluating instruction; modern trends of supervisory practices.

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ED 831   EVALUATION OF SECONDARY SCHOOL INSTRUCTION
              3 cr. (3 and 0)
       Techniques of determining effectiveness of classroom instruction emphasizing curriculum.

ED 832   EVALUATION OF INSTRUCTION IN THE ELEMENTARY SCHOOL
              3 cr. (3 and 0)
       Determination of effectiveness of instructional techniques and programs in terms of predetermined objectives.

ED 851   ORGANIZATION AND ADMINISTRATION OF THE ELEMENTARY
              SCHOOL
              3 cr. (3 and 0)
       Leadership roles, self-images, and administrative behavior; organizational principles, patterns and trends in elementary schools; planning, developing and assessing elementary programs; building and grounds management; office and business management; student activities; staff selection and development.

ED 852   ORGANIZATION AND ADMINISTRATION OF THE SECONDARY
              SCHOOL
              3 cr. (3 and 0)
       Leadership roles, self-images, and administrative behavior; organizational principles, patterns and trends in secondary schools; planning, developing and assessing secondary school program; building and ground management; office management; student activities; scheduling staff selection and development.

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 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 462/662.

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 462/662.

ED 863   PRACTICUM IN READING
              3 cr. (2 and 2)
       Supervised practicum emphasizing diagnostic and remedial work with readers in public schools. **Prerequisites:** ED 462/662 and permission of instructor.

ED 871   INTERPERSONAL AND GROUP RELATIONSHIPS
3 cr. (3 and 0)

Human relations, staff interaction, informal and small group processes, supervisor–teacher counseling, conducting group meetings, staff participation in decision-making, creating a climate conducive to change and success, human motivation.

ED 881   INDIVIDUAL TESTING
3 cr. (3 and 0)

Interpretation of Wechsler scales with supervised practice in their administration. **Prerequisites:** ED 801, 802, 808, 809 and permission of instructor.

The following courses are applicable only to the Master of Education degree with emphasis in the specific subject areas. Complete descriptions are found in the sections for the College of Agricultural Sciences, the College of Liberal Arts and the College of Sciences.

English
R. E. Barfield, Advisor

ENGL 751   CHILDREN'S LITERATURE FOR TEACHERS
3 cr. (3 and 0)

ENGL 761   ENGLISH LITERATURE FOR TEACHERS I
3 cr. (3 and 0)

ENGL 762   ENGLISH LITERATURE FOR TEACHERS II
3 cr. (3 and 0)

History and Government
P. K. Hill, Advisor

HIST 715   HISTORY OF THE BLACK AMERICAN
3 cr. (3 and 0)

HIST 719   UNITED STATES HISTORY SINCE 1900
3 cr. (3 and 0)

HIST 732   MODERNIZATION OF EAST ASIA
3 cr. (3 and 0)

HIST 741   COMPARATIVE HISTORY OF THE AMERICAS
3 cr. (3 and 0)

Mathematics
J. D. Fulton, Advisor

**MATH 701   MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
                 TEACHERS—NUMBER SYSTEMS I**
3 cr. (3 and 0)

**MATH 702   MODERN MATHEMATICS FOR ELEMENTARY
                 TEACHERS—NUMBER SYSTEMS II**
3 cr. (3 and 0)

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MATH 703 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—GEOMETRY
3 cr. (3 and 0)

MATH 705 MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
TEACHERS—ALGEBRA, PROBABILITY, AND STATISTICS
3 cr. (3 and 0)

MATH 712 MODERN ALGEBRAIC CONCEPTS
3 cr. (3 and O)

MATH 721 MATRIX ALGEBRA I
3 cr. (3 and 0)

MATH 722 MATRIX ALGEBRA II
3 cr. (3 and 0)

MATH 725 COMBINATORIAL MATHEMATICS FOR TEACHERS
3 cr. (3 and 0)

MATH 730 MODERN GEOMETRY FOR TEACHERS
3 cr. (3 and 0)

MATH 731 NON-EUCLIDEAN GEOMETRY
3 cr. (3 and 0)

MATH 732 PROJECTIVE GEOMETRY
3 cr. (3 and 0)

MATH 741 INTRODUCTION TO LINEAR PROGRAMMING WITH
APPLICATIONS
3 cr. (3 and 0)

MATH 751 FUNDAMENTAL CONCEPTS OF CALCULUS I
3 cr. (3 and 0)

MATH 752 FUNDAMENTAL CONCEPTS OF CALCULUS II
3 cr. (3 and 0)

MATH 761 PROBABILITY AND STATISTICS
3 cr. (3 and 0)

MATH 771 NUMERICAL METHODS IN SECONDARY MATHEMATICS I
3 cr. (3 and 0)

MATH 772 NUMERICAL METHODS IN SECONDARY MATHEMATICS II
3 cr. (3 and 0)

MATH 781 HISTORY OF MATHEMATICS
3 cr. (3 and 0)

MATH 783 THEORY OF NUMBERS
3 cr. (3 and 0)

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MATH 791　　MATHEMATICAL PROBLEMS IN THE CURRICULUM
　　　　　　　3 cr. (3 and 0)

Natural Sciences
F. J. Keller, Advisor

ASTR 701　　SOLAR SYSTEM ASTRONOMY FOR HIGH SCHOOL TEACHERS
　　　　　　　3 cr. (3 and 0)

ASTR 711　　STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS
　　　　　　　3 cr. (3 and 0)

BOT 701　　　EVOLUTIONARY BOTANY FOR TEACHERS
　　　　　　　3 cr. (2 and 3)

BOT 702　　　MODERN BOTANICAL CONCEPTS FOR TEACHERS
　　　　　　　3 cr. (3 and 0)

CH 700　　　 PHYSICAL SCIENCE IN ELEMENTARY SCHOOL—CHEMISTRY
　　　　　　　3 cr. (2 and 3)

CH 701　　　 REVIEW OF GENERAL CHEMISTRY I
　　　　　　　3 cr. (3 and 0)

CH 702　　　 CHEMISTRY FOR HIGH SCHOOL TEACHERS
　　　　　　　3 cr. (2 and 3)

CH 703　　　 SPECIAL PROBLEMS IN CHEMISTRY FOR SECONDARY SCHOOL
　　　　　　　3–6 cr. (3–6 and 0)

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

GEOL 700　　EARTH SCIENCE I
　　　　　　　3 cr. (2 and 3)

GEOL 750　　EARTH SCIENCE II
　　　　　　　3 cr. (2 and 3)

PHYS 700　　PHYSICAL SCIENCE IN ELEMENTARY SCHOOL PHYSICS
　　　　　　　3 cr. (3 and 0)

PHYS 701　　PHYSICS FOR HIGH SCHOOL TEACHERS I
　　　　　　　4 cr. (3 and 3)

PHYS 702　　PHYSICS FOR HIGH SCHOOL TEACHERS II
　　　　　　　4 cr. (3 and 3)

PHYS 703　　MODERN PHYSICS FOR HIGH SCHOOL TEACHERS
　　　　　　　3 cr. (3 and 0)

PHYS 715　　EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS I
　　　　　　　4 cr. (2 and 4)

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PHYS 716   EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS II
4 cr. (2 and 4)

PHYS 723   WEATHER SCIENCE FOR SCIENCE TEACHERS
3 cr. (3 and 0)

ZOOL 700   MODERN DEVELOPMENTS IN ZOOLOGY FOR HIGH SCHOOL
TEACHERS
3 cr. (3 and 0)

ZOOL 701   MAN'S IMPACT ON ECOLOGY
3 cr. (3 and 0)

ZOOL 702   FIELD METHODS IN ZOOLOGY FOR HIGH SCHOOL TEACHERS
3 cr. (2 and 3)

INDUSTRIAL EDUCATION

A. F. Newton, Head, Department of Industrial Education

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

The Master of Industrial Education degree allows for specialization in four areas: industrial arts education, vocational–technical education, administration and supervision for the two-year college, and education for industry.

Sufficient flexibility is permitted to structure each student's plan of study to meet the objectives for any of the four areas of specialization listed above. The industrial arts education area is designed for teachers desiring to improve competencies in teaching industrial arts, pre-vocational education and career education in the middle school, junior high, and senior high schools. Persons desiring to improve their competencies in teaching and administering vocational or technical subjects in secondary or post-secondary institutions enter the vocational–technical area of specialization. The education for industry area is designed to prepare training directors, educational specialists, training coordinators and personnel for other occupations in industry which are related to education. The program in administration and supervision for the two-year college is specifically designed for persons preparing for administrative or supervisory positions in the technical colleges.

In addition to the general requirements for admission to the Graduate School, departmental requirements for admission to each of the areas of specialization are as follows:

1. Industrial Industrial arts education applicants must hold or meet the minimum requirements for an industrial arts teacher's certificate.

2. Vocational–technical education applicants must hold or meet the minimum requirements for a trade and industrial teacher's certificate, or

show vocational or technical competence through training, work experience, or proficiency test results.

3. The program in administration and supervision for the two-year college requires the applicant to show evidence of competency in a teaching area, or to have a minimum of 24 semester hours of courses appropriate to the vocational or technical program to be administered or supervised.

4. The education for industry program requires the applicant to have a minimum of 24 hours of undergraduate courses appropriate to the occupation or industry in which the applicant desires to enter.

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

1. Eighteen hours in subjects which contribute to the student's technical, administrative, and/or supervisory competence.

2. Six hours in research or six hours in special problems.

3. Six hours must be taken outside the major department.

IN ED 605   COURSE ORGANIZATION AND EVALUATION
3 cr. (3 and 0)

IN ED 608   TRAINING PROGRAMS IN INDUSTRY
3 cr. (3 and 0)

IN ED 610   SPECIAL INSTITUTE COURSE: TOPICS IN INDUSTRIAL
EDUCATION
3 cr. (3 and 0)

IN ED 614   ELECTRONICS FOR TEACHERS
3 cr. (1 and 6)

IN ED 615   CONSTRUCTION PRACTICES
3 cr. (2 and 3)

IN ED 618   TECHNOLOGICAL CONCEPTS IN MANUFACTURING
3 cr. (2 and 3)

IN ED 622   HISTORY AND PHILOSOPHY OF INDUSTRIAL AND VOCATIONAL
EDUCATION
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)

IN ED 635   ADVANCED INDUSTRIAL METALWORKING PRACTICES
3 cr. (2 and 3)

IN ED 636   ADVANCED MATERIAL FORMING
2 cr. (1 and 3)

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IN ED 638   ADVANCED MACHINING
           3 cr. (1 and 6)

IN ED 640   ADVANCED TECHNIQUES OF THE GRAPHIC ARTS
           4 cr. (2 and 4)

IN ED 644   GRAPHIC ARTS PRODUCTION CONTROL
           3 cr. (2 and 3)

IN ED 652   ADVANCED PROJECTS
           1–6 cr. (0 and 3–18)

IN ED 660   INTRODUCTION TO CAREER EDUCATION
           3 cr. (3 and 0)

IN ED 696   PUBLIC RELATIONS
           3 cr. (3 and 0)

IN ED 815   SEMINAR IN INDUSTRIAL EDUCATION
           1 cr. (1 and 0)
Students and faculty discuss and study new technological and professional advances. May be taken up to three times.

IN ED 820   RECENT PROCESS DEVELOPMENTS
           3 cr. (3 and 0)

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New developments in production processes; ultrasonic and electrical discharge machining, high energy rate forming, precision casting methods, recent joining techniques.

IN ED 840   SCHOOL SHOP DESIGN
           3 cr. (3 and 0)
All aspects of unit shops, general shops and comprehensive shops for schools offering vocational industrial subjects and industrial arts courses.

IN ED 845   CURRICULUM PLANNING AND DEVELOPMENT IN INDUSTRIAL
           EDUCATION
           3 cr. (3 and 0)
Curriculum construction, departmental coordination of subject matter with other school subjects, curriculum modification, staff organization in curriculum development, selection and organization of course materials.

IN ED 860   CURRICULUM MATERIALS DEVELOPMENT IN INDUSTRIAL
           EDUCATION
           3 cr. (3 and 0)
Developing instructional materials and laboratory activities appropriate to learning and reinforcing concepts taught in industrial education. For industrial arts and vocational–technical education majors.

IN ED 861   ADMINISTRATION AND SUPERVISION OF VOCATIONAL
           EDUCATION
           3 cr. (3 and 0)
Principles and practices of administering and supervising various types of schools and classes under Federal vocational acts and state regulations.

IN ED 865   AMERICAN INDUSTRIES
                3 cr. (3 and 0)
     Concepts and principles of American industry and technology; identification of content of industrial arts courses taught in public schools. Fifteen plant visits supplement study of industrial organization, economics, management, production, and products.

IN ED 894   PROJECT RESEARCH
                1–6 cr. (1–6 and 0)
     Research related to departmental projects. (Open only to students planning to pursue advanced graduate study. Joint use with IN ED 895, 896 not permitted for degree.)

IN ED 895   SPECIAL PROBLEMS I
                3 cr. (3 and 0)
     Special problems in industrial education varying with interests, experiences, and needs of students.

IN ED 896   SPECIAL PROBLEMS II
                3 cr. (3 and 0)
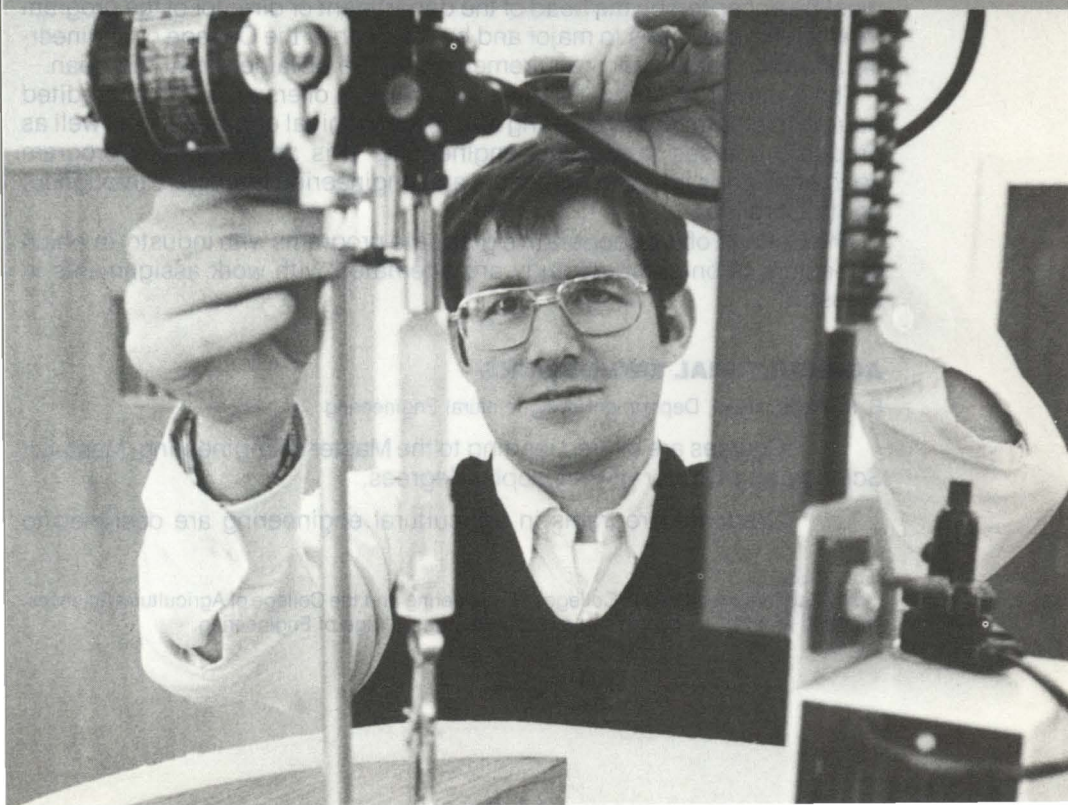   Continuation of IN ED 895.

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AGRICULTURAL ENGINEERING
AUTOMATIC CONTROL
BIOENGINEERING
CERAMIC ENGINEERING
CHEMICAL ENGINEERING
CIVIL ENGINEERING
ELECTRICAL ENGINEERING
ENGINEERING MECHANICS
ENVIRONMENTAL SYSTEMS ENGINEERING
FLUID MECHANICS
MATERIALS ENGINEERING
MECHANICAL ENGINEERING
SYSTEMS ENGINEERING
WATER RESOURCES ENGINEERING

COLLEGE OF ENGINEERING

COLLEGE OF ENGINEERING
L. C. Wilcox, Dean

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

Agricultural Engineering*	Engineering Mechanics
Bioengineering	Environmental Systems Engineering
Ceramic Engineering	Materials Engineering
Chemical Engineering	Mechanical Engineering
Civil Engineering	Systems Engineering
Electrical Engineering	Water Resources Engineering

In addition to the M.S. and Ph.D. degrees, the professional degree, Master of Engineering, is awarded in agricultural engineering, ceramic engineering, chemical engineering, civil engineering, electrical engineering, environmental systems engineering, mechanical engineering, and water resources engineering. Admission, program, and graduation requirements for this degree are recommended by the college.

Admission to the M.Engr. program is open to individuals with baccalaureate degrees in ECPD accredited engineering programs or their equivalent, and whose academic and professional records indicate motivation for and ability to complete additional professional study. Applicants must be accepted by the head of the department or director of the program in which he/she plans to major and by the dean of the College of Engineering. Further details and requirements may be obtained from the dean.

The External Master of Engineering program offers an ECPD accredited degree in electrical engineering and in mechanical engineering as well as graduate courses in systems engineering. It is an off-campus program specifically designed for engineers and engineering managers throughout South Carolina.

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

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

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

Graduate programs in agricultural engineering are designed to

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

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, biological science, and selected engineering sciences.

AGE 616 AGRICULTURAL MACHINERY DESIGN
    3 cr. (2 and 3) S

AGE 622 SOIL AND WATER RESOURCES ENGINEERING II
    3 cr. (2 and 3) S

AGE 631 AGRICULTURAL STRUCTURES DESIGN
    3 cr. (2 and 3) F

AGE 633 DESIGN CRITERIA FOR PLANT AND ANIMAL ENVIRONMENT
    2 cr. (2 and 0) S

AGE 642 AGRICULTURAL PROCESS ENGINEERING
    3 cr. (2 and 3) S

AGE 665 ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS
    2 cr. (1 and 3) S

AGE 781 SPECIAL PROBLEMS
    1–3 cr.
    Student selects subject and conducts library, laboratory and/or field research; technical report documenting study required; may be repeated for maximum of six credits. For Master of Engineering degree candidates only.

AGE 806 INSTRUMENTATION IN AGRICULTURAL AND BIOLOGICAL
    RESEARCH
    3 cr. (2 and 3)
    Fundamental mathematical and physical principles of measuring and recording physical phenomena in agricultural research; methods and instruments used in measuring temperature, humidity, fluid pressure and flow, force, velocity, acceleration, mechanical strain and displacement, color and chemical composition; transducers and sensing elements, amplifiers, and recording instruments related through appropriate electrical circuitry. Not open to engineering students. **Prerequisite:** General physics.

AGE 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 com-

paction causes and effects, tractive efforts of wheel and track-type vehicles and off-the-road locomotion. **Prerequisite:** AGE 416/616 or equivalent.

AGE 822   WATER MOVEMENT IN SOILS
3 cr. (3 and 0) F

Theory and principles of water movement in soils; theory and application of flow of water through soil in unsaturated and saturated states, flow nets and seepage forces, and fundamentals of engineering design with respect to ground water problems and soil moisture relationships. **Prerequisite:** MATH 208 or equivalent.

AGE 865   HEAT AND MOISTURE TRANSFER IN BIOLOGICAL MATERIALS
3 cr. (3 and 0) S

Heat and moisture diffusion in biological materials; criteria for selecting proper operational mathematics to solve certain boundary value problems; integral transforms of Laplace, Fourier, and Hankel applied to various geometric configurations; influence of respiration heat and transpiration moisture production. **Prerequisites:** MATH 453/653 or 457/657, or permission of instructor.

AGE 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.

AGE 882   SYSTEMS ENGINEERING
3 cr. (2 and 3) F

Systems analysis methods applied to engineering of agricultural operations; activity network analysis, critical path method, PERT, linear programming, modeling, simulation, linear systems analysis, application of digital computation in analysis of complex systems.

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

AGE 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.

AGE 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

AUTOMATIC CONTROL

The courses listed are offered by the faculties of the Departments of Chemical Engineering, Electrical and Computer Engineering, and Mechanical Engineering for students majoring in those departments who desire to minor in automatic control. This integrated sequence provides

the opportunity for in-depth study of classical and modern control theory applied to linear and non-linear systems in areas ranging from textile processes and machinery to aerospace systems.

AC 610   INTRODUCTION TO DIGITAL CONTROL
              3 cr. (3 and 0)

AC 810   MODELING AND CONTROL OF ENGINEERING SYSTEMS
              3 cr. (3 and 0)
    Mathematical modeling of engineering systems using state-space approach. Fluid, thermal, mechanical, and electrical systems are represented by matrix differential equations and are analyzed to determine eigenvalues, eigenvectors, and time solutions. Both lumped parameter and distributed parameter systems are treated; multivariable control techniques as applied to determine suitable control laws for systems with more than one input and output. **Prerequisite:** An undergraduate automatic control course.

AC 811   MODERN CONTROL THEORY
              3 cr. (3 and 0)
    Detailed treatment of state space analysis and design methods; matrix theory; development of state space models from transfer functions; solution of matrix differential equations; and analysis of state space models for controllability, observability, stability, and trajectory characteristics. **Prerequisite:** An undergraduate automatic control course.

AC 815   NONLINEAR CONTROLS
              3 cr. (3 and 0)
    Control systems in which nonlinear elements occur; sometimes introduced to achieve results not obtainable by other methods; graphical and analytical procedures include describing function technique, method of harmonic balance, and phase plane method; stability as analyzed by Liapunov's second method. **Prerequisite:** An undergraduate automatic control course.

AC 820   DIGITAL CONTROL I
              3 cr. (3 and 0)
    Components and techniques needed to design digital control systems; logic and switching circuit components and subsystems, control logic circuits, input and output device functions, A/D and D/A conversion techniques, data transmission techniques, and computer interface concepts.

AC 821   DIGITAL CONTROL II
              3 cr. (3 and 0)
    Use of computers, digital instrumentation, and data conversion equipment in controls; digital and analog computers, transducers, telemetering, sampling and filtering signal conditioning, data logging and sequence control; static optimization. **Prerequisite:** AC 410/610 or E&CE 412/612.

AC 910   ADAPTIVE AND OPTIMAL CONTROL
              3 cr. (3 and 0)
    Adaptive and optimal control; performance criteria, system identification,

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use of computer for optimum design, calculus of variations, maximum principle, and dynamic programming. **Prerequisites**: AC 811 and MATH 837 or permission of instructor.

BIOENGINEERING

F. W. Cooke, Head, Division of Interdisciplinary Studies

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

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 principal areas of concentration are biomaterials and biomechanics, systems physiology, medical computing and clinical (hospital) engineering. The materials and mechanics effort is concerned with the development of materials and devices (including artificial organs) for surgical implantation. Systems physiology is concerned with analyzing the complex of physical, chemical and biological processes that constitute living systems. Heavy reliance is placed on computer assisted modeling, direct laboratory experience and bioinstrumentation. The clinical engineering effort is designed to prepare masters candidates to deal directly with the many facets of modern medical technology, especially computers, which are encountered in hospitals.

The faculty is augmented by six adjunct medical faculty and most research programs are conducted in collaboration with leading institutions for clinical or research medicine. All students have some direct experience with an appropriate aspect of this medical involvement.

Students enrolling in this program usually have a strong background in one of the more traditional engineering disciplines such as materials, engineering mechanics, mechanical engineering, electrical engineering or chemical engineering. Some background in general biology and physiology is recommended but is not a prerequisite. Students with degrees in science may also be considered for admission if they can demonstrate proficiency in certain prescribed engineering courses.

Candidates are allowed wide flexibility in planning their program but are encouraged to seek advice and direction from the faculty because of the rapid evolution of this emerging discipline.

BIOE 601   COMPUTERS FOR BIOSCIENTISTS
            1 cr. (1 and 0)

BIOE 602   MEDICAL APPLICATIONS OF ENGINEERING SCIENCE
            3 cr. (3 and 0)

BIOE 650   SPECIAL TOPICS IN BIOMEDICAL ENGINEERING
            1–4 cr.

BIOE 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.

BIOE 801   BIOMATERIALS
             3 cr. (3 and 0)
    Primary and secondary factors determining performance of artificial organs in terms of materials used and design properties for each specific site of implantation. Topics include: metallurgy of stainless steel, cobalt-chromium alloys, dental amalgams, chemistry of medical polymers, physical properties of reinforced structures, ceramic-metallic bonding and corrosion in biological media.

BIOE 802   RESEARCH TECHNIQUES IN BIOMATERIALS EVALUATION
             3 cr. (1 and 6)
    Autoradiography, microradiography, electron beam microprobe, electron microscopy, optical microscopy, ultraviolet fluorescence, immunoelectrophoresis, blood chemistry analysis, urine chemistry analysis; techniques employed in determining compatibility of biomaterials with the physiological environment; research techniques associated with determining thrombogenic characteristics of biomaterials; corrosion and wear of biomaterials. **Prerequisite:** BIOE 801.

BIOE 803   POLYMERS AS BIOMATERIALS
             3 cr. (3 and 0)
    Problems and accomplishments in bioengineering pertaining to utilization of polymeric materials; interactions caused by contact of such compositions with living systems; review of state of the art of this branch of biomaterials; presentation of outlook to an active research area.

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BIOE 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.

BIOE 846   ELEMENTS OF BIOENGINEERING I
             3 cr. (3 and 0)
    Instrumentation for biological systems; signal conditioning, telemetry, impedance measurements, noise; biological materials and mechanics; physiology of cells and tissue, physical properties of tissue, mathematical models of muscular action; nervous system; physiology of central nervous system, information coding, analogs of nerves, EEG, EKG, nerve conduction velocity.

BIOE 847   ELEMENTS OF BIOENGINEERING II
             3 cr. (3 and 0)
    Cardiovascular systems; physiology of blood, heart, vascular bed, and organ blood flow; hemodynamics, properties of blood as a fluid, fluid flow equations,

turbulence, pulse propagation; electrocardiography, pacemakers, blood pressure and flow instrumentation; respiration; dynamics of breathing, gas exchange, and regulation; digestive system and temperature regulation.

BIOE 850   SPECIAL TOPICS IN BIOMEDICAL ENGINEERING
1–4 cr. (0–4 and 12–0)
Directed study of advanced topics in bioengineering intended to develop indepth areas of particular student interest. Credit may be earned for more than one semester. **Prerequisite:** Permission of instructor.

BIOE 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.

BIOE 880   APPLIED HEALTH ENGINEERING LABORATORY
1 cr. (0 and 3)
Exposure of advanced bioengineering graduate students to the "real world" of the medical community. Trips will be taken to medical facilities so students can see firsthand current types of engineering problems; class projects designed to provide possible solutions to some of these problems. **Prerequisite:** BIOE 847 and permission of instructor.

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BIO 891   MASTERS'S THESIS RESEARCH
Credit to be arranged.

BIOE 980   INTERNSHIP
1–5 cr.
Observation and assignment in a medical college or dental college, hospital, veterinary clinic, dental clinic, health service, or industrial department. Credits to be arranged; for Ph.D. students only. **Prerequisite:** Four semesters of graduate work in bioengineering.

BIOE 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

The following courses offered by various departments represent a typical core curriculum for the student in bioengineering. Descriptions for all 800-level courses can be found under the respective department headings.

AN PH 801   ELECTRON MICROSCOPY OF ANIMAL AND PLANT TISSUES
3 cr. (1 and 6)

AN PH 803   CARDIOVASCULAR AND RESPIRATORY PHYSIOLOGY
4 cr. (3 and 3)

AN PH 805   PHARMACOLOGY
3 cr. (2 and 3)

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

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

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

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

E&CE 827   INSTRUMENTATION AND MEASUREMENTS
3 cr. (3 and 0)

E&CE 870   BIOSYSTEMS ANALYSIS
3 cr. (3 and 0)

MATE 605   PHYSICAL METALLURGY
3 cr. (3 and 0)

MATE 651   CORROSION OF MATERIALS
3 cr. (2 and 3)

ME 601   STRENGTH ANALYSIS AND DESIGN OF MACHINES
3 cr. (3 and 0)

SE 860   DYNAMIC PROGRAMMING
3 cr. (3 and 0)

ZOOL 658   CELL PHYSIOLOGY
3 cr. (2 and 3)

ZOOL 660   GENERAL PHYSIOLOGY
4 cr. (3 and 3)

CERAMIC ENGINEERING

G. C. Robinson, Head, Department of Ceramic Engineering

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

CR AR 601   ADVANCED POTTERY
3 cr. (2 and 3)

CRE 602   SOLID STATE CERAMICS
3 cr. (3 and 0)

CRE 603   GLASSES
3 cr. (3 and 0)

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CRE 610   ANALYTICAL PROCESSES
           3 cr. (2 and 3)

CRE 612   RAW MATERIAL PREPARATION
           3 cr. (3 and 0)

CRE 616   ELECTRONIC CERAMICS
           3 cr. (3 and 0)

CRE 618   PROCESS CONTROL
           3 cr. (3 and 0)

CRE 619   SCIENCE OF ENGINEERING MATERIALS
           3 cr. (3 and 0)

CRE 620   SCIENCE OF ENGINEERING MATERIALS
           3 cr. (3 and 0)

CRE 701   SPECIAL PROBLEMS
           3 cr. (1–3 and 0)
     Practical problems in ceramic engineering analysis or design. Students are assigned individual problems with topics varying from year to year in keeping with developments and interests and experience of students and instructor; can be repeated for additional credit.

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CRE 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.

CRE 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.

CRE 814   CERAMIC PHYSICAL PROCESSING
           3 cr. (3 and 0)
     Role of physical processing in determining structure and composition of products.

CRE 815   COLLOIDAL AND SURFACE SCIENCE
           3 cr. (3 and 0)
     Theory and application of colloidal and surface chemistry to ceramic materials and processes.

CRE 816   CONSTITUTION AND STRUCTURE OF GLASSES
           3 cr. (3 and 0)
     Modern concepts of glass structure and properties.

CRE 821   ANALYTICAL PROCEDURES AND EQUIPMENT I
          3 cr. (2 and 3)
Theory and application of powder x-ray diffractometry, emission spectroscopy, electron microscopy, and optical microscopy to ceramic problems.

CRE 822   ANALYTICAL PROCEDURES AND EQUIPMENT II
          3 cr. (2 and 3)
Continuation of CRE 821.

CRE 824   MECHANICAL PROPERTIES OF CERAMIC MATERIALS
          3 cr. (3 and 0)
Stress-strain-time relations in elasticity, plasticity, and rupture showing effects of high and low temperature and structures.

CRE 825   MAGNETIC AND ELECTRICAL CERAMIC MATERIAL
          3 cr. (3 and 0)
Application of magnetic and electrical theory to ceramic insulators, semiconductors, and ferroelectric and ferromagnetic products.

CRE 826   CERAMIC COATINGS
          3 cr. (3 and 0)
Glassy and crystalline coatings emphasizing fundamentals of application, adhesion theories, and development of required properties.

CRE 828   SOLID STATE CERAMIC SCIENCE
          3 cr. (3 and 0)
Bonding and structure of crystalline materials as related to mechanical, thermal, and chemical properties of solids.

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

CHEMICAL ENGINEERING

W. B. Barlage, Jr., Head, Department of Chemical Engineering

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

Students will be accepted with backgrounds in chemistry, physics or branches of engineering other than chemical engineering. Special programs will be planned for non-chemical engineering graduates.

Minors for doctoral students may be taken in chemistry, physics, mathematics, life science, or other branches of engineering.

CHE 601   TRANSPORT PHENOMENA
          3 cr. (3 and 0)

CHE 607   UNIT OPERATIONS LABORATORY II
          2 cr. (0 and 6)

| CHE 615 | INTRODUCTION TO NUCLEAR ENGINEERING I |
| | 3 cr. (3 and 0) |

| CHE 616 | INTRODUCTION TO NUCLEAR ENGINEERING II |
| | 3 cr. (3 and 0) |

| CHE 621 | PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS I |
| | 3 cr. (2 and 3) |

| CHE 622 | PROCESS DEVELOPMENT, DESIGN, AND OPTIMIZATION OF CHEMICAL ENGINEERING SYSTEMS II |
| | 3 cr. (0 and 9) |

| CHE 624 | INTRODUCTION TO INDUSTRIAL POLLUTION |
| | 3 cr. (3 and 0) |

| CHE 630 | CHEMICAL ENGINEERING THERMODYNAMICS |
| | 3 cr. (3 and 0) |

| CHE 650 | CHEMICAL ENGINEERING KINETICS |
| | 3 cr. (3 and 0) |

| CHE 653 | PROCESS DYNAMICS |
| | 3 cr. (3 and 0) |

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| CHE 660 | INTRODUCTION TO OCCUPATIONAL SAFETY AND HEALTH |
| | 3 cr. (3 and 0) |

| CHE 661 | INDUSTRIAL HYGIENE ANALYSIS AND INSTRUMENTATION |
| | 3 cr. (2 and 3) |

| CHE 662 | AIR RESOURCES ENGINEERING |
| | 3 cr. (3 and 0) |

| CHE 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**: CHE 453/653 and MATH 208 or permission of instructor.

| CHE 803 | HEAT, MASS, AND MOMENTUM TRANSFER |
| | 3 cr. (3 and 0) |

Fundamental mechanisms of molecular and turbulent transport of heat, mass and momentum.

| CHE 804 | CHEMICAL ENGINEERING THERMODYNAMICS |
| | 3 cr. (3 and 0) |

Equilibria of physical and chemical systems, generalized properties of hydrocarbons, and application of thermodynamic methods in equipment design.

CHE 805   CHEMICAL ENGINEERING KINETICS
3 cr. (3 and 0)
Kinetics of chemical reactions, particularly in design and operation of chemical reactors.

CHE 806   PROCESS SYSTEMS ANALYSIS AND SIMULATION
3 cr. (3 and 0)
Formulation and solution of mathematical models describing dynamic and steady state behavior of chemical and physical process systems; methodology of systems analysis, and techniques of analog and digital solutions.

CHE 808   CHEMICAL ENGINEERING DESIGN AND ANALYSIS
3 cr. (1 and 6)
Design and analysis of chemical process equipment through solution of comprehensive problems involving unit operations, kinetics, thermodynamics, strength of materials, and chemistry.

CHE 812   POLYMER ENGINEERING
3 cr. (3 and 0)
Synthetic polymer design; reactor designs used in polymer production, effect on reactor design of kinetics of step and addition polymerization, epoxy curing reactions, polymer solubility behavior, and influence of polymerizer design and polymerization conditions on polymer crystallinity; morphological changes occuring in fiber and film processing. **Prerequisite:** Permission of instructor.

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CHE 814   APPLIED NUMERICAL METHODS IN PROCESS SIMULATION
3 cr. (3 and 0)
Numerical solution techniques as applied to chemical process sytems; 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.

CHE 818   POLYMER PROCESSING
3 cr. (3 and 0)
Processing of polymeric materials; injection molding, calendering, extrusion and surface activation of plastic film; physical science principles such as crystallization, surface chemistry, heat transfer and rheology applied to process operations. **Prerequisite:** FM 817.

CHE 821   HEAT TRANSPORT
3 cr. (3 and 0)
Heat transport by conduction, convection and radiation.

CHE 822   MASS TRANSFER AND DIFFERENTIAL CONTACT OPERATIONS
3 cr. (3 and 0)
Diffusion theory in binary and multicomponent gas and liquid systems, HTU concept, design considerations in absorption and extraction.

CHE 823   MASS TRANSFER AND STAGEWISE CONTACT OPERATIONS
3 cr. (3 and 0)
Stagewise contact operations emphasizing distillation; vapor-liquid equilib-

ria, integral and differential distillation, binary and multicomponent rectification, analytical methods, batch rectification, azeotropic and extractive distillation.

CHE 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.

CHE 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.

CHE 852 AIR POLLUTION CONTROL PROCESSES
3 cr. (3 and 0)
Operational and design variables in equipment for removal of gas, liquid and solid phase pollutants from air; basic theory of small particle dynamics; performance and design.

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

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CHE 903 TRANSPORT PHENOMENA
3 cr. (3 and 0)
Problems in transport phenomena taken from current literature. **Prerequisite:** CHE 803.

CHE 904 CHEMICAL ENGINEERING THERMODYNAMICS
3 cr. (3 and 0)
Continuation of CHE 804 including non-ideal behavior of mixtures, statistical thermodynamics and irreversible process. **Prerequisite:** CHE 804.

CHE 945 SELECTED TOPICS IN CHEMICAL ENGINEERING
3 cr. (3 and 0)
Primarily a more comprehensive study of topics first covered in CHE 845 and 846.

CHE 946 SELECTED TOPICS IN CHEMICAL ENGINEERING
3 cr. (3 and 0)
Primarily a more comprehensive study of topics first covered in CHE 845 and 846.

CHE 991 DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

Descriptions for the following 800-level interdepartmental courses are listed under Automatic Control and Fluid Mechanics.

AC 610 INTRODUCTION TO DIGITAL CONTROL
3 cr. (3 and 0)

| AC 810 | MODELING AND CONTROL OF ENGINEERING SYSTEMS |
| | 3 cr. (3 and 0) |

| AC 811 | MODERN CONTROL THEORY |
| | 3 cr. (3 and 0) |

| AC 815 | NONLINEAR CONTROLS |
| | 3 cr. (3 and 0) |

| AC 820 | DIGITAL CONTROL I |
| | 3 cr. (3 and 0) |

| AC 821 | DIGITAL CONTROL II |
| | 3 cr. (3 and 0) |

| AC 910 | ADAPTIVE AND OPTIMAL CONTROL |
| | 3 cr. (3 and 0) |

| FM 801 | FOUNDATION OF FLUID MECHANICS |
| | 3 cr. (3 and 0) F |

| FM 811 | EXPERIMENTAL FLUID MECHANICS |
| | 3 cr. (2 and 3) F |

| FM 812 | THEORY OF INCOMPRESSIBLE IDEAL FLOW |
| | 3 cr. (3 and 0) S |

| FM 814 | TURBULENT BOUNDARY LAYER |
| | 3 cr. (3 and 0) S |

| FM 815 | NUMERICAL METHODS IN FLUID MECHANICS |
| | 3 cr. (3 and 0) F |

| FM 816 | FLOW IN OPEN CHANNELS |
| | 3 cr. (3 and 0) S |

| FM 817 | NON-NEWTONIAN FLOW |
| | 3 cr. (3 and 0) S |

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CIVIL ENGINEERING

J. E. Clark, Acting Head, Department of Civil Engineering

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

Students may pursue programs in traffic and transportation, structures, ocean and coastal engineering, construction, soils and foundation engineering, and public works engineering. Opportunities for study and research also exist in several interdisciplinary programs including water resources engineering, environmental systems engineering and bioengineering. Each student's educational and research program can be arranged to suit his/her personal and professional goals.

CE 603	USE OF COMPUTERS IN STRUCTURAL ANALYSIS AND DESIGN
	3 cr. (2 and 2)
CE 610	TRAFFIC ENGINEERING OPERATIONS
	3 cr. (3 and 0) S
CE 612	URBAN TRANSPORTATION PLANNING
	3 cr. (3 and 0) F
CE 617	AIRPHOTO INTERPRETATION I
	3 cr. (2 and 3) F
CE 619	GENERAL PHOTOGRAMMETRY
	3 cr. (2 and 3) S
CE 631	APPLIED SOIL MECHANICS
	3 cr. (2 and 2)
CE 634	CONSTRUCTION COSTS AND ESTIMATES
	3 cr. (2 and 3)
CE 635	ENGINEERING PROJECT ANALYSIS
	3 cr. (2 and 2)
CE 636	SUBSURFACE CONSTRUCTION
	3 cr. (3 and 0)
CE 641	APPLIED HYDRAULICS
	3 cr. (3 and 0)
CE 653	ADVANCED STRUCTURAL ANALYSIS
	3 cr. (3 and 0)
CE 662	PORT AND HARBOR ENGINEERING
	3 cr. (3 and 0)
CE 801	STRUCTURAL ENGINEERING
	3 cr. (3 and 0)

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Analysis and design of tall buildings subjected to wind stresses; analysis of space frames; analysis and design of continuous trusses; secondary stresses in trusses; introduction to matrix methods of analysis; introduction to design of arches. **Prerequisite:** CE 453/653 or equivalent.

CE 802   PRESTRESSED CONCRETE ANALYSIS AND DESIGN
             3 cr. (3 and 0)

Design and analysis of prestressed concrete beams, columns and floor slabs; composite design of steel and concrete. **Prerequisite:** CE 402.

CE 803   REINFORCED CONCRETE STRUCTURAL SYSTEMS
             3 cr. (3 and 0)

Behavior of reinforced concrete beams, columns, and frames related to design practice; effect of past and present research in formulation of reinforced concrete design codes. **Prerequisite:** CE 402.

CE 804   THEORY AND DESIGN OF THIN PLATES
              3 cr. (3 and 0)
    Elastic analysis and design of circular, rectangular, and continuous plates by classical and numerical methods. **Prerequisite:** A knowledge of Fourier series and partial differential equations.

CE 805   PLASTIC DESIGN OF STEEL STRUCTURES
              3 cr. (3 and 0)
    Inelastic behavior of metal frameworks; concepts of plastic hinge and collapse configurations; requirements for stability; connections; mimimum weight and cost design. **Prerequisites:** CE 302, CE 453/653.

CE 806   DESIGN OF STEEL MEMBERS
              3 cr. (3 and 0)
    Behavior of steel members related to design practice; experimental investigations of, and design practice for, primary buckling, twist buckling, local buckling, web buckling and interaction. **Prerequisite:** CE 302.

CE 807   NUMERICAL AND APPROXIMATE METHODS OF STRUCTURAL
              ANALYSIS
              3 cr. (3 and 0)
    Application of finite difference equations, iterative procedures and relaxation methods to solution of structural problems; introduction to matrix formulation of structural problems, application of matrix methods to vibration of structures; analysis and stability of statically loaded beams, frames, space frames and stiffened shell structures. **Prerequisite:** CE 453/653.

CE 808   FINITE ELEMENT METHODS IN STRUCTURAL ANALYSIS
              3 cr. (3 and 0)
    Basic formulation of finite element structural analysis; types of elements; application to linear elastic analysis; elastic instability; dynamic response; and inelastic analysis. **Prerequisite:** CE 801 or permission of instructor.

CE 811   HIGHWAY GEOMETRIC DESIGN
              3 cr. (2 and 3)
    Geometric design of roadways, at-grade intersections, and interchanges in accordance with conditions imposed by driver ability, vehicle performance, safety and economics. **Prerequisite:** CE 310/610.

CE 812   AIRPHOTO INTERPRETATION II
              3 cr. (2 and 3)
    Principles of airphoto interpretation as applied to transportation planning; identification and analysis of cultural, industrial and recreational land use features to predict future needs of transportation system. Transportation projects utilizing airphoto interpretation required.

CE 813   HIGHWAY AND AIRPORT PAVEMENT DESIGN
              3 cr. (3 and 0)
    Structural design of rigid and flexible pavements; design of bases and 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.

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CE 814   TRAFFIC FLOW THEORY
              3 cr. (3 and 0)
    Qualitative and quantitative description of traffic flow, study of parameters used to characterize traffic flow, procedures for adjusting traffic flow parameters to optimize flow, solution of traffic flow problems by methods of analogy and queuing theory, and discussion of digital simulation of vehicular motion and traffic flow. **Prerequisite:** CE 310/610.

CE 815   HIGHWAY SAFETY ENGINEERING
              3 cr. (3 and 0)
    Methodology for conducting highway traffic accident studies; accident characteristics as related to vehicle driver, roadway, and vehicle; statistical applications to accident data and studies; and consideration of current trends and problems in highway safety. **Prerequisite:** CE 310/610.

CE 816   HIGHWAY PLANNING
              3 cr. (3 and 0)
    Various aspects of highway planning; planning surveys, needs studies, impact studies, sufficiency ratings, highway finance, highway administration, and extensive treatment of economic evaluation of alternative highway projects by benefit cost ratio, annual cost, rate of return and investment return procedures.

CE 817   MASS TRANSIT PLANNING
              3 cr. (3 and 0)
    Mass transit planning; characteristics of modern mass transit systems, case studies of mass transit in selected cities, transit studies, marketing and financing mass transit, recent innovation in mass transit, current issues in mass transit planning, and future developments in mass transit.

CE 818   AIRPORT PLANNING AND DESIGN
              3 cr. (3 and 0)
    Planning and design of airports and other air transportation facilities; characteristics of air transport; future role of air transport in overall transportation program.

CE 819   TRANSPORTATION RESEARCH
              2–4 cr.
    Independent investigation of problems in transportation engineering.

CE 822   AGGREGATES AS CONSTRUCTION MATERIALS
              3 cr. (2 and 3)
    Identification and suitability of aggregates for embankment, drainage, and roadbed structures, concrete mixes, and bituminous mixtures. **Prerequisite:** CE 320/620.

CE 830   ADVANCED SOIL MECHANICS
              3 cr. (3 and 0)
    Stresses in soils, plastic equilibrium of soil masses, failure conditions, earth pressures, analysis of flexible retaining wall and bulkheads, solution of problem by elastic theory. **Prerequisite:** CE 330.

CE 831 FOUNDATION ENGINEERING
    3 cr. (2 and 3)
  Requirements for satisfactory foundations, theory and design of shallow foundations, pressure distribution beneath rigid and flexible shallow foundations, bearing capacity and settlement of deep foundations, foundation failures. Laboratory includes site investigation field tests and determination of design parameters. **Prerequisite:** CE 830.

CE 835 DESIGN OF EARTH STRUCTURES
    3 cr. (3 and 0)
  Design and construction of earth and rock fill dams, appurtenances and embankment details, highway embankments, methods of stabilization, compaction, and compaction control, drainage systems for seepage and pressure control. **Prerequisite:** CE 330.

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 901 THEORY AND DESIGN OF SHELLS
    3 cr. (3 and 0)
  Elastic analysis and design of shell structures such as cylindrical shells, folded plates, domes, roof structures with double curvature. **Prerequisite:** A knowledge of Fourier series and partial differential equations.

CE 902 STRUCTURAL VIBRATION
    3 cr. (3 and 0)
  Analysis and design of structures subjected to dynamic loading; investigation of response for lumped and distributed parameter systems of one or many degrees of freedom; approximate design methods; earthquake analysis and design; and blast resistant design. **Prerequisite:** Permission of instructor.

CE 991 DOCTORAL DISSERTATION RESEARCH
    Credit to be arranged.

ELECTRICAL ENGINEERING

A. L. Duke, Head, Department of Electrical and Computer Engineering

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

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Students may direct their program toward the traditional fields of networks, controls, communications, electronics, power systems, and computers, or one of the multi-disciplinary fields such as biomedical engineering, systems or operations research.

E&CE 603   ENERGY CONVERSION
3 cr. (3 and 0) F

E&CE 606   INTRODUCTION TO INTEGRATED CIRCUITS
3 cr. (3 and 0) F

E&CE 610   DISCRETE SYSTEM DESIGN
3 cr. (3 and 0) F, S

E&CE 611   ELECTRICAL SYSTEMS
2 cr. (0 and 4) F, S

E&CE 612   DIGITAL CONTROL SYSTEMS
3 cr. (3 and 0) S

E&CE 616   INTRODUCTION TO MODERN CONTROL SYSTEMS
3 cr. (3 and 0) F

E&CE 620   POWER SYSTEM ANALYSIS I
3 cr. (3 and 0) S

E&CE 621   ELECTRICAL MACHINERY
3 cr. (2 and 2) F

E&CE 622   ELECTRONICS III
3 cr. (2 and 2) F, S

E&CE 623   DESIGN FOR LARGE-SCALE INTEGRATION FUNCTIONS
3 cr. (3 and 0) S

E&CE 624   POWER SYSTEMS ANALYSIS II
3 cr. (3 and 0) S

E&CE 625   MICROPROCESSORS
3 cr. (2 and 2) F

E&CE 626   DIGITAL COMPUTER DESIGN
3 cr. (3 and 0) S

E&CE 627   OPERATIONAL AMPLIFIERS
2 cr. (2 and 0) S

E&CE 628   COMMUNICATIONS THEORY I
3 cr. (3 and 0) F, S

E&CE 629   COMPUTER ORGANIZATION
3 cr. (3 and 0) F

E&CE 630   COMMUNICATIONS THEORY II
3 cr. (3 and 0) S

E&CE 631   DIGITAL ELECTRONICS
3 cr. (2 and 2) S

E&CE 632   INSTRUMENTATION
3 cr. (3 and 0) S

E&CE 634   POWER ELECTRONICS
3 cr. (3 and 0) F

E&CE 635   COMMUNICATION CIRCUITS
3 cr. (3 and 0) S

E&CE 636   RADIATION AND WAVE PROPAGATION
3 cr. (3 and 0) F

E&CE 637   LASER TECHNOLOGY AND APPLICATIONS
3 cr. (3 and 0) S

E&CE 651   SYSTEM DESIGN PROJECT
2 cr. (0 and 4) F, S

E&CE 652   PROGRAMMING SYSTEMS
3 cr. (3 and 0) S

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E&CE 660   COMPUTER-AIDED ANALYSIS AND DESIGN
3 cr. (3 and 0) F

E&CE 661   ANALOG/HYBRID COMPUTATION AND SIMULATION
3 cr. (2 and 2) S

E&CE 667   INTRODUCTION TO DIGITAL SIGNAL PROCESSING
3 cr. (3 and 0) F

E&CE 701   SPECIAL PROBLEMS
1–3 cr. F, S
Practical problems in engineering analysis or design in students' fields of interest. May be repeated for additional credit.

E&CE 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 807   POWER SYSTEM TECHNIQUES
3 cr. (3 and 0) S
Electric power system operation; development of models of transmission line components and networks; computer methods for solving linear and nonlinear

systems of network equations; operating problems in load flow, scheduling and economic dispatch. **Prerequisite:** Permission of instructor.

E&CE 808   ELECTROMECHANICAL ENERGY CONVERSION
              3 cr. (3 and 0) F
DC and AC motors and generators; principles of electromechanical energy conversion; steady state and dynamic operation of DC and AC machines; the machine as part of a control system. Laboratory experience included. **Prerequisite:** Permission of instructor.

E&CE 812   SAMPLED DATA SYSTEMS
              3 cr. (3 and 0) F
Analysis and design of control systems in which sampling elements occur; sampling theory and data reconstruction; use of classical z-transform analysis techniques augmenting modern control theory methods; stability, compensation, and performance.

E&CE 817   POWER SYSTEM TRANSIENT ANALYSIS
              3 cr. (3 and 0) F
Dynamic operation of power systems; development of models for dynamic operation of synchronous machines and transmission systems; computer methods for solving transient problems; applications to power systems including control problem, fault analysis and stability analysis. **Prerequisite:** Permission of instructor.

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E&CE 819   DETECTION AND ESTIMATION THEORY
              3 cr. (3 and 0) F
Theory of statistical testing of hypotheses applied to detection and estimation of communication signal parameters; detection of signals with random amplitude, phase and arrival time in noise; detection of single and multiple observation; estimates and their properties; signal resolution. **Prerequisites:** E&CE 815 and 820.

E&CE 820   THEORY OF COMMUNICATIONS I
              3 cr. (3 and 0) F
Modern communications systems emphasizing modulation and methods of taking into account effects of noise on various systems. **Prerequisite:** E&CE 428/628 or equivalent.

E&CE 821   THEORY OF COMMUNICATIONS II
              3 cr. (3 and 0) S
Continuation of E&CE 820.

E&CE 822   INFORMATION THEORY
              3 cr. (3 and 0) F
Statistical problems encountered in information handling; relations of probability, information, and coding theory; unified treatment of set theory, sample space, random variables, information measure and capacity applied to communication.

E&CE 823   INTEGRATED CIRCUIT TECHNOLOGY
              3 cr. (3 and 0) F

Characteristics of semiconductor devices as used in integrated circuits; monolithic and hybrid construction related to electrical performance; categorization of circuits by technology and design guidelines.

E&CE 825   SOLID-STATE ELECTRONICS
3 cr. (3 and 0) S

Modern physics approach to electron in solids; elementary quantum mechanics, statistics, plasmas, and band theory; application of these principles to modern amplifiers, e.g., the traveling-wave tube, tunnel diode, masers, and parametric amplifiers.

E&CE 827   INSTRUMENTATION AND MEASUREMENTS
3 cr. (3 and 0) F

Instrumentation capable of measuring physical parameters, including spectrophotometry, spectroscopy, mass spectrometry, gas chromatography, NMR and ESR; electronic components such as detectors, pulse height analyzers, and data processing and telemetry equipment.

E&CE 830   ELECTROMAGNETICS
3 cr. (3 and 0) F

Vector analysis, electrostatics, electrostatic fields in material bodies, solution of boundary-value problems, stationary currents, static magnetic fields, magnetic field in material bodies, quasi-stationary magnetic fields. **Prerequisite:** Permission of instructor.

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E&CE 832   ANTENNA DESIGN AND APPLICATIONS
3 cr. (3 and 0)

Radiation from simple antennas, arrays of antennas, and apertures; capture area of antennas, impedances, broad band designs, noise, and propagation considerations.

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 850   COMPUTATION AND SIMULATION
3 cr. (3 and 0) F

Computer modeling as related to engineering problems; matching problems and computers to obtain most effective solution.

E&CE 851   THEORY AND DESIGN OF DIGITAL-ANALOG MACHINES
3 cr. (3 and 0) S

Theory and design of general purpose, special purpose, hybrid and sequential machines emphasizing practical applications.

E&CE 852   DIGITAL AND INFORMATION PROCESSES
3 cr. (3 and 0) F

Techniques and problems of computer and information processing technol-

ogy; algorithmic approach to problem solving, software concepts, and machine organization. **Prerequisite:** Prior knowledge of computer programming.

E&CE 853   COMPUTER DATA DISPLAYS
3 cr. (3 and 0) S

Methods and hardware required for visually displaying computer output; cathode ray, discrete readout, and large screen displays. **Prerequisite:** E&CE 429/629 or approval of instructor.

E&CE 855   ARTIFICAL INTELLIGENCE
3 cr. (3 and 0) F

Problem of creating intelligent behavior in machines, emphasizing computer-oriented approaches; models of cognitive processes, goal-seeking behavior, self-organizing systems, learning algorithms, game-playing machines, pattern recognition, and heuristic programming; practical applications such as machine aids to human problem-solving and computer control of external manipulators; current developments.

E&CE 856   PATTERN RECOGNITION
3 cr. (3 and 0) S

Several approaches to general pattern recognition problem with practical computer-oriented applications; feature extraction, classification algorithms, discriminant functions, learning schemes, statistical methods, information theoretic approaches, applications, current developments.

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E&CE 857   CODING THEORY
3 cr. (3 and 0) S

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-Chandnuri 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

Structure and capabilities of sequential machines; machine identification regular expressions, linear machines, and stochastic machines.

E&CE 870   BIOSYSTEMS ANALYSIS
3 cr. (3 and 0) F

Classical and recent mathematical models of biological systems, particularly as they relate to modern systems theory and as they apply to humans biomedical instrumentation; data collection and processing.

E&CE 890   SELECTED TOPICS IN ELECTRICAL ENGINEERING
1–3 cr. (1–3 and 0) F, S

Topics not covered in other courses; current literature and results of curren research. Topics vary from year to year in keeping with developments in the field can be repeated for additional credit.

E&CE 891   MASTER'S THESIS RESEARCH
Credit to be arranged.

E&CE 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

Descriptions for the following 800-level interdepartmental courses are listed under Automatic Control.

AC 610   INTRODUCTION TO DIGITAL CONTROL
3 cr. (3 and 0)

AC 810   MODELING AND CONTROL OF ENGINEERING SYSTEMS
3 cr. (3 and 0)

AC 811   MODERN CONTROL THEORY
3 cr. (3 and 0)

AC 815   NONLINEAR CONTROLS
3 cr. (3 and 0)

AC 820   DIGITAL CONTROL I
3 cr. (3 and 0)

AC 821   DIGITAL CONTROL II
3 cr. (3 and 0)

AC 910   ADAPTIVE AND OPTIMAL CONTROL
3 cr. (3 and 0)

ENGINEERING MECHANICS

E. H. Bishop, Head, Department of Mechanical Engineering

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

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

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

EM 621   HYDROLOGY AND HYDRAULICS
2 cr. (2 and 0)

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EM 625	ADVANCED STRENGTH OF MATERIALS
	3 cr. (3 and 0)

EM 650	MECHANICAL VIBRATIONS
	3 cr. (3 and 0)

EM 670	EXPERIMENTAL STRESS ANALYSIS
	3 cr. (2 and 3)

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

Application of variational principles in solid mechanics problems; virtual work, Castigliano's theorems on deflection and rotation, stationary potential energy, energy stability criterion, and Hamilton's principle. **Prerequisite:** EM 831 or permission of instructor.

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

Theory of stress and deformation for continuous media; linear stress-strain relations for elastic material; two-dimensional problems including Airy stress function, polynomial solutions, plane stress and plane strain in rectangular and polar coordinates, torsion and bending of prismatic bars and thermal stresses. **Prerequisites:** EM 304 and MATH 208.

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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 MATH 658.

EM 834	PRINCIPLES OF STRUCTURAL STABILITY
	3 cr. (3 and 0)

Practical criteria for analysis of conservative and nonconservative systems stability; methods of adjacent equilibrium, initial imperfections, total potential energy, and vibration as applied to practical problems. **Prerequisite:** EM 831.

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

Kinematics and dynamics of particles and rigid bodies; Lagrange and Hamilton's formulation of mechanics; two-body central force problem; rendezvous of two bodies in a central force field; rotation of rigid bodies about a fixed point in space; vector analysis and matrix methods as aids in mathematical analysis. **Prerequisite:** EM 202 or permission of instructor.

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

EM 980   SPECIAL TOPICS IN MECHANICS
      3 cr. (3 and 0)
   Directed study of advanced topics in solid and fluid mechanics to develop in depth the candidate's area of interest.

EM 981   SPECIAL TOPICS IN MECHANICS
      3 cr. (3 and 0)
   Directed study of advanced topics in solid and fluid mechanics to develop in depth the candidate's area of interest.

EM 991   DOCTORAL DISSERTATION RESEARCH
      Credit to be arranged.

Descriptions for the following interdepartmental courses are listed under Fluid Mechanics.

FM 801   FOUNDATION OF FLUID MECHANICS
      3 cr. (3 and 0)

FM 811   EXPERIMENTAL FLUID MECHANICS
      3 cr. (2 and 3)

FM 812   THEORY OF INCOMPRESSIBLE IDEAL FLOW
      3 cr. (3 and 0)

FM 814   TURBULENT BOUNDARY LAYER
      3 cr. (3 and 0)

FM 815   NUMERICAL METHODS IN FLUID MECHANICS
      3 cr. (3 and 0)

FM 816   FLOW IN OPEN CHANNELS
      3 cr. (3 and 0)

FM 817   NON-NEWTONIAN FLOW
      3 cr. (3 and 0)

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ENVIRONMENTAL SYSTEMS ENGINEERING

T. M. Keinath, Acting Head, Department of Environmental Systems Engineering

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

     Environmental systems engineering is an interdisciplinary field concerned with the engineering aspects of the control of man's environment. Emphasis is placed on applying basic principles of the sciences through research and design to environmental engineering problems.

     The M.Engr., M.S., and Ph.D. programs are planned to augment the student's previous engineering or science background with specialization in the

design, operations and management areas of water or air quality control. Students with a baccalaureate degree in any branch of engineering, as well as chemistry, physics, and biology majors with a strong mathematical background, may be admitted to the program. No foreign language is required.

The Ph.D. program is designed to accommodate the background and objectives of the candidate. The major field of study generally is interdisciplinary in nature, consisting of courses in several areas of engineering and the basic sciences. Dissertation research is guided by Environmental Systems Engineering faculty.

ESE 601   ENVIRONMENTAL ENGINEERING
3 cr. (3 and 0)

ESE 602   WATER AND WASTE TREATMENT SYSTEMS
3 cr. (3 and 0)

ESE 643   ENVIRONMENTAL ENGINEERING CHEMISTRY I
3 cr. (3 and 0) F

ESE 644   ENVIRONMENTAL ENGINEERING CHEMISTRY LABORATORY I
1 cr. (0 and 3) F

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1–4 cr. (1–4 and 0)
Problems are selected in the field of environmental engineering to meet the interests and experience of student and instructor. Formal report is required. Restricted to Master of Engineering students.

ESE 802   PRINCIPLES OF WATER TREATMENT SYSTEMS
4 cr. (4 and 0)
Fundamental principles important to water and wastewater treatment systems. Topics considered are the principles of biological and chemical reactions, mass and heat transfer, reactor kinetics, adsorption and ion exchange, classification and thickening, transient response analysis and control theory, statistics, and methods of operations research.

ESE 803   LABORATORY IN PRINCIPLES OF WATER TREATMENT
1 cr. (0 and 3)
Demonstrations and selected laboratory exercises which illustrate the fundamental principles of water and wastewater treatment systems including respirometer studies, reactor systems, dispersion, gas transfer, adsorption, thickening, and control systems. Emphasis is placed on the relation between theory and experimental results. **Prerequisite:** ESE 802 or concurrent registration in ESE 802.

ESE 804   DESIGN AND OPERATION OF WATER TREATMENT SYSTEMS
4 cr. (4 and 0)
An investigation of the design and operational criteria that are significant to the processes employed for the treatment of water and wastewater. Topics include coagulation and flocculation, filtration, adsorption and ion exchange, membrane

separation, chemical precipitation and water stabilization, chemical oxidation and disinfection, activated sludge, fixed-film biological reactors, anaerobic digestion, solids handling and disposal, and municipal and industrial economics. **Prerequisite:** ESE 802 and 803.

ESE 805   LABORATORY IN DESIGN AND OPERATION OF WATER
              TREATMENT SYSTEMS
              1 cr. (0 and 3)

Laboratory exercises in selected water and wastewater treatment processes. Coagulation, flocculation, filtration, reverse osmosis, softening, activated sludge, anaerobic digestion, and sludge handling and disposal are typical topics studied. Emphasis is directed toward the operation of these processes and on securing suitable design parameters. **Prerequisites:** ESE 802, 803, and 804 or concurrent registration in ESE 804.

ESE 806   INTEGRATED PROBLEMS IN WATER TREATMENT SYSTEMS
              2 cr. (2 and 0)

Integration of water and wastewater treatment processes into complex systems emphasizing functional design and operation through consideration of process economics and plant control systems. The team approach is employed in the design and analysis of several integrated water treatment systems. **Prerequisites:** ESE 802, 803, 804, and 805.

ESE 831   AIR QUALITY MONITORING
              3 cr. (2 and 3)

Principles of ambient and source measurements of air pollutants and siting of air pollution monitors. Laboratory exercises include source testing and ambient air analysis. **Prerequisite:** Permission of instructor.

ESE 832   AIR POLLUTION METEOROLOGY
              3 cr. (3 and 0)

Applications of meteorology to air pollution, micrometeorology, plume rise modeling, atmospheric diffusion, deposition and washout of pollutants, air chemistry, and applications of diffusion modeling to air quality planning. **Prerequisite:** Permission of instructor.

ESE 846   POLLUTION OF THE AQUATIC ENVIRONMENT
              3 cr. (3 and 0)

Effects of domestic and industrial waste pollution on the physical, chemical and biological characteristics of natural water. Associated environmental determinants of human disease, toxicology and epidemiology of chronic disease are considered.

ESE 847   POLLUTION OF THE AQUATIC ENVIRONMENT LABORATORY
              1 cr. (0 and 3) S

Field and laboratory investigations into physical, chemical, and biological effects resulting from pollution of aquatic environment.

ESE 848   ENVIRONMENTAL ENGINEERING CHEMISTRY II
              2 cr. (2 and 0)

Applications of principles of organic chemistry and biochemistry to problems

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of environmental control and waste treatment; treatability and potential health hazards of complex organic compounds emphasized.

ESE 849   ENVIRONMENTAL ENGINEERING CHEMISTRY LABORATORY II
2 cr. (1 and 3) S (alternate years)

Theory and application of instrumental methods of analysis as applied to measurements for environmental control; spectroscopy and spectrophotometric techniques, electrochemical analyses, chromatographic methods of analysis, and light scattering and electrophoretic measurements. Demonstrations and selected experiments in interfacing analytical instruments with the small digital computer are conducted.

ESE 860   ECOLOGICAL MODELS
3 cr. (2 and 3)

Systems analysis applied to ecology; construction of models which predict ecological consequences of abuses to environment; frequency response analysis, energy models, information flow, and transfer functions for population interactions. **Prerequisites:** BIOE 601, a course in ecology or directed outside reading.

ESE 861   ENVIRONMENTAL SYSTEMS ENGINEERING SEMINAR
1 cr. (1 and 0) F, S

Current advances and research developments in various areas of environmental engineering. Off-campus speakers, students, and faculty participate.

ESE 862   ENVIRONMENTAL QUALITY CASE STUDY
1 cr. (0 and 3) F

An in-depth analysis and investigation of a significant current or recent situation affecting or involving some facet of environmental quality. Study will be conducted by a team of students and will result in a comprehensive position paper which integrates the pertinent social, political, and economic considerations in the case with the technical aspects.

ESE 881   SPECIAL PROBLEMS
1–4 cr. F, S, SS

Problems selected to meet interests and experience of student and instructor.

ESE 883   SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING
1–4 cr.

A comprehensive study of a topic in environmental engineering not covered in another course. Topics will vary to keep pace with current developments. May be taken concurrently with ESE 884 which (if offered) would be a different topic.

ESE 884   SELECTED TOPICS IN ENVIRONMENTAL ENGINEERING
1–4 cr.

A comprehensive study of a topic in environmental engineering not covered in another course. Topics will vary to keep pace with current developments. May be taken concurrently with ESE 883 which (if offered) would be a different topic.

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

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ESE 991   DOCTORAL DISSERTATION RESEARCH
             Credit to be arranged.

FLUID MECHANICS

The courses listed are offered by the faculties of the Departments of Chemical Engineering, Engineering Mechanics, and Mechanical Engineering for students majoring in those departments who desire to minor in fluid mechanics. This integrated sequence provides the opportunity for in-depth penetration of this study area as well as breadth of application to such diverse fields of technology as propulsion systems, water distribution systems, chemical systems, biological systems, and air and water pollution.

FM 801*   FOUNDATION OF FLUID MECHANICS
            3 cr. (3 and 0) F
Derivations of basic equations for multi-dimensional flow fields; analytical techniques for solving laminar inviscid flows; theories of similitude. **Prerequisites:** Graduate standing and permission of instructor.

FM 811*   EXPERIMENTAL FLUID MECHANICS
            3 cr. (2 and 3)
Techniques and fundamental principles in measuring fluid properties, velocity, pressure, temperature and methods of flow visualization. Details of instrumentations introduced in lab. **Prerequisite:** FM 801.

FM 812   THEORY OF INCOMPRESSIBLE IDEAL FLOW
            3 cr. (3 and 0) S
Analytical treatment of inviscid fluid flow; superposition of flows, distributing singularities, conformal mapping and non-steady flow problems. **Prerequisite:** FM 801.

FM 814*   TURBULENT BOUNDARY LAYER
            3 cr. (3 and 0) S
Semi-empirical theories on Reynolds stress terms; analytical methods of solving turbulent boundary layer momentum and energy equations for flows with pressure gradient and/or heat transfer; theories pertinent to experimental techniques used for turbulent boundary layer study. **Prerequisite:** FM 801.

FM 815   NUMERICAL METHODS IN FLUID MECHANICS
            3 cr. (3 and 0) F
Stability and convergence; numerical solution techniques; applications from literature ranging from hydrodynamic shocks to flow in ocean or lakes, depending on interest of class; finite element techniques; solution of efficiency; generalized coordinate systems; coordinate extensions. **Prerequisite:** FM 801.

FM 816*   FLOW IN OPEN CHANNELS
            3 cr. (3 and 0) S
Free surface flow problems including applications of digital computer, concepts of boundary layer theory, uniform and varied flow, hydraulic jump, design

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*These courses will be offered on a fixed schedule. All other courses are offered as needed.

criteria for prismatic channels and transitions, some applications of unsteady flow. **Prerequisites**: Graduate standing and permission of instructor.

FM 817*   NON-NEWTONIAN FLOW
              3 cr. (3 and 0) S
      Rheology, experimental classification, and viscometry of non-Newtonian fluids such as polymer melts and solutions; design procedures for flow, mixing and heat transfer of non-Newtonian fluids. **Prerequisites**: Graduate standing and permission of instructor.

MATERIALS ENGINEERING

G. C. Robinson, Head, Department of Ceramic Engineering

Courses are offered leading to the Master of Science degree.

Students with a baccalaureate degree in engineering or science may be accepted. This is a multidisciplinary program in which the relationship between the structures and the properties of materials is emphasized to provide an understanding of material behaviors in a variety of applications.

To accomplish this understanding, the student is exposed to learning experiences in the fields of chemistry, engineering, mathematics and physics in order to comprehend and be able to predict the properties and behaviors of ceramics, metals and polymers. The student may select areas of concentration in either materials science or the industrial application of materials. Further study in specific areas of interest to the student is accomplished by taking courses associated with his/her research which, in turn, will culminate in a master's thesis.

MATE 605   PHYSICAL METALLURGY
             3 cr. (3 and 0)

MATE 650   SPECIAL TOPICS IN MATERIALS ENGINEERING
             1–4 cr.

MATE 651   CORROSION OF MATERIALS
             3 cr. (2 and 3)

MATE 661   ELEMENTS OF METALLURGY
             3 cr. (2 and 3)

MATE 662   HEAT TREATMENT OF STEELS
             3 cr. (2 and 3)

MATE 663   METALLURGY OF WELDING AND NON-DESTRUCTIVE TESTING
             3 cr. (2 and 3)

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*These courses will be offered on a fixed schedule. All other courses are offered as needed.

MATE 664	INDUSTRIAL CORROSION OF METALS
	3 cr. (2 and 3)

MATE 665	INTRODUCTION TO PLASTICS
	3 cr. (3 and 0)

MATE 800	SEMINAR IN MATERIALS RESEARCH
	1 cr. (1 and 0)

Presentation and discussion of special topics and original research in materials engineering. Required of all materials engineering graduate students each semester in residence; credit may be earned for more than one semester.

MATE 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 as well as non-metals; ductile and brittle fractures; fatigue, creep and stress corrosion cracking in metals. **Prerequisite:** MATE 304 or equivalent.

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

MECHANICAL ENGINEERING

E. H. Bishop, Head, Department of Mechanical Engineering

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

Students will be accepted with backgrounds in physics, applied mathematics, or any branch of engineering. Programs may be selected with concentrations in applied mechanics, automatic controls, dynamic systems analysis, energy conversion, mechanical engineering design, fluid mechanics, heat transfer, and thermodynamics.

ME 601	STRENGTH ANALYSIS AND DESIGN OF MACHINES
	3 cr. (3 and 0)

ME 602	INNOVATIVE DESIGN III
	3 cr. (2 and 3)

ME 604	CONTROL SYSTEM COMPONENTS
	3 cr. (2 and 2)

ME 607	APPLIED HEAT TRANSFER
	3 cr. (3 and 0)

ME 608	NUMERICAL METHODS IN ENGINEERING ANALYSIS
	3 cr. (3 and 0)

ME 611	GAS POWER SYSTEMS
	3 cr. (3 and 0)

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ME 619   POWER STATION ENGINEERING
3 cr. (3 and 0)

ME 622   PRINCIPLES OF TURBOMACHINERY
3 cr. (3 and 0)

ME 625   KINEMATICS: KINEMATIC DESIGN OF MACHINES
3 cr. (3 and 0)

ME 650   VENTILATION DESIGN AND OPERATION
3 cr. (2 and 3)

ME 651   CONTROL OF PHYSICAL STRESSES
3 cr. (3 and 0)

ME 652   SAFETY ENGINEERING
3 cr. (2 and 3)

ME 807   MECHANICAL SYSTEMS I
3 cr. (3 and 0)

Integration and application of selected topics from strength of materials, elasticity, kinematics and dynamics; nature of stress and strain in engineering materials, computer synthesis and analysis of planar linkages, rigid body dynamics applied to engineering systems, and energy techniques. **Prerequisites:** EM 304 and ME 405.

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ME 808   MECHANICAL SYSTEMS II
3 cr. (3 and 0)

Continuation of ME 807; application of equations of elasticity, dynamics of distributed systems, three-dimensional kinematics and Lagrange's equations. Two design projects required.

ME 809   THERMAL SYSTEMS
3 cr. (3 and 0)

Derivation and application of equations of fluid mechanics and heat transfer to analysis and design of heat transfer and fluid systems; development of ability to identify and analyze primary problem areas affecting performance of mechanical engineering thermal and fluid systems.

ME 810   MACROSCOPIC THERMODYNAMICS
3 cr. (3 and 0)

First, second and third laws of thermodynamics with engineering applications; thermodynamic property relations; chemical equilibrium. Required for thermal science majors. **Prerequisite:** ME 312 or equivalent.

ME 815   KINETIC THEORY OF GASES
3 cr. (3 and 0)

Distribution functions and derivation of perfect gas law; mean-free path methods and unified treatment of transport phenomena and properties: viscosity, heat conduction, specific heats; flow phenomena: free-molecule flow, Poiseuille flow, and flow in tubes at low pressure; mutual and thermal diffusion; Maxwell-Boltzmann distribution law. **Prerequisite:** ME 810.

ME 816   ENERGY CONVERSION
3 cr. (3 and 0)
Theory and technology associated with conversion of chemical and nuclear energy into more useful forms; application to electric power generation using fossil fuel boilers, boiling water reactors, and pressurized water reactors as heat sources; environmental and safety aspects of each system. **Prerequisite:** ME 411/611 or equivalent.

ME 830   CONDUCTIVE HEAT TRANSFER
3 cr. (3 and 0)
Physical properties; steady conduction in one- and two-dimensional systems; conduction under periodic and transient conditions; conduction in systems with moving heat sources; numerical methods of computation. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

ME 831   CONVECTIVE HEAT TRANSFER
3 cr. (3 and 0)
Derivation of continuity, momentum and energy equations for boundary layer flow; solutions for confined and external flow regimes in laminar and turbulent flow. **Prerequisites:** ME 304 or equivalent, and MATH 208.

ME 832   RADIATIVE HEAT TRANSFER
3 cr. (3 and 0)
Radiation properties; enclosure theory; radiation exchange between solid bodies; radiation exchange in the presence of absorbing, transmitting and emitting media; combined radiation, conduction and convection exchange. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

ME 833   HEAT TRANSFER WITH CHANGE OF PHASE
3 cr. (3 and 0)
Nucleate boiling in a pool, film boiling in a pool, forced nucleate boiling, forced film boiling, effect of impurities on boiling phenomena, dropwise condensation, filmwise condensation, effect of noncondensable gases on condensation, boiling and condensing processes in systems. **Prerequisites:** ME 304 or equivalent, and permission of instructor.

ME 842   ADVANCED MECHANICAL ENGINEERING DESIGN I
3 cr. (3 and 0)
Optimization techniques, decision theory, probabilistic approaches to design, and principles of mechanical sciences applied to analysis and design of machines, devices and engineering systems. **Prerequisite:** ME 401 or permission of instructor.

ME 843   ADVANCED MECHANICAL ENGINEERING DESIGN II
3 cr. (3 and 0)
Continuation of ME 842. **Prerequisite:** ME 842.

ME 845   VIBRATION OF CONTINUOUS MEDIA
3 cr. (3 and 0)
Fundamental principles of generation, propagation, absorption, reflection and scattering of vibrational waves in solids and fluids; free and forced oscillation of

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flexible strings, bars, membranes, and plates; theory of wave motion in liquids and gases. **Prerequisite:** Permission of instructor.

ME 890   ENGINEERING PROJECT
                1–3 cr. (0 and 3–9)
      Comprehensive analytical and/or experimental treatment of phenomena of current interest in mechanical engineering emphasizing modern technological problems. Can 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 894   SEMINAR
                1 cr. (1 and 0)
      Selected original research papers and literature ranging from mathematical-theoretical to experimental-applied. Published papers presented by students or invited lecturers form the basis for discussions of new developments and/or applications.

ME 930   ADVANCED TOPICS IN HEAT TRANSFER
                1–6 cr. (1–6 and 0)
      Topics not covered in other courses. May be repeated for maximum of six credits.

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ME 991   DOCTORAL DISSERTATION RESEARCH
                Credit to be arranged.

Descriptions for the following 800-level interdepartmental courses are listed under Automatic Control and Fluid Mechanics.

AC 610   INTRODUCTION TO DIGITAL CONTROL
                3 cr. (3 and 0)

AC 810   MODELING AND CONTROL OF ENGINEERING SYSTEMS
                3 cr. (3 and 0)

AC 811   MODERN CONTROL THEORY
                3 cr. (3 and 0)

AC 815   NONLINEAR CONTROLS
                3 cr. (3 and 0)

AC 820   DIGITAL CONTROL I
                3 cr. (3 and 0)

AC 821   DIGITAL CONTROL II
                3 cr. (3 and 0)

AC 910	ADAPTIVE AND OPTIMAL CONTROL
	3 cr. (3 and 0)
FM 801	FOUNDATION OF FLUID MECHANICS
	3 cr. (3 and 0) F
FM 811	EXPERIMENTAL FLUID MECHANICS
	3 cr. (2 and 3) F
FM 812	THEORY OF INCOMPRESSIBLE IDEAL FLOW
	3 cr. (3 and 0) S
FM 814	TURBULENT BOUNDARY LAYER
	3 cr. (3 and 0) S
FM 815	NUMERICAL METHODS IN FLUID MECHANICS
	3 cr. (3 and 0) F
FM 816	FLOW IN OPEN CHANNELS
	3 cr. (3 and 0) S
FM 817	NON-NEWTONIAN FLOW
	3 cr. (3 and 0) S

SYSTEMS ENGINEERING

E. L. Thomas, Jr., Program Coordinator

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

Systems engineering is an interdisciplinary field of study designed to accommodate students who wish to study engineering subjects and concepts that go beyond those normally found in the traditional engineering programs. Systems engineering encompasses efforts to transform an operational need into a description of system requirements and a preferred system design. This system analysis and synthesis effort includes the logistics engineering needed to integrate operations and support considerations into the mainstream engineering design process to insure development and production of a supportable and cost-effective system. It also includes the management and control efforts for technical planning, monitoring, measuring, evaluating and directing the project.

Systems engineering uses the methods and tools of systems theory, operations research, statistics, economic analysis, optimization, programming, modeling and simulation. While the necessary theory is taught, primary emphasis is placed on practical applications of methods and tools of real world problem solving.

A student has flexibility in designing a plan of study to meet specific degree objectives. The program can provide a balanced study across engineering, business, social sciences and computer technology. Con-

centration may be in an area such as traffic and transportation, computer systems design, communications and information systems, control systems, optimization of environmental systems, construction management systems, health care delivery systems, energy production/utilization systems, signal processing, and industrial system operations.

Students with a bachelor's degree in engineering or sciences may be accepted, while those with other backgrounds may be accepted but will be required to make up certain prerequisite courses before formal entrance into the program.

SE 650   INTRODUCTION TO SYSTEMS ENGINEERING
          3 cr. (3 and 0)

SE 652   RELIABILITY ENGINEERING
          3 cr. (3 and 0)

SE 680   INTRODUCTION TO METHODS OF OPERATIONS RESEARCH
          3 cr. (3 and 0)

SE 681   LINEAR METHODS OF OPERATIONS RESEARCH AND
          APPLICATIONS
          3 cr. (3 and 0)

SE 684   ENGINEERING ECONOMIC ANALYSIS
          3 cr. (3 and 0)

SE 686   WORK FLOW SYSTEMS AND CONTROL
          3 cr. (3 and 0)

SE 803   ENGINEERING OPTIMIZATION AND APPLICATIONS
          3 cr. (3 and 0)
          Nonlinear programming, search methods, dynamic programming and discrete optimization; quadratic programming, linearization, direct search, gradient methods, penalty functions, recursive optimization and implicit enumeration. **Prerequisite:** Permission of instructor.

SE 804   ADVANCED PHYSICAL SYSTEM ANALYSIS
          3 cr. (3 and 0) S
          Complex problem formulation using component terminal equations and linear graph theory; instrumentation and measurement processes for multi-terminal subsystems; nonlinear systems and state model formulation; solutions to mixed systems of algebraic and differential equations.

SE 805   ANALYTICAL METHODS OF SYSTEMS ANALYSIS
          3 cr. (3 and 0)
          Application of selected mathematical topics from operations research and systems engineering; linear algebra, graph theory, topology, calculus of finite differences and operational calculus. **Prerequisite:** Permission of instructor.

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SE 807   DISCRETE SYSTEMS SIMULATION
3 cr. (3 and 0)

Discrete and Monte Carlo simulation used to model and study stochastic operational systems; simulation languages GPSS V and GASP IV. **Prerequisite:** Permission of instructor.

SE 808   CONTINUOUS SYSTEMS SIMULATION
3 cr. (3 and 0)

Continuous systems simulation and feedback type simulation models and their use in analyzing engineering, business, governmental and military systems; concept of industrial dynamics; simulation languages GASP IV and DYNAMO. **Prerequisite:** Permission of instructor.

SE 860   DYNAMIC PROGRAMMING
3 cr. (3 and 0)

Theory and methodology of dynamic programming; calculus of variations, Bellman's principle of optimality, multistage optimization countercurrent flow, adaptive control. **Prerequisite:** Permission of instructor.

SE 861   NONLINEAR PROGRAMMING AND METHODS OF SEARCH
3 cr. (3 and 0)

Methods for nonlinear, continuous problems; classical optimization, separable programming, quadratic programming, geometric programming, gradient methods, feasible directions and accelerating adaptive direct search methods. **Prerequisite:** SE 480/680 or equivalent, or permission of instructor.

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SE 880   ADVANCED METHODS OF OPERATIONS RESEARCH
3 cr. (3 and 0)

Application and theory of selected topics in discrete optimization; linear integer programming, network analysis, implicit enumeration, surrogate and aggregate constraints. **Prerequisite:** Permission of instructor.

SE 885   DESIGN AND ANALYSIS OF SIMULATION MODELS
3 cr. (3 and 0)

Design and validation of operations research-type simulation models; analysis of statistical properties of input data of these models. **Prerequisites:** SE 809 and EX ST 805 or equivalent.

SE 886   OPERATIONS RESEARCH IN PRODUCTION CONTROL I
3 cr. (3 and 0)

Latest techniques in scientific inventory management, scheduling, and forecasting; operations research, statistics, computer methods, and case studies.

SE 887   OPERATIONS RESEARCH IN PRODUCTION CONTROL II
3 cr. (3 and 0) S
Continuation of SE 886. **Prerequisite:** SE 886.

SE 888   APPLIED QUEUING THEORY AND MARKOV PROGRAMMING
3 cr. (3 and 0)

Analysis of single and multiple channel queues using mathematical queuing theory; Markov programming including rewards and value and policy iteration techniques.

SE 890   SPECIAL TOPICS IN SYSTEMS ENGINEERING
              1–6 cr. (1–6 and 0)
Topics not covered in other courses; studies of current literature and results of recent and current research. Topics vary from year to year in keeping with developments; can be repeated for additional credit.

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

SE 895   SYSTEMS ENGINEERING SEMINAR
              1 cr. (1 and 0)
Specific industrial and governmental applications of systems engineering throughout life cycle of system. Students present and lead discussions on current research and advanced techniques in systems engineering. **Prerequisite**: Permission of instructor.

SE 991   DOCTORAL DISSERTATION RESEARCH
              Credit to be arranged.

WATER RESOURCES ENGINEERING

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A. G. Law, Program Coordinator

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

Water resources engineering is an interdisciplinary program. Areas of concentration are water resources planning and management, surface water systems, ocean and coastal resources, and water-soil transport systems. The program provides training to meet modern water resources challenges encountered in careers with industry, government agencies, and consulting firms.

Individual programs are designed to enhance and build upon the student's previous engineering or science background. Major and minor work may be selected from the offerings of a wide variety of departments in addition to those in the water resources engineering course listing. Both thesis and non-thesis options are available for the master of science degree.

WRE 650   WATER RESOURCES ENGINEERING
              3 cr. (3 and 0)

WRE 660   PHYSICAL OCEANOGRAPHY
              3 cr. (3 and 0)

WRE 661   OCEANOGRAPHICAL ENGINEERING
              3 cr. (3 and 0)

WRE 865   HYDROLOGY I
              3 cr. (3 and 0)
Hydrologic cycle as a hydrologic system; deterministic hydrology; all aspects of physical hydrology emphasizing balanced approach to ground water hydrology and surface water hydrology; meteorology, infiltration, soil moisture, and evapotranspiration; probability analysis and partial system synthesis by unit hydrograph techniques. **Prerequisite:** Permission of instructor.

WRE 866   HYDROLOGY II
              3 cr. (3 and 0)
Continuation of WRE 865; deterministic hydrology emphasizing parametric hydrology, system synthesis and correlation analysis; statistical hydrology, time series analysis and stochastic hydrology. **Prerequisite:** WRE 865 or permission of instructor.

WRE 870   STREAM AND ESTUARINE ANALYSIS
              3 cr. (3 and 0)
Physical, chemical, and biological processes and relationships which exist in streams and estuaries; estuarine environment, free-flowing streams, mechanisms which describe transport of conservative and non-conservative materials through estuarine system; estuary as a resource and techniques for its management. **Prerequisite:** EM 320 or permission of instructor.

WRE 871   COASTAL HYDRODYNAMICS   **143**
              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.

WRE 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.

WRE 875   WATER RESOURCES PLANNING
              3 cr. (3 and 0)
Water resources planning emphasizing river basin and regional aspects; purposes and objectives of water resources development, historical review of water resources development in United States, changing emphasis over time, current practice and guidelines as well as new approaches and techniques, public and private sector involvement in water resources planning and development, formulation of alternative plans and their analysis, public participation and resolution of conflicts, institutional and social dimensions of water resources planning and plan implementation, water quality and water quantity and their interactions. **Prerequisite:** Permission of instructor.

WRE 876   WATER RESOURCES SYSTEMS
3 cr. (3 and 0)

Water resources systems area; application of current operations research and systems engineering techniques and their use in analysis, evaluation, design, operation and management of water resources systems; water quality systems, hydrologic systems, integrated multipurpose systems including reservoirs, regional environmental control systems, power-generating facilities, industrial water supply and pollution abatement systems. **Prerequisite:** Permission of instructor.

WRE 881   SPECIAL PROBLEMS IN WATER RESOURCES ENGINEERING
1–4 cr. (1–4 and 0)

Individual directed study in some phase of water resources engineering emphasizing water quality, water quantity, social-economic-political aspects. May be taken more than one semester.

WRE 883   SELECTED TOPICS IN WATER RESOURCES ENGINEERING
1–3 cr. (1–3 and 0)

Topics not covered in other courses; current developments in water resources. Topics vary to keep pace with recent developments and to satisfy emerging needs in professional practice; may be taken more than one semester.

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

FORESTRY
RECREATION AND PARK ADMINISTRATION

COLLEGE OF FOREST AND RECREATION RESOURCES
W. H. D. McGregor, Dean

The College of Forest and Recreation Resources awards the Master of Science degree in forestry. In addition, the college awards two professional degrees, the Master of Forestry and the Master of Recreation and Park Administration.

The College of Forest and Recreation Resources is concerned with the management, use, and stewardship of our forest resources and with improving the quality of life through rewarding use of leisure. These two general areas of study offer broad opportunities in the management of our forest and recreation resources for their maximum service to present and future generations.

FORESTRY

R. M. Allen, Head, Department of Forestry

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

Enrollment in the Master of Forestry and Master of Science programs is open to students having baccalaureate degrees in forestry, wood utilization and disciplines related to these fields. The candidate may be required to satisfy undergraduate deficiencies before being admitted to full status.

A formal thesis is required for the M.S. degree. For the M. For., a non-thesis degree, a minimum of 36 semester hours of graduate course work must be completed with at least 18 of the required hours from courses numbered 700 or above.

FOR 601   LOGGING AND MILLING
           3 cr. (2 and 3) S

FOR 602   FOREST MENSURATION
           3 cr. (2 and 3) S

FOR 603   FOREST SOILS SEMINAR
           1 cr. (1 and 0) S

FOR 604   FOREST ECONOMICS
           3 cr. (3 and 0) S

FOR 606   WOOD AND WOOD FIBER IDENTIFICATION
           2 cr. (1 and 3) S

FOR 608   AERIAL PHOTOGRAPHS IN FORESTRY
           3 cr. (2 and 3) F

FOR 609   MULTIPLE-USE FORESTRY
      3 cr. (3 and 0) F

FOR 610   SILVICULTURE
      4 cr. (3 and 3) S

FOR 611   HARVESTING FOREST PRODUCTS
      3 cr. (2 and 3) S

FOR 612   FOREST PROTECTION
      2 cr. (2 and 0) S

FOR 614   MANAGEMENT PLANS
      1 cr. (0 and 3) S

FOR 616   FOREST POLICY AND ADMINISTRATION
      2 cr. (2 and 0) S

FOR 617   FOREST MANAGEMENT AND REGULATION
      4 cr. (3 and 3) F

FOR 618   FOREST VALUATION
      3 cr. (3 and 0) S

FOR 620   FOREST PRODUCTS
      2 cr. (2 and 0) F

FOR 621   WOOD PROPERTIES I
      3 cr. (2 and 3) F

FOR 622   WOOD PROPERTIES II
      3 cr. (2 and 3) S

FOR 624   FOREST GENETICS AND TREE BREEDING
      3 cr. (3 and 0) S

FOR 629   WOOD DESIGN
      3 cr. (2 and 3) F

FOR 631   RECREATION RESOURCE PLANNING IN FOREST MANAGEMENT
      3 cr. (3 and 0) F

FOR 801   DATA PROCESSING IN FORESTRY PROBLEMS
      3 cr. (2 and 3) F
Illustration, analysis and discussion of specific approaches used in forestry problems for handling, arranging and analyzing large volumes of field data and for presenting in concise, meaningful form.

FOR 802   ADVANCED MENSURATION
      3 cr. (2 and 3) S (even numbered years)
Continuation of FOR 602 emphasizing specialized sampling techniques and statistical methods often required only in forestry, compilation of timber volume

tables, and forest survey problems. **Prerequisites:** EX ST 301, FOR 302/602 or permission of instructor.

FOR 803   PHOTO-INTERPRETATION
                 3 cr. (2 and 3) S (odd numbered years)
     Current methodology in aerial photo interpretation techniques, flight plans, taking and processing aerial photographs, and using aerial photographs in timber inventories and cruising. **Prerequisites:** EX ST 301, FOR 308/608 or permission of instructor.

FOR 804   ADVANCED FOREST ECONOMICS
                 3 cr. (2 and 3) S (odd numbered years)
     Examination, discussion and application of economic principles to forestry problems in use of land, labor and capital; use of theory to problems of resource allocation and efficiency in forest management. **Prerequisites:** FOR 304/604 and 418/618, or permission of instructor.

FOR 807   SPECIAL PROBLEMS IN FORESTRY
                 Credit to be arranged. F, S, SS
     Special problems in forestry research methods that do not directly pertain to the candidate's thesis.

FOR 808   SEMINAR
                 1 cr. (1 and 0) F, S
     Discussions of research and current developments in forestry. Students and staff participate; may be taken up to two semesters for credit; graded on pass–fail basis.

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

RECREATION AND PARK ADMINISTRATION

H. Brantley, Head, Department of Recreation and Park Administration

Courses are offered leading to the Master of Recreation and Park Administration degree.

This program is designed for persons who wish to increase their competence in providing leisure services. Flexibility permits individual development in professional interest areas of administration, resource management, comprehensive planning, therapeutics or interpretation.

A minimum of 30 semester hours is required. Each candidate completes an original, independent project to meet degree requirements.

Applicants whose academic records do not meet full status admission requirements may be considered if successful work experience in a recreation position can be demonstrated. Students from non-recreation disciplines are required to develop background knowledge of recreation through undergraduate course work.

RPA 600   SUPERVISION OF RECREATION PERSONNEL, PATTERNS, AND
      PROCESSES
      3 cr. (3 and 0)

RPA 602   RECREATION ADMINISTRATION
      3 cr. (3 and 0)

RPA 607   METHODS OF ENVIRONMENTAL INTERPRETATION
      3 cr. (2 and 3)

RPA 611   THERAPEUTIC RECREATION FOR SELECTED POPULATIONS
      3 cr. (3 and 0)

RPA 612   THERAPEUTIC RECREATION AND MENTAL HEALTH
      3 cr. (3 and 0)

RPA 613   THERAPEUTIC RECREATION FOR PHYSICALLY DISABLED
      3 cr. (3 and 0)

RPA 701   PHILOSOPHICAL FOUNDATIONS OF RECREATION AND PARK
      ADMINISTRATION
      3 cr. (3 and 0)
    Current theories and philosophies in recreation as it is influenced by and has
influence on leisure and man's rapidly changing environment in America. Student
develops own professional philosophy of recreation and leisure for world of to-
morrow.

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RPA 702   GROUP PROCESSES IN LEISURE SERVICE
      3 cr. (3 and 0)
    Improvement in human relations' skills and knowledge of interpersonal needs
and problems of individuals and groups; student gains understanding of how others
affect him and how he affects others and becomes more effective professional
recreator and park administrator, supervisor, interpreter and educator.

RPA 703   SEMINAR IN RECREATION AND PARK ADMINISTRATION
      3 cr. (3 and 0)
    Case problems relating to administration of a park and recreation agency.

RPA 704   COMPREHENSIVE RECREATION PLANNING
      3 cr. (3 and 0)
    Comprehensive recreation planning theories and practices at federal, state
and local level. Selected case study projects are undertaken in cooperation with
other university departments and governmental agencies.

RPA 705   RECREATIONAL ASPECTS OF WATER RESOURCES
      3 cr. (3 and 0)
    Relationship of recreation to water; history and legislative background; gov-
ernmental involvement; current research related to planning, pollution, and de-
mand. Future policy decisions are considered.

RPA 706   URBAN RECREATION ANALYSIS
          3 cr. (3 and 0)
     Principles of providing recreation services in urban areas.

RPA 707   PRINCIPLES OF ENVIRONMENTAL INTERPRETATION
          3 cr. (3 and 0)
     Methods of providing learning experiences in out-of-doors focusing on meaning, scope and values of interpretation.

RPA 708   SELECTED TOPICS
          3 cr. (3 and 0)
     Problems of recreation and leisure through a directed reading program and seminar. Student also studies problem areas of own specialization.

RPA 709   SPECIAL PROBLEMS
          1–3 cr. (1–3 and 0)
     Directed, individual comprehensive investigation of special problem to utilize knowledge gained in formal courses, to provide experience and training in research, and to prepare for professional goals. Topics vary in areas of interest or experience of student and instructor. Report of findings required.

RPA 710   CURRENT ISSUES IN RECREATION
          1 cr. (1 and 0)
     Current topics seminar emphasizing student preparation, organization and communication of material and ideas not covered in formal courses. May be repeated for a maximum of three semester hours of credit.

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ACCOUNTING
BUSINESS ADMINISTRATION
ECONOMICS
ENGINEERING MANAGEMENT
MANAGEMENT
MANAGEMENT SCIENCE
TEXTILE AND POLYMER SCIENCE
TEXTILE CHEMISTRY
TEXTILE SCIENCE

COLLEGE OF INDUSTRIAL MANAGEMENT AND TEXTILE SCIENCE
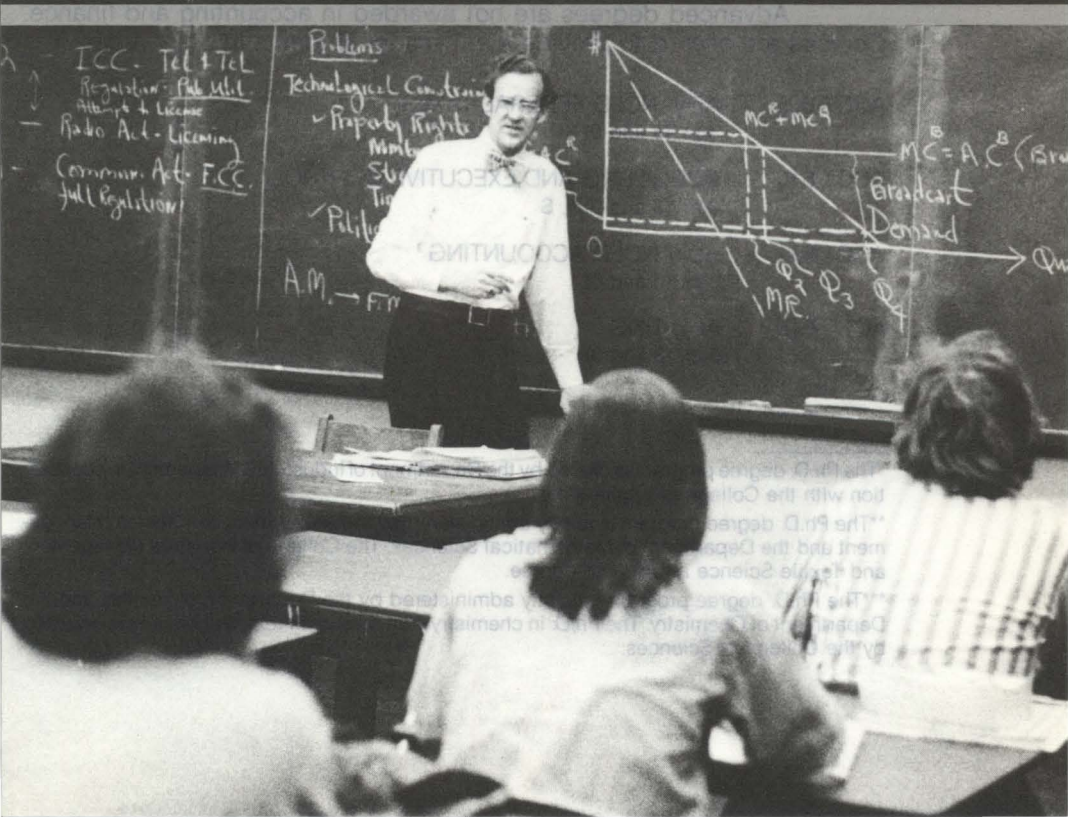
COLLEGE OF INDUSTRIAL MANAGEMENT AND TEXTILE SCIENCE

W. D. Trevillian, Dean

The College of Industrial Management and Textile Science awards advanced degrees in the following areas of study:

Economics	Textile and Polymer Science
Engineering Management*	Textile Chemistry***
Management	Textile Science
Management Science**	

Courses are also offered in accounting to provide electives for students in other areas.

In addition, the Department of Industrial Management jointly offers the Master of Business Administration degree (M.B.A.) with Furman University. Courses are taught on the Furman campus by faculty from both institutions.

Graduate programs offered by the College of Industrial Management and Textile Science are designed to equip students for professional careers in business, industry, government, and education.

ACCOUNTING

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C. C. Davis, Head, Department of Accounting and Finance

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

ACCT 605   ADVANCED FEDERAL TAXES
3 cr. (3 and 0)

ACCT 610   BUDGETING AND EXECUTIVE CONTROL
3 cr. (3 and 0) F, S

ACCT 611   ADVANCED ACCOUNTING
3 cr. (3 and 0)

ACCT 615   AUDITING
3 cr. (3 and 0)

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*The Ph.D. degree program is offered by the Department of Industrial Management in cooperation with the College of Engineering.

**The Ph.D. degree program is jointly administered by the Department of Industrial Management and the Department of Mathematical Sciences. The College of Industrial Management and Textile Science awards the degree.

***The Ph.D. degree program is jointly administered by the Department of Textiles and the Department of Chemistry. The Ph.D. in chemistry with a major in textile chemistry is awarded by the College of Sciences.

ACCT 616   AUDITING PRACTICE AND PROCEDURE
3 cr. (3 and 0)

FIN 602   CAPITAL BUDGETING
3 cr. (3 and 0)

ECONOMICS

T. B. Yandle, Head, Department of Economics

Courses are offered leading to the Master of Arts degree.

Applicants to this curriculum must have completed at least 12 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 is also required. When necessary, the economic theory, mathematics, and statistics courses may be taken at Clemson before enrolling in or during the early part of the program.

The graduate program will include one course in econometrics or mathematical economics, and one course in statistics as part of the major.

Candidates must also have a reading knowledge of one modern foreign language or the successful completion of a course in computer science equivalent to COMP SC 205. Additional information about this requirement may be found in the section on language requirements for the master's degree.

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ECON 603   DEVELOPMENT OF ECONOMIC THOUGHT
3 cr. (3 and 0)

ECON 604   COMPARATIVE ECONOMIC SYSTEMS
3 cr. (3 and 0)

ECON 607   NATIONAL INCOME AND EMPLOYMENT ANALYSIS
3 cr. (3 and 0) F, S

ECON 608   ARBITRATION
3 cr. (3 and 0)

ECON 610   ECONOMIC DEVELOPMENT
3 cr. (3 and 0)

ECON 612   INTERNATIONAL TRADE
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 650   ECONOMICS OF THE CONSUMER AND THE FIRM IN A MARKET
            SYSTEM
            3 cr. (3 and 0)

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 803   ADVANCED ECONOMIC CONCEPTS AND APPLICATIONS II
            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 806   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. **Pre-
requisites:** ECON 314, ECON 802 or permission of instructor.

ECON 808   SEMINAR IN 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 po-
tential role of public employee unions in decision-making process.

ECON 811   SEMINAR IN LABOR ECONOMICS
            3 cr. (3 and 0)
Wage and employment theory, labor markets, labor history and current prob-
lems in labor and manpower economics.

ECON 813   SEMINAR IN COMMUNITY GOODS AND 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 814   WELFARE ECONOMICS
            3 cr. (3 and 0)
Effect of economic activity on welfare of society; ways of measuring welfare;
political aspects of welfare economics; effects stemming from particular market
imperfections; how taxes, subsidies, and prices can be used to maximize welfare.

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ECON 821   ECONOMIC THEORY I
        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 822   ECONOMIC THEORY II
        3 cr. (3 and 0) S
    Macroeconomic theory involving static and dynamic models and their use in analysis of economic problems and policies.

ECON 831   SEMINAR IN URBAN DEVELOPMENT ECONOMICS
        3 cr. (3 and 0)
    Economic analysis of development of urban areas within system of cities; central place theory and general equilibrium models of interregional economic activity emphasizing central place systems, spatial interaction, and stochastic processes; internal development of city focusing on housing and land use patterns, transportation, and urban form.

ECON 891   MASTER'S 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.

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ENGINEERING MANAGEMENT

B. J. Todd, Head, Department of Industrial Management

Courses are offered leading to the Doctor of Philosophy degree.

This program is offered in cooperation with the Department of Industrial Management and the College of Engineering. It is designed to develop a high-level manager/scholar who can apply the most advanced concepts and methods of management science, administrative theory and research techniques to engineering and scientific projects and enterprises.

Entering students must have completed, or must schedule during their first semester, basic courses in accounting, calculus, economics and statistics.

In addition to a management core, the program includes supporting courses in economics and statistical theory. The elective policy allows a student to select an engineering option (12 credits) from the following areas: environmental planning and management, water resources planning and management, food and agricultural management systems, transportation, industrial systems, engineering analysis systems, computer application and simulation, computer organization and system structure, programming systems, computing systems, and energy transmission and distribution.

All candidates for the Ph.D. degree in engineering management are required to take responsibility for and instruct an undergraduate course in either management, economics, engineering or mathematics.

EMGT 910   SEMINAR IN OPERATIONS MANAGEMENT
1–3 cr. (1–3 and 0)
New methodological developments, both analytical and philosophical, in operations management; development of theory of management science; converting management theory to practice while considering behavioral and economic aspects of the problem. **Prerequisite:** Permission of instructor.

EMGT 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.

EMGT 912   SEMINAR IN FINANCIAL ANALYSIS
3 cr. (3 and 0)
Management of firm's financial affairs in attempt to develop an optimal capital structure. **Prerequisite:** Permission of instructor.

EMGT 913   MANAGEMENT SYSTEMS ANALYSIS
3 cr. (3 and 0)

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Design, construction, and analysis of stochastic simulation models for typical management decisions; design, input-output, variance reduction, applications, validation, implementation, optimum seeking techniques, designed experiments. Emphasis on effect of model results on managerial policy decisions. **Prerequisite:** COMP SC 205 or equivalent.

EMGT 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

MANAGEMENT

B. J. Todd, Head, Department of Industrial Management

Courses are offered leading to the Master of Science degree.

Requirements for this degree include a minimum of 31 semester hours of work beyond the bachelor's degree. All students take a core curriculum of 16 hours in the areas of quantitative economic analysis, corporate finance, managerial policy, operations management, human resource management and systems simulation. Electives and a minor area of study may be selected from the disciplines of management, economics, engineering and mathematics or statistics. Proficiency in computer programming and statistics is a department requirement.

A thesis or non-thesis option is allowed. For the non-thesis program, at least one formal paper or report of substantial content proving the student's ability to do original effective writing is required. This research and writing requirement carries one semester-hour credit. The formal paper must be approved by the student's major advisor.

The department also jointly administers the Master of Business Administration degree (M.B.A.) with the Department of Economics and Business of Furman University. Classes are held on the Furman campus in Greenville, South Carolina. The program is primarily for the industrial manager/engineer who is employed full time. Further information may be obtained by writing the Director, Clemson-Furman M.B.A. Program, Furman University, Greenville, SC 29613.

MGT 800   MANAGEMENT GAMING
              1 cr. (0 and 3)
     Introduction to management game literature and practical application of management games as educational adjuncts. Student participation required in a comprehensive, computerized management simulation game. **Prerequisite:** Permission of instructor.

MGT 801   QUANTITATIVE ECONOMIC ANALYSIS
              3 cr. (3 and 0)
     Mathematical formulation of economic theory as it applies to management decision making; analytical ideas, rigorous techniques of economic analysis. **Prerequisite:** IM 404/604 or permission of instructor.

MGT 802   FINANCE
              3 cr. (3 and 0) F
     Analysis of financial condition of business firms as means of recognizing current and long-term financial needs; selection of most feasible actions necessary to secure best possible financing under varied circumstances.

MGT 803   OPERATIONS MANAGEMENT
              3 cr. (3 and 0)
     Selected topics of advanced management science techniques including quality control, inventory analysis and control, economics of equipment replacement, macro and micro production planning and control, scheduling heuristics, network analysis and queuing, Koenig's theorem. **Prerequisite:** IM 402/602 or equivalent.

MGT 804   MANAGERIAL POLICY
              3 cr. (3 and 0) F
     Management policy making emphasizing determining objectives and developing sound policies for achieving them. Managerial Policy builds upon and integrates the other graduate courses; case method is used extensively; written and oral presentation required.

MGT 805   ADVANCED QUALITY CONTROL
              3 cr. (3 and 0)
     Statistical techniques employed in complex quality control schemes including recent developments in statistical quality control. **Prerequisite:** MATH 301 and IM 304, or equivalent.

MGT 810   MANAGEMENT AND THE LAW
              3 cr. (3 and 0)
     Legal environment in which managers operate; legal processes, institutions

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and machinery and those areas in the substantive law, including both private law and governmental regulations, that affect various managerial functions. **Prerequisite:** IM 322 or equivalent or permission of instructor.

MGT 811   ADVANCED MARKETING ANALYSIS
            3 cr. (3 and 0)
    Seminar in marketing approaching topic from viewpoint of highest level management and emphasizing decision making process in marketing. **Prerequisite:** IM 412/612 or permission of instructor.

MGT 812   TRANSPORTATION PLANNING AND POLICY
            3 cr. (3 and 0)
    Transportation policy and planning in U.S. from 1789 to present; various transport modes with respect to economic efficiency and environmental effect; feasibility and likely results of substituting one mode for another in context of integrated transportation system; future transportation systems and attendant problems and policies. **Prerequisite:** IM 405/605 or permission of instructor.

MGT 816   MANAGEMENT OF HUMAN RESOURCES
            3 cr. (3 and 0) S
    Advanced consideration of topics covered in IM 416/616. **Prerequisite:** IM 416/616 or permission of instructor.

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

H ADM 610   HOSPITAL INTERNSHIP
            3 cr. (0 and 9)

H ADM 800   THE FUNCTION AND ORGANIZATION OF HOSPITALS AND
            HEALTH SERVICES ADMINISTRATION
            3 cr. (3 and 0)
    Overview of organization, function, place in community and society of hospitals, individual health services and public health services. This course in conjunction with an administrative internship prepares student for major responsibilities in health service administration.

IM 601   QUANTITATIVE MARKETING ANALYSIS
            3 cr. (3 and 0) F, S

IM 602   OPERATIONS PLANNING AND CONTROL
            3 cr. (3 and 0)

IM 604   MANAGERIAL ECONOMICS
            3 cr. (3 and 0) F, S

IM 605   ECONOMICS OF TRANSPORTATION
            3 cr. (3 and 0) F

IM 606   THEORY OF INDUSTRIAL LOCATION
            3 cr. (3 and 0) S

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IM 608   WORK SIMPLIFICATION AND STANDARDIZATION
3 cr. (3 and 0) F, S

IM 612   MARKETING MANAGEMENT
3 cr. (3 and 0) S

IM 613   MARKETING COMMUNICATIONS
3 cr. (3 and 0)

IM 615   BUSINESS POLICY
3 cr. (3 and 0)

IM 616   MANAGEMENT OF HUMAN RESOURCES
3 cr. (3 and 0)

IM 617   LOGISTICS MANAGEMENT
3 cr. (3 and 0)

IM 618   MANAGEMENT INFORMATION SYSTEMS
3 cr. (3 and 0)

IM 619   MARKETING INFORMATION
3 cr. (3 and 0)

IM 620   MANAGEMENT OF DEFENSE EXPENDITURES
3 cr. (3 and 0) F

IM 621   CONSUMER BEHAVIOR
3 cr. (3 and 0)

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MANAGEMENT SCIENCE

C. V. Aucoin, Program Coordinator

Courses are offered leading to the Doctor of Philosophy degree.

The Departments of Industrial Management and Mathematical Sciences jointly offer and administer this program. Applicants should have a demonstrated aptitude for quantitative analysis and a primary interest in scientific management research and practice. It is for persons interested in using and developing the growing array of statistical and quantitative techniques being used in decision-making by the larger and more sophisticated American, foreign, and multinational firms. Such techniques include probability models; statistical analysis; linear, nonlinear, and dynamic programming; and decision theory.

The program structure blends courses in statistical theory, operations research, functional areas of management, econometrics, and economics to provide a balanced offering of advanced work in each field contributing to the degree.

MGT SC 611   INTRODUCTION TO ECONOMETRICS
3 cr. (3 and 0)

MGT SC 613   MANAGEMENT SCIENCE I
3 cr. (3 and 0) F

MGT SC 614   STATISTICAL ANALYSIS
3 cr. (3 and 0) F

MGT SC 806   REGIONAL SCIENCE METHODS
3 cr. (3 and 0)
Regional growth theory, regional development and planning; role of re-sources and migration in regional development, definition of regions, concept of planning regions, objectives and measures of regional development. **Prerequisite:** Permission of instructor.

MGT SC 807   ECONOMETRIC METHODS I
3 cr. (3 and 0)
Economic models expressed as systems of equations are presented. Prob-lems of identification, parameter estimation, measurement errors, and statistical inference are treated. Techniques of simulation, forecasting, model validation, and interpretation are discussed and illustrated.

MGT SC 808   ECONOMETRIC METHODS II
3 cr. (3 and 0) S
Continuation of MGT SC 807; current economic models and estimation procedures. **Prerequisite:** MGT SC 807.

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MGT SC 812   MANAGEMENT SCIENCE II
3 cr. (3 and 0)
Continuation of MGT SC 613; dynamic, integer, and nonlinear programming emphasizing applications of different types of mathematical programming to busi-ness and industrial problems. **Prerequisite:** MGT SC 413/613, or permission of instructor.

Descriptions for the following courses are found under Engineering Management and Management.

E MGT 913   MANAGEMENT SYSTEMS ANALYSIS
3 cr. (3 and 0)

MGT 801   QUANTITATIVE ECONOMIC ANALYSIS
3 cr. (3 and 0)

MGT 802   FINANCE
3 cr. (3 and 0) F

MGT 803   OPERATIONS MANAGEMENT
3 cr. (3 and 0)

MGT 816   MANAGEMENT OF HUMAN RESOURCES
3 cr. (3 and 0) S

The following courses are offered by the Department of Mathematical Sciences as part of the core curriculum for this program. Descriptions for the following 800- and 900-level courses are found under Mathematical Sciences in the College of Sciences.

MATH 602   THEORY OF PROBABILITY
3 cr. (3 and 0)

MATH 603   STATISTICAL INFERENCE
3 cr. (3 and 0)

MATH 652   LINEAR PROGRAMMING
3 cr. (3 and 0)

MATH 671   APPLIED STATISTICAL DECISION THEORY
3 cr. (3 and 0)

MATH 673   INTRODUCTION TO NONLINEAR OPTIMIZATION
3 cr. (3 and 0)

MATH 801   GENERAL LINEAR HYPOTHESIS I
3 cr. (3 and 0)

MATH 802   GENERAL LINEAR HYPOTHESIS II
3 cr. (3 and 0)

MATH 803   STOCHASTIC PROCESSES I
3 cr. (3 and 0)

MATH 805   DATA ANALYSIS
3 cr. (3 and 0)

MATH 809   TIME SERIES ANALYSIS, FORECASTING AND CONTROL
3 cr. (3 and 0)

MATH 811   NONLINEAR PROGRAMMING
3 cr. (3 and 0)

MATH 812   DYNAMIC PROGRAMMING
3 cr. (3 and 0)

MATH 813   ADVANCED LINEAR PROGRAMMING
3 cr. (3 and 0)

MATH 814   NETWORK FLOWS AND INTEGER PROGRAMMING
3 cr. (3 and 0)

MATH 817   STOCHASTIC MODELS IN OPERATIONS RESEARCH I
3 cr. (3 and 0)

MATH 818   STOCHASTIC MODELS IN OPERATIONS RESEARCH II
3 cr. (3 and 0)

MATH 867	SYSTEMS AND SOFTWARE
	3 cr. (3 and 0)
MATH 868	AN INTRODUCTION TO NUMERICAL PROCESSES
	3 cr. (3 and 0)
MATH 907	MULTIVARIATE ANALYSIS
	3 cr. (3 and 0)

TEXTILE AND POLYMER SCIENCE

E. A. Vaughn, Head, Department of Textiles

Courses are offered leading to the Doctor of Philosophy degree.

Qualification to pursue the degree is accomplished by obtaining a grade of A or B in at least three courses that are representative of the major areas of textile and polymer science or by standing special examinations in three courses. Courses currently considered representative are TEXT 821, Fiber Physics; TEXT 835, Textile Structures; TC 811, Polymer Science; TC 831, Physical Chemistry of Dyeing, or TC 831, Chemistry of Natural Polymers.

Other courses, tailored to the individual's objectives, will be selected by the student and his/her advisory committee. The student will normally take a minor in a selected field of science or engineering and will satisfy the requirements established by the minor department. This usually involves 12–24 credit hours in the minor field. A reading knowledge of one foreign lanaguage selected by the advisory committee is also required.

TEXTILE CHEMISTRY

E. A. Vaughn, Head, Department of Textiles

Courses are offered leading to the Master of Science degree. (The Doctor of Philosophy degree in chemistry with a major in textile chemistry is awarded by the Department of Chemistry in conjunction with the Department of Textiles.)

Applicants must have a bachelor's degree in textile chemistry, textile science, the physical or life sciences, engineering, or related disciplines and must have training in chemistry, physics and mathematics.

The student's major area of study normally will be in fiber chemistry, polymer chemistry, the chemistry of dyeing and/or finishing of fibers and textiles, or the chemistry of composite systems. The minor area of study usually will be in chemistry, physics, engineering, life sciences, or mathematics. Each candidate will conduct an original, independent, scientific investigation in his/her major area and will report the results and conclusions in a thesis.

TC 615   INTRODUCTION TO POLYMER SCIENCE AND ENGINEERING
3 cr. (3 and 0)

TC 616   CHEMICAL PREPARATION OF TEXTILES
3 cr. (2 and 3)

TC 657   DYEING AND FINISHING I
3 cr. (3 and 0)

TC 658   DYEING AND FINISHING II
3 cr. (3 and 0)

TC 659   DYEING AND FINISHING LABORATORY
1 cr. (0 and 3)

TC 675   CELLULOSE CHEMISTRY
2 cr. (2 and 0)

TC 811   POLYMER SCIENCE I
3 cr. (3 and 0)
Chemistry, kinetics, and mechanisms of polymerization reactions; fabrication, preparation, properties, and structure of polymers, copolymers, terpolymers, etc., emphasizing fiber forming polymers, polymer solution chemistry and methods for molecular characterization.

TC 812   POLYMER SCIENCE II
3 cr. (3 and 0)
Classical and statistical thermodynamics applicable to the theory of molecular modeling of polymer melt structure emphasizing transport properties, viscoelastic behavior, and non-Newtonium properties with particular attention to fiber forming polymers.

TC 821   CHEMISTRY OF NATURAL POLYMERS I
3 cr. (3 and 0)
Chemistry of natural polymers emphasizing cellulose and fibrous proteins; monosaccharides; cellulose and related polysaccharides including degradation and substitution reactions; globular and fibrous proteins in terms of structure, conformation, and chemistry of constituent amino acids.

TC 822   CHEMISTRY OF NATURAL POLYMERS II
3 cr. (3 and 0)
Chemistry of amino acids; polypeptides and proteins; synthesis and chemical reactions of both globular and fibrous proteins. **Prerequisite:** TC 315 or TC 821 or permission of instructor.

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.

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

TEXTILE SCIENCE

E. A. Vaughn, Head, Department of Textiles

Courses are offered leading to the Master of Science degree.

Applicants must have a bachelor's degree in textile chemistry, textile science, the physical or life sciences, engineering, or related disciplines.

A student's major area of study usually is in fiber science, polymer science, or textile technology. The minor normally is in the life or physical sciences, engineering, mathematics, or management. Each student must complete an original, independent, scientific or technical investigation and report the results and conclusions in a thesis.

TEXT 603   FIBER PROCESSING
            3 cr. (2 and 2)

TEXT 611   FABRIC DEVELOPMENT
            3 cr. (2 and 2)

TEXT 621   FIBER SCIENCE
            3 cr. (2 and 2)

TEXT 622   PROPERTIES OF TEXTILE STRUCTURES
            3 cr. (2 and 2)

TEXT 626   INSTRUMENTATION
            3 cr. (3 and 0)

TEXT 640   COLOR SCIENCE
            3 cr. (3 and 0)

TEXT 660   TEXTILE PROCESSES
            3 cr. (3 and 0)

TEXT 821   FIBER PHYSICS
            3 cr. (3 and 0)

Concepts and theories of fiber structure; methods of investigating natural and man-made fiber structure; examination of various interpretations of fiber structure based upon methods used to investigate structure; analytical and empirical models of fiber structure.

TEXT 835   TEXTILE STRUCTURES I
            3 cr. (3 and 0)

Pioneering works relating fiber properties to yarn properties; yarn geometry, fiber arrangements in twisted yarns, extension and breakage of continuous filament yarns, deformation of staple fiber yarns.

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TEXT 836   TEXTILE STRUCTURES II
             3 cr. (3 and 0)
     Pioneering works relating fiber properties to yarn properties; analysis of cloth geometry and mechanics, conventional yarn bearing fabrics, tensile properties of woven structures, fabric shear and buckling, geometry and mechanics of knitted fabrics.

TEXT 840   SPECTROPHOTOMETRY
             3 cr. (1 and 6)
     Application of modern instruments and computers to color matching and control of color in industrial environment.

TEXT 866   FIBER FORMATION
             3 cr. (3 and 0)
     Formation of fibers by wet, dry, and melt spinning emphasizing rheology of solutions and melts, fiber structure, stretching and drawing processes, and inter-relationships of polymer properties and processes that determine fiber properties.

TEXT 870   ADVANCES IN TEXTILE MANUFACTURING
             3 cr. (3 and 0)
     Comparisons among cotton, woolen, and worsted processing systems with respect to suitability to fiber characteristics, processing of fiber blends, modern yarn production, non-woven fabrics, and latest developments in textile machinery.

TEXT 880   SELECTED TOPICS   **165**
             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.

ENGLISH
HISTORY
POLITICAL SCIENCE
PSYCHOLOGY
SOCIOLOGY

COLLEGE OF LIBERAL ARTS
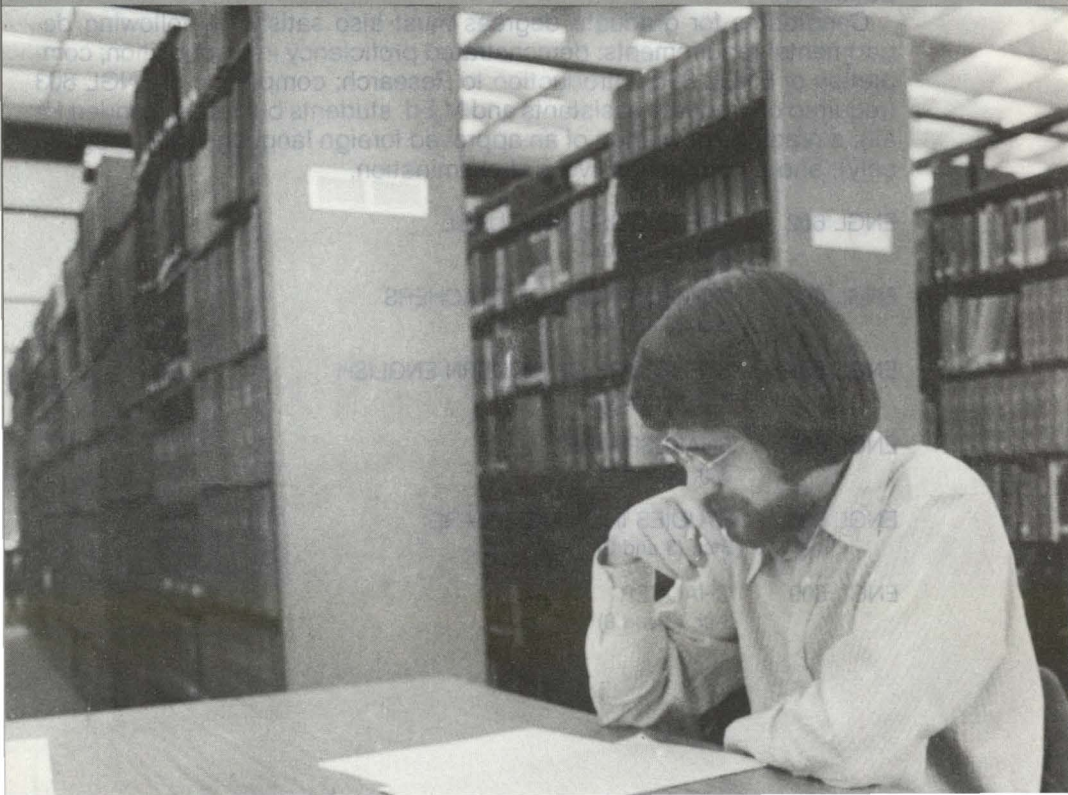
COLLEGE OF LIBERAL ARTS

H. M. Cox, Dean

The College of Liberal Arts awards advanced degrees in English and history. Graduate courses are also offered in political science, psychology and sociology to provide electives for students in other areas.

ENGLISH

R. W. Moran, Head, Department of English

Courses are offered leading to the Master of Arts degree.

An applicant for the M.A. degree in English must present at least 12 semester credits of undergraduate courses in English beyond the sophomore level. An applicant for the M.Ed. degree in secondary education with emphasis in English must present at least nine such credits. The credits should include one course each in the English language, Shakespeare, and American literature; students deficient in these requirements may seek provisional admission.

M.A. students complete either 24 semester credits of approved graduate courses and write a thesis; or, under the non-thesis option, complete 36 credits of approved graduate courses. The M.Ed. degree program in secondary education with emphasis in English requires a total of 30 credits, with a minimum of six and a maximum of 12 credits taken in the College of Education.

Candidates for graduate degrees must also satisfy the following departmental requirements: demonstrated proficiency in composition; completion of ENGL 890, Introduction to Research; completion of ENGL 603 (required of graduate assistants and M.Ed. students but recommended for all); a reading knowledge of an approved foreign language (M.A. program only); and a comprehensive oral examination.

ENGL 602   THE ENGLISH LANGUAGE
3 cr. (3 and 0)

ENGL 603   COMPOSITION FOR TEACHERS
3 cr. (3 and 0)

ENGL 604   STRUCTURE OF MODERN ENGLISH
3 cr. (3 and 0)

ENGL 605   SHAKESPEARE
3 cr. (3 and 0)

ENGL 606   STUDIES IN SHAKESPEARE
3 cr. (3 and 0)

ENGL 609   CHAUCER
3 cr. (3 and 0)

ENGL 610	MEDIEVAL ENGLISH LITERATURE
	3 cr. (3 and 0)
ENGL 611	THE CLASSICS IN TRANSLATION
	3 cr. (3 and 0)
ENGL 613	CLASSICAL DRAMA
	3 cr. (3 and 0)
ENGL 614	MEDIEVAL DRAMA
	3 cr. (3 and 0)
ENGL 616	MODERN DRAMA
	3 cr. (3 and 0)
ENGL 622	AMERICAN LITERATURE I
	3 cr. (3 and 0)
ENGL 623	AMERICAN LITERATURE II
	3 cr. (3 and 0)
ENGL 624	AMERICAN LITERATURE III
	3 cr. (3 and 0)
ENGL 625	THE ROMANTIC PERIOD
	3 cr. (3 and 0)
ENGL 627	THE VICTORIAN PERIOD
	3 cr. (3 and 0)
ENGL 631	THE RESTORATION AND EIGHTEENTH CENTURY
	3 cr. (3 and 0)
ENGL 635	SOUTHERN LITERATURE
	3 cr. (3 and 0)
ENGL 636	MILTON AND HIS AGE
	3 cr. (3 and 0)
ENGL 637	THE ENGLISH NOVEL
	3 cr. (3 and 0)
ENGL 638	TWENTIETH CENTURY POETRY
	3 cr. (3 and 0)
ENGL 639	TWENTIETH CENTURY FICTION
	3 cr. (3 and 0)
ENGL 640	APPLIED LITERARY CRITICISM
	3 cr. (3 and 0)
ENGL 641	CONTINENTAL FICTION IN TRANSLATION
	3 cr. (3 and 0)

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ENGL 643   SEVENTEENTH CENTURY POETRY AND PROSE
            3 cr. (3 and 0)

ENGL 645   RENAISSANCE NON-DRAMATIC LITERATURE
            3 cr. (3 and 0)

ENGL 646   TUDOR–STUART DRAMA
            3 cr. (3 and 0)

ENGL 647   THE AMERICAN NOVEL
            3 cr. (3 and 0)

ENGL 648   AMERICAN HUMOR
            3 cr. (3 and 0)

ENGL 661   STUDIES IN ENGLISH LITERATURE TO 1700
            3 cr. (3 and 0)

ENGL 662   STUDIES IN ENGLISH LITERATURE SINCE 1700
            3 cr. (3 and 0)

ENGL 751   CHILDREN'S LITERATURE FOR TEACHERS
            3 cr. (3 and 0)
            Literature for grades pre-school through junior high.

ENGL 761   ENGLISH LITERATURE FOR TEACHERS I
            3 cr. (3 and 0)
            English literature from *Beowulf* to 1700.

ENGL 762   ENGLISH LITERATURE FOR TEACHERS II
            3 cr. (3 and 0)
            English literature from 1700 to present.

ENGL 801   STUDIES IN THE TEACHING OF ENGLISH: MODERN GRAMMAR
            AND RHETORIC
            3 cr. (3 and 0)
            Principal theories and practices in modern grammar, rhetoric, stylistics and
semantics related to teaching composition.

ENGL 802   STUDIES IN MIDDLE ENGLISH LITERATURE
            3 cr. (3 and 0)
            Principal works in verse and prose from c. 1100–1500.

ENGL 803   STUDIES IN RENAISSANCE ENGLISH LITERATURE
            3 cr. (3 and 0)
            Principal works in verse and prose from c. 1500–1700.

ENGL 804   STUDIES IN NEO-CLASSIC AND ROMANTIC LITERATURE
            3 cr. (3 and 0)
            Principal works in verse and prose from c. 1700–1832.

ENGL 805   STUDIES IN VICTORIAN AND MODERN ENGLISH LITERATURE
            3 cr. (3 and 0)
            Principal works in verse and prose from c. 1832 to present.

ENGL 810   STUDIES IN COLONIAL AND REVOLUTIONARY AMERICAN
            LITERATURE
            3 cr. (3 and 0)
    Principal works in verse and prose from c. 1607–1830.

ENGL 811   STUDIES IN ROMANTIC AND REALISTIC AMERICAN LITERATURE
            3 cr. (3 and 0)
    Principal works in verse and prose from 1830–1900.

ENGL 812   STUDIES IN MODERN AMERICAN LITERATURE
            3 cr. (3 and 0)
    Principal works in verse and prose from c. 1900 to present.

ENGL 820   STUDIES IN THEORETICAL AND APPLIED LITERARY CRITICISM
            3 cr. (3 and 0)
    Principal statements of literary critics from classical era to present.

ENGL 825   STUDIES IN LITERARY GENRES
            3 cr. (3 and 0)
    Principal literary genres.

ENGL 830   STUDIES IN LINGUISTICS
            3 cr. (3 and 0)
    Concepts of traditional and modern grammarians; development of English
language.

ENGL 840   STUDIES IN WORLD LITERATURE
            3 cr. (3 and 0)
    Masterpieces of Oriental and Occidental writers and related works.

ENGL 881   DIRECTED READING
            3 cr. (3 and 0)
    Tutorial work in linguistics of American, British, or European literature not
offered in other courses. **Prerequisite:** Permission of department head.

ENGL 890   INTRODUCTION TO RESEARCH
            1 cr. (1 and 0)
    Literary history and research; use of libraries and bibliographical tools;
exposition of scholarship. Required of all candidates for the Master of Arts degree.

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

HISTORY

A. Schaffer, Head, Department of History

Courses are offered leading to the Master of Arts degree.

A student who wishes to study for the M.A. degree in history must
have earned an overall grade-point ratio of 2.5 on his/her undergraduate
work, including a grade-point ratio of 3.0 on at least 24 semester credits in
history.

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During graduate study the student is expected to demonstrate a reading knowledge of either French or German and be prepared to do thesis research in primary materials beyond those held by the Clemson University Library.

HIST 600   STUDIES IN UNITED STATES HISTORY
                  3 cr. (3 and 0)

HIST 640   STUDIES IN LATIN AMERICAN HISTORY
                  3 cr. (3 and 0)

HIST 650   STUDIES IN ANCIENT HISTORY
                  3 cr. (3 and 0)

HIST 660   STUDIES IN BRITISH HISTORY
                  3 cr. (3 and 0)

HIST 670   STUDIES IN EARLY EUROPEAN HISTORY
                  3 cr. (3 and 0)

HIST 671   STUDIES IN MODERN EUROPEAN HISTORY
                  3 cr. (3 and 0)

HIST 692   STUDIES IN DIPLOMATIC HISTORY
                  3 cr. (3 and 0)

HIST 693   STUDIES IN SOCIAL HISTORY
                  3 cr. (3 and 0)

HIST 694   STUDIES IN COMPARATIVE HISTORY
                  3 cr. (3 and 0)

HIST 695   STUDIES IN THE HISTORY OF IDEAS
                  3 cr. (3 and 0)

HIST 696   STUDIES IN LEGAL HISTORY
                  3 cr. (3 and 0)

HIST 715   HISTORY OF THE BLACK AMERICAN
                  3 cr. (3 and 0)
Relative position of the black American at various times in American history. For public school teachers; not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.

HIST 719   UNITED STATES HISTORY SINCE 1900
                  3 cr. (3 and 0)
American history from 1900 to present, including current problems of ecology, race relations, automation and unemployment, education, domestic and foreign commerce, and social disorganization. Not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.

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HIST 732   MODERNIZATION OF EAST ASIA
                 3 cr. (3 and 0)
    China, Japan and Korea in 20th century emphasizing social and political changes resulting from acceptance of Western ideas. Not open to candidates for Master of Arts degree in history or Master of Education degree with emphasis in secondary education, history.

HIST 741   COMPARATIVE HISTORY OF THE AMERICAS
                 3 cr. (3 and 0)
    Concept of a unique Western Hemispheric identity through comparative analysis of common and divergent historical institutions and experiences emphasizing conquest and colonization, slavery and race relations, frontiers, land patterns, industrialization and urbanization, and 20th century reform movements. Not open to candidates for Master of Arts degree in history or Master of Education degree in secondary education, history.

HIST 811   INTRODUCTION TO HISTORICAL RESEARCH
                 3 cr. (3 and 0)
    Introduction to methodology of history and to the problem inherent in seeking historical objectivity.

HIST 814   MODERN EUROPEAN HISTORIOGRAPHY
                 3 cr. (3 and 0)
    Major historical works about European society since 1500.

HIST 821   STUDIES IN EIGHTEENTH CENTURY UNITED STATES HISTORY
                 3 cr. (3 and 0)
    Research in 18th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 822   STUDIES IN NINETEENTH CENTURY UNITED STATES HISTORY
                 3 cr. (3 and 0)
    Research in 19th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 823   STUDIES IN TWENTIETH CENTURY UNITED STATES HISTORY
                 3 cr. (3 and 0)
    Research in 20th century United States history. Topics vary with interests and/or expertise of instructor.

HIST 824   SEMINAR IN THE AMERICAN SOUTH
                 3 cr. (3 and 0)
    Topics in Southern history emphasizing the South's distinctive features.

HIST 861   SEMINAR IN MEDIEVAL ENGLAND
                 3 cr. (3 and 0)
    Political and institutional development emphasizing government records. **Prerequisites:** HIST 361, 363 or equivalents.

HIST 862   SEMINAR IN MEDIEVAL ENGLAND TO 1485
                 3 cr. (3 and 0)
    Political and intellectual development emphasizing chronicles and local records. **Prerequisites:** HIST 361, 363 or equivalents.

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HIST 863   SEMINAR IN TUDOR ENGLAND
3 cr. (3 and 0)
Selected topics in English history, 1485–1603.

HIST 864   SEMINAR IN STUART ENGLAND
3 cr. (3 and 0)
Selected topics in English history in 17th century.

HIST 865   SEMINAR IN MODERN ENGLAND SINCE 1715
3 cr. (3 and 0)
Selected topics emphasizing imperial politics. **Prerequisites**: HIST 361, 363 or equivalents.

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

POLITICAL SCIENCE

C. W. Dunn, Head, Department of Political Science

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

POL SC 609   DIRECTED STUDY IN AMERICAN INSTITUTIONS
3 cr. (3 and 0)

POL SC 622   PROBLEMS OF PUBLIC ADMINISTRATION
3 cr. (3 and 0)

POL SC 623   MUNICIPAL ADMINISTRATION
3 cr. (3 and 0)

POL SC 624   ADMINISTRATIVE LAW
3 cr. (3 and 0)

POL SC 625   GOVERNMENTAL BUDGETARY PROCESS
3 cr. (3 and 0)

POL SC 626   GOVERNMENT ORGANIZATION THEORY
3 cr. (3 and 0)

POL SC 627   GOVERNMENT PERSONNEL ADMINISTRATION
3 cr. (3 and 0)

POL SC 628   AMERICAN DEFENSE POLICY ANALYSIS
3 cr. (3 and 0)

POL SC 629   AMERICAN POLITICS AND EDUCATION
3 cr. (3 and 0)

POL SC 632   AMERICAN CONSTITUTIONAL LAW I
3 cr. (3 and 0)

POL SC 633   AMERICAN CONSTITUTIONAL LAW II
3 cr. (3 and 0)

POL SC 642   POLITICAL PARTIES AND POLITICS
3 cr. (3 and 0)

POL SC 662   INTERNATIONAL ORGANIZATIONS
3 cr. (3 and 0)

PSYCHOLOGY

C. B. Caffrey, Head, Department of Psychology

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

PSCH 602   ABNORMAL PSYCHOLOGY
3 cr. (3 and 0)

PSYCH 642   SENSATION AND PERCEPTION
3 cr. (3 and 0)

PSYCH 644   SENSATION AND PERCEPTION LABORATORY
1 cr. (0 and 3)

PSYCH 690   SPECIAL TOPICS IN PSYCHIATRY AND NEUROLOGY
3 cr. (3 and 0)

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PSYCH 699   CURRENT ISSUES IN PSYCHOLOGY
3 cr. (3 and 0)

SOCIOLOGY

J. Lowe, Head, Department of Sociology

Advanced degrees are not awarded in sociology. Courses are offered to provide a minor for students majoring in other areas.

SOC 621   CONTEMPORARY SOCIOLOGICAL THEORY
3 cr. (3 and 0)

SOC 631   APPLIED ORGANIZATIONAL SOCIOLOGY
3 cr. (3 and 0)

SOC 641   SOCIAL STRATIFICATION
3 cr. (3 and 0)

SOC 651   SOCIOLOGY OF HEALTH AND ILLNESS
3 cr. (3 and 0)

RS 601   HUMAN ECOLOGY
3 cr. (3 and 0)

RS 659   THE COMMUNITY
3 cr. (3 and 0)

RS 881   SPECIAL PROBLEMS IN RURAL SOCIAL RESEARCH
3 cr. (3 and 0)

Recent research problems and literature emphasizing research design, analysis, theoretical generalizations, and application programs. **Prerequisite:** Six semester hours of 600-level sociology and/or rural sociology courses or permission of instructor.

FAMILY HEALTH NURSING

COLLEGE OF NURSING

COLLEGE OF NURSING

G. Labecki, Dean

The College of Nursing offers a graduate program leading to the Master of Science degree. The major is in family health nursing and is accompanied by an emphasis in a specialty area. Nursing education preparation is optional.

Students are prepared in making physical, social, and psychological assessments. Intervention is planned independently or interdependently with a physician. Clinical experience is under the supervision of nurse faculty preceptors prepared on a doctoral level. In certain settings and with particular conditions, physicians may also be preceptors.

While the student is prepared as a family practitioner, he or she may select a developmental stage or particular condition upon which to devote attention and increase nursing expertise, such as care of mothers and infants, children, adults, the aged, or those needing rehabilitation.

Families are seen primarily in their homes, community agencies, clinics, a family practice center, physician's offices, or hospitals. A College of Nursing nurse's clinic, where facilities for assessing clients can be provided and nursing intervention or referrals can be carried out, is an outstanding feature of the program. Supporting course content is given on the family, the community, the nursing role and process, structure of the health care system, research, and joint endeavors with another professional discipline, i.e., architecture. In order to understand man as a whole, one looks for affiliative, cognitive and biophysical clues which would maintain or restore health. Electives, including nursing education, are provided.

In addition to meeting University admission requirements, students applying to this program should be graduates of baccalaureate programs accredited by the National League for Nursing and licensed to practice in a state or territory. Every effort should be made to earn credits in statistics before admission.

The program can be completed within a three-semester period but may take longer depending upon the student's needs or wishes. The degree is awarded upon satisfactory completion of a minimum of 32 semester hours of approved graduate credit. There is a thesis or non-thesis option, the latter requiring nine additional semester hours of electives.

FAMILY HEALTH NURSING

I. D. Cahill, Director of Graduate Program

Courses are offered leading to the Master of Science degree.

NURS 801   FAMILY HEALTH NURSING
             3 cr. (1 and 6)
Nursing assessment and application of modern concepts of care to nuclear and extended family; physiological and psychosocial nature of health and illness,

forces for health and illness, dynamics of family health, helping relationship, crises intervention. Incorporates longitudinal analysis of care of selected families and clinical area of study.

NURS 805   AFFILIATIVE EXPRESSIONS OF BEHAVIOR IN RELATION TO
            HEALTH CARE
            2 cr. (2 and 0)
Certain affiliative expressions of behavior, relevant to nursing care, such as powerlessness, aggression, attachment and dependency, mourning and loss, identity, and human sexuality as they become repetitive, regressive or dominant under stress or illness; set factors which provide predisposition to behaviors. **Prerequisites:** All nursing baccalaureate degree requirements or equivalents.

NURS 807   SEMINAR
            1–3 cr.
Research methodology emphasizing research in clinical nursing; ethics in research with human subjects; selected original research papers and other topics and activities related to developments in nursing. Research activity does not include thesis advisement.

NURS 812   THE DYNAMICS OF COMMUNITY HEALTH
            3 cr. (3 and 0)
Relation of family health to community; epidemiological appraisal of community health; significance of process in planning and decision making; values guiding use and availability of health resources.

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NURS 815   THE PROMOTION AND MAINTENANCE OF HEALTH
            3 cr. (1 and 6)
Incorporation of longitudinal analysis of study of families selected in NURS 801; continuity and coordination of health care; collaboration among professionals; continuing expansion of concepts of care; emerging system of health maintenance; definition of health.

NURS 827   FOUNDATIONS OF NURSING EDUCATION
            3 cr. (3 and 0)
Philosophies influencing development of nursing education; influence of experimentalism and existentialism; influences of contemporary theorists such as McGrath, Orem, Phoenix, M. Rogers, Skinner and Tyler.

NURS 828   THE COLLEGE TEACHER OF NURSING
            3 cr. (3 and 0)
Role and responsibilities of the nurse–teacher in senior and community college nursing programs; curriculum development, use of teaching methods and materials, and clinical laboratory.

NURS 830   THE CLINICAL SPECIALTY IN NURSING
            6 cr. (3 and 9)
Theory and practice in selected clinical specialty emphasizing extended role in nursing; contribution of clinical specialist to comprehensive care of family.

NURS 881   SPECIAL PROBLEMS
Credit to be arranged.

Exploration of a problem in clinical specialization including a philosophical stance and development, testing and evaluation of hypotheses. Investigation may be done in an off-campus setting; approval of the study and periodic conferences to be arranged with major advisor in clinical specialty; printed and bound copy of report to be submitted.

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

BIOCHEMISTRY
BOTANY
CHEMISTRY
GEOLOGY
MATHEMATICAL SCIENCES
MICROBIOLOGY
PHYSICS
ZOOLOGY

COLLEGE OF SCIENCES

COLLEGE OF SCIENCES

H. E. Vogel, Dean

The College of Sciences offers the Master of Science degree in biochemistry, botany, chemistry, mathematics, microbiology, physics and zoology and the Doctor of Philosophy degree in biochemistry, chemistry, mathematics, physics and zoology.

Graduate programs leading to the Ph.D. with major emphasis in either botany or microbiology are available through an interdepartmental plant physiology program. In addition, the Ph.D. in management science is awarded jointly with the Departments of Industrial Management and Mathematical Sciences. Graduate courses are also offered in geology as a minor for students majoring in these and other areas.

All graduate programs offered in this college emphasize a broad academic foundation in the disciplinary area combined with intensive study and research in a specific area culminating in a thesis or dissertation.

Although the college does not award any professional graduate degrees, courses specifically designed for professional level graduate work are available in almost all departments with special attention being paid to secondary level public school teachers who wish to take a major concentration in the sciences while pursuing a professional degree in education.

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BIOCHEMISTRY

J. M. Shively, Head, Department of Biochemistry

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

Enrollment in the biochemistry program is open to students with baccalaureate degrees in agricultural, biological or physical sciences, or engineering. Entering students must have satisfactory academic records in mathematical, physical, and biological sciences. Students with deficiencies may be admitted but will be required to correct these deficiencies during the first year.

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

Biochemistry 623, 624, 625 and 626 (8 cr. hr.) constitute the core of the biochemistry program. All students are expected to complete these courses if they have not had their equivalent at another accredited institution.

In addition to core courses, the M.S. degree requires a minimum of 16 credit hours of course work. Twelve of the 16 credits must be in 800-level courses. A minimum of four credits must be in biochemistry courses. A thesis is required.

In addition to core courses, the Ph.D. degree requires an additional

minimum of 27 credit hours of course work with 15 credits in 800-level
biochemistry courses and 12 credits in an approved minor area. Success-
ful completion of written and oral comprehensive exams (after three
semesters in residence) will admit the student to candidacy for the Ph.D.
degree.

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

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

BIOCH 622   A PHYSICAL APPROACH TO BIOCHEMISTRY
             3 cr. (3 and 0)

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

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

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

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

BIOCH 810   ADVANCED BIOCHEMICAL TECHNIQUES
             1–3 cr. (0 and 3–9)
     Physical and chemical techniques for analysis of biological materials. Em-
phasis is on instrumentation. **Prerequisites**: BIOCH 422/622 and 425/625; or 423/
623 and 425/625; or 406/606 and 408/608; or permission of instructor.

BIOCH 815   LIPIDS AND BIOMEMBRANES
             3 cr. (3 and 0)
     Isolation, chemical and physical properties, and metabolism of lipids;
purification, structure, function, and biosynthesis of biomembranes. **Prerequisites**:
BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

BIOCH 817   CHEMISTRY AND METABOLISM OF HORMONES
             3 cr. (3 and 0)
     Isolation, assay, and chemistry of the various hormones. Hormonal control of
metabolism and body functions as well as endocrinopathies of hormone imbalance.
Prerequisites: BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

BIOCH 819   INTERMEDIARY METABOLISM
             3 cr. (3 and 0)
     Dynamic processes of intermediary metabolism emphasizing control of
catabolism and anabolism in both plants and animals. Subject matter will be
covered in lectures, guided reading of original current and classical literature, and

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in discussion. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

BIOCH 820   NUCLEIC ACIDS AND PROTEIN BIOSYNTHESIS
                3 cr. (3 and 0)

Isolation, composition, structure, maturation and functions of nucleic acids; mechanisms of protein synthesis. Students review recent papers in literature, file reports, and write a potential experimental research proposal. **Prerequisites:** BIOCH 422/622 or 423/623, and 424/624 or permission of instructor.

BIOCH 821   PROTEINS
                3 cr. (3 and 0)

Isolation, composition, structure, and properties of proteins. Methods of isolation, analysis, characterization; and properties of "unusual" protein systems. **Prerequisite:** BIOCH 422/622 or 423/623 or permission of instructor.

BIOCH 822   ENZYMES
                3 cr. (3 and 0)

Kinetics, mechanism of action, inhibition and general properties of enzymes. **Prerequisite:** BIOCH 422/622 or 423/623.

BIOCH 824   CELLULAR REGULATION AT THE MOLECULAR LEVEL
                3 cr. (3 and 0)

Cellular regulation at translational and transcriptional level. Students present recent papers from literature and write a research proposal. **Prerequisite:** BIOCH 820 or permission of instructor.

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BIOCH 831   PHYSICAL BIOCHEMISTRY
                3 cr. (3 and 0)

Description and theory of physical methods and instrumentation used in analysis of biological macromolecules. **Prerequisites:** BIOCH 422/622 or 423/623 and one semester of physical chemistry with permission of instructor.

BIOCH 851   BIOCHEMISTRY SEMINAR
                1 cr. (1 and 0)

Students review current topics in biochemistry.

BIOCH 871   ADVANCED TOPICS
                1-3 cr. (1-3 and 0)

Course offerings include bioenergetics, metabolic control mechanisms, biochemistry of unusual systems and current advances in more traditional areas. Topic to be discussed each semester will be announced prior to registration. **Prerequisite:** Permission of instructor.

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

BIOCH 991   DOCTORAL DISSERTATION RESEARCH
                Credit to be arranged.

BOTANY

C. J. Umphlett, Head, Department of Botany

Courses are offered leading to the Master of Science degree. The Doctor of Philosophy degree is offered in plant physiology with an emphasis in botany.

Candidates for graduate work in botany or plant physiology should have a strong undergraduate background in the biological and physical sciences, especially botany and chemistry. Undergraduate curriculums which provide this background are botany, biology or chemistry, or a curriculum in the agricultural plant sciences such as agronomy, forestry or horticulture.

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 opportunities for doctoral research in botany. It is described under Plant Physiology in the College of Agricultural Sciences.

BOT 611   INTRODUCTORY MYCOLOGY
3 cr. (2 and 3) F (even numbered years)

BOT 613   PHYCOLOGY
3 cr. (2 and 3) S (odd numbered years)

BOT 621   PLANT PHYSIOLOGY
4 cr. (3 and 3) F, S, SS (odd numbered years)

BOT 631   INTRODUCTORY PLANT TAXONOMY
3 cr. (2 and 3) F, SS (even numbered years)

BOT 632   PLANT GEOGRAPHY
3 cr. (3 and 0) S (odd numbered years)

BOT 635   PLANT BIOSYSTEMATICS
3 cr. (3 and 0) S (odd numbered years)

BOT 641   PLANT ECOLOGY
3 cr. (2 and 3) F

BOT 646   BIOLOGICAL OCEANOLOGY
4 cr. (3 and 3) S (even numbered years)

BOT 651   PLANT ANATOMY
4 cr. (3 and 3) F

BOT 655   VASCULAR PLANT MORPHOLOGY
4 cr. (3 and 3) S (odd numbered years)

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BOT 656 **PLANT MICROTECHNIQUE**
2 cr. (0 and 6) S (even numbered years)

BOT 661 **CYTOLOGY**
3 cr. (3 and 0) S (even numbered years)

BOT 701 **EVOLUTIONARY BOTANY FOR TEACHERS**
3 cr. (2 and 3) F, SS
Survey of plant kingdom emphasizing evolutionary relationships of plant divisions based primarily on morphology; non-vascular plants; vascular plants. Open only to teachers or those in Master of Education degree program.

BOT 702 **MODERN BOTANICAL CONCEPTS FOR TEACHERS**
3 cr. (3 and 0) S, SS
Topics stressing functional processes in plants; physiology, ecology, genetics, and evolution. Open only to teachers or those in Master of Education degree program.

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 811 **ADVANCED MYCOLOGY I**
4 cr. (3 and 3) S (odd numbered years)
Modern and classic involvements in biology of cells, organisms and populations of lower fungi (Phycomycetes). **Prerequisite:** BOT 451/651 or permission of instructor.

BOT 812 **ADVANCED MYCOLOGY II**
4 cr. (3 and 3) F (odd numbered years)
Modern and classic involvements in biology of cells, organisms, and populations of higher fungi (Ascomycetes and Basidiomycetes). **Prerequisite:** BOT 411/611 or permission of instructor.

BOT 815 **PHYCOLOGY COLLOQUIM**
3 cr. (3 and 0) F (odd numbered years)
Phenomena associated with algae. Discussion topics, taken from current scientific literature, present to students a forum for criticizing research, for conceiving new ideas for research, for developing research outlines and proposals, and for incorporating knowledge gained from phycology into a more inclusive understanding of physical and biological systems. **Prerequisite:** BOT 413/613 or permission of instructor.

BOT 821　　　INORGANIC PLANT METABOLISM
　　　　　　4 cr. (3 and 3) F (odd numbered years)
　　Plant, soil, water nutrient relations, permeability, uptake and translocation, transpiration, and mineral nutrition. **Prerequisite:** BOT 421/621 or permission of instructor.

BOT 822　　　ORGANIC PLANT METABOLISM
　　　　　　3 cr. (3 and 0) S (even numbered years)
　　Respiration and photosynthesis; synthesis, translocation, storage, transformation and degradation of organic materials, fats, carbohydrates, proteins, pigments, and nucleic acids. **Prerequisites:** BOT 421/621, general biochemistry, or permission of instructor.

BOT 823　　　PLANT GROWTH & DEVELOPMENT
　　　　　　3 cr. (3 and 0) F (even numbered years)
　　Vegetative and reproductive growth and development from seed to maturity, flowering, fruiting and senescence; natural and synthetic growth regulators, and morphogenesis. **Prerequisites:** BOT 421/621, organic chemistry, or permission of instructor.

BOT 824　　　MODE OF ACTION OF GROWTH SUBSTANCES
　　　　　　4 cr. (3 and 3) S (odd numbered years)
　　Physiology and biochemistry of both natural and synthetic growth regulators, hormones, growth retardants, herbicides, and other inhibitors; methodology and mechanism of action. **Prerequisites:** BOT 421/621 and general biochemistry or BOT 822 or permission of instructor.

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BOT 826　　　PHYSIOLOGY OF THE FUNGI
　　　　　　3 cr. (3 and 0) S (even numbered years)
　　Fungal growth and cultivation, organic and inorganic metabolism, reproductive physiology, physiology as a taxonomic tool, and ecological interactions of fungi from a physiological viewpoint. **Prerequisites:** BOT 411/611, BOT 421/621, BIOCH 423/623, or permission of instructor.

BOT 831　　　ADVANCED PLANT TAXONOMY
　　　　　　3 cr. (2 and 3) S (even numbered years)
　　Principles of plant classification; relationships and characteristics of major groups of vascular plants. Student collects and identifies spring flora of area. **Prerequisite:** BOT 331/631 or permission of instructor.

BOT 861　　　PLANT CELL BIOLOGY
　　　　　　3 cr. (3 and 0) S (even numbered years)
　　Structure, development and activities of plant cells; ultrastructural organization uniquely associated with dynamics of cellular growth and development in plants. **Prerequisite:** BOT 461/661 or AN PH 801 or permission of instructor.

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

BOT 991   DOCTORAL DISSERTATION RESEARCH
           Credit to be arranged.

CHEMISTRY

H. G. Spencer, Head, Department of Chemistry and Geology

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

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 Department of Textiles.

Students in either degree program must present satisfactory research seminars and must be competent in computer programming. They must also pass a language requirement in French, German, or Russian as described in the sections on language requirements for the Master of Science and the Doctor of Philosophy degrees. Teaching in undergraduate courses is an integral part of graduate work and is required for at least one semester of all graduate students.

Master of Science degree candidates must complete 24 hours of course work and present a satisfactory thesis.

Doctor of Philosophy degree candidates, lacking a course in atomic and molecular structure, must complete CH 635. Qualification to pursue the Ph.D. degree is accomplished 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 to the Ph.D. degree requires completion of a cumulative examination in the area of concentration. This examination, consisting of eight examinations given monthly, is followed by an oral presentation before the advisory committee.

CH 602   INORGANIC CHEMISTRY
          3 cr. (3 and 0)

CH 611   INSTRUMENTAL ANALYSIS
          4 cr. (2 and 6)

CH 621   ADVANCED ORGANIC CHEMISTRY
          3 cr. (3 and 0)

CH 627   ORGANIC SPECTROSCOPY
          3 cr. (2 and 3)

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

CH 632   PHYSICAL CHEMISTRY
3 cr. (3 and 0)

CH 635   SPECTROSCOPY AND MOLECULAR STRUCTURE
3 cr. (3 and 0)

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

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

CH 654   CHEMICAL SYNTHESIS
3 cr. (1 and 6)

CH 691   INTRODUCTION TO RADIOCHEMISTRY
3 cr. (2 and 3)

CH 700   PHYSICAL SCIENCE IN ELEMENTARY SCHOOL—CHEMISTRY
3 cr. (2 and 3)

Selecting, carrying out, and discussing experiments which can be performed with limited equipment and time in elementary school; experiments useful in teaching basic chemical principles. Restricted to elementary school teachers.

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 secondary school teachers.

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 secondary school teachers.

CH 703   SPECIAL PROBLEMS IN CHEMISTRY FOR SECONDARY SCHOOL
3–6 cr. (3–6 and 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 evelution procedure; student completes project which can be used in his or her teaching situation. Restricted to secondary school teachers; may be repeated for additional credit.

CH 805   THEORETICAL INORGANIC CHEMISTRY
3 cr. (3 and 0)

Application of modern theory to inorganic chemistry. **Prerequisites:** CH 402/602 and 435/635, or permission of instructor.

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CH 807   CHEMISTRY OF THE TRANSITION ELEMENTS
3 cr. (3 and 0)
Chemistry of transition elements emphasizing coordination compounds formed by these elements. **Prerequisite**: CH 402/602.

CH 808   CHEMISTRY OF THE NON-METALLIC ELEMENTS
3 cr. (3 and 0)
Inorganic chemistry of non-metallic elements, especially boron, silicon, phosphorus, and sulfur. **Prerequisite**: CH 402/602.

CH 811   ANALYTICAL CHEMISTRY
3 cr. (3 and 0)
Art of analytical chemistry; sample selection, sample treatment, practical aspects of instrumentation, analytical chemistry of 70 chemical elements and several organic functional groups; understanding of complete, economically feasible analytical procedures for determination of components of complex mixtures.

CH 812   CHEMICAL SPECTROSCOPIC METHODS
3 cr. (2 and 3)
Emission and absorption spectroscopy, chemical microscopy, X-ray diffraction and fluorescence techniques in analytical chemistry; theory and operation of instruments.

CH 814   ELECTROANALYTICAL CHEMISTRY
3 cr. (2 and 3)
Theory and practical application of modern electrochemistry applied to analytical chemistry.

CH 821   ORGANIC CHEMISTRY I
3 cr. (3 and 0)
Theoretical concepts of organic chemistry and mechanisms of organic reactions. **Prerequisite**: CH 421/621 or permission of instructor.

CH 822   ORGANIC CHEMISTRY II
3 cr. (3 and 0)
Modern synthetic organic chemistry and stereochemistry. **Prerequisite**: CH 421/621 or permission of instructor.

CH 824   FUNDAMENTAL PRINCIPLES OF POLYMER CHEMISTRY
3 cr. (3 and 0)
Organic chemistry of natural and synthetic macromolecules.

CH 831   CHEMICAL THERMODYNAMICS
3 cr. (3 and 0)
Classical thermodynamics emphasizing theory and significance of energetics and systems of variable composition. **Prerequisite**: CH 331/631 or its equivalent.

CH 834   STATISTICAL THERMODYNAMICS
3 cr. (3 and 0)
Statistical thermodynamics; ensemble method, ideal gases, internal de-

grees of freedom, solid state, imperfect gases, distribution function method in fluids, and time-dependent fluctuations. **Prerequisite:** CH 831.

CH 835   CHEMICAL KINETICS
          3 cr. (3 and 0)
     Rate processes and reaction mechanisms; order of reaction, theory of rate processes, relation of reaction rates to mechanism, homogenous and heterogenous catalysis, experimental methods, chain reactions, diffusion, and effects of solvent, temperature and pressure on reaction rates and mechanisms. Lectures supplemented by assigned problems, paper and oral examination of topic of special interest to student.

CH 837   QUANTUM CHEMISTRY
          3 cr. (3 and 0)
     Mathematical and conceptual formulation of quantum theory of electronic structure of atoms and molecules; eigenvalue solution of one-dimensional Schröedinger 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; Mossbauer spectrometry and tracer analysis.

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CH 851   SEMINAR
          1–2 cr.
     Students and faculty review current topics in chemistry. May be taken more than one semester.

CH 861   PRINCIPLES OF BIOCHEMISTRY
          3 cr. (3 and 0) S
     Rigorous, quantitative treatment of properties of biological molecules using modern techniques of organic, physical and analytical chemistry to study structural relationships and biological activity. **Prerequisites:** Satisfactory performance on placement examinations in organic and physical chemistry.

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

CH 906   SPECIAL TOPICS IN INORGANIC CHEMISTRY
          1–4 cr. (1–4 and 0)
     Crystals, non-aqueous solvents, chemical applications of group theory, rare-earth elements and non-stoichiometric compounds. Topics vary with interests of students; may be taken more than one semester.

CH 910   SPECIAL TOPICS IN ANALYTICAL CHEMISTRY
          1–4 cr. (1–4 and 0)
     Separation methods, advanced electrochemistry, new techniques in analytical chemistry, organic analytical reagents, data acquisition and processing,

instrument–computer interfacing. Topics vary with interests of students; may be taken more than one semester.

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 more than one semester.

CH 930   ADVANCED TOPICS IN PHYSICAL CHEMISTRY
           1–4 cr. (1–4 and 0)

Special problems in molecular spectroscopy, molecular orbital treatments, applications of group theory to chemical structure, irreversible thermodynamics, special topics in statistical mechanics. Topics vary with interests of students; may be taken more than one semester.

CH 950   MICROANALYTICAL TECHNIQUES
           3 cr. (1 and 6)

Procedures for analyzing organic compounds for elemental composition. Student perfects laboratory techniques.

CH 991   DOCTORAL DISSERTATION RESEARCH
           Credit to be arranged.

GEOLOGY

P. K. Birkhead, Program Coordinator

Advanced degrees are not awarded in geology. Courses are offered as a minor or as interdisciplinary support for students in other areas.

GEOL 600   ENVIRONMENTAL GEOLOGY
            3 cr. (3 and 0)

GEOL 602   STRUCTURAL GEOLOGY
            3 cr. (2 and 2)

GEOL 603   INVERTEBRATE PALEONTOLOGY
            3 cr. (2 and 3)

GEOL 604   ECONOMIC GEOLOGY
            3 cr. (3 and 0)

GEOL 605   GEOMORPHOLOGY
            4 cr. (3 and 3)

GEOL 606   MINERALOGY
            3 cr. (2 and 3)

GEOL 607   QUATERNARY GEOLOGY
            3 cr. (2 and 2)

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GEOL 608   GEOHYDROLOGY
               3 cr. (3 and 0)

GEOL 609   PETROLOGY
               3 cr. (2 and 3)

GEOL 610   OPTICAL MINERALOGY
               3 cr. (1 and 4)

GEOL 611   RESEARCH PROBLEMS
               1–3 cr. (0 and 3–9)

GEOL 613   STRATIGRAPHY AND SEDIMENTATION
               3 cr. (3 and 0)

GEOL 615   GEOLOGY PRACTICED IN INDUSTRY AND GOVERNMENT
               3 cr. (3 and 0)

GEOL 700   EARTH SCIENCE I
               3 cr. (2 and 3)
     Physical geology for secondary school teachers of earth science and physical sciences; materials of earth's crust, processes of formation and change, geologic features of earth. Field trips provide observation of materials, operating processes, and results of processes in nature. Restricted to secondary school teachers.

GEOL 750   EARTH SCIENCE II
               3 cr. (2 and 3)
     Historical geology for secondary school teachers of earth science and physical sciences; record of change of earth, both physical and biological, through geologic time to present. Lab demonstration and field trips illustrate methods used in deciphering record as presented. Restricted to secondary school teachers.

MATHEMATICAL SCIENCES

J. W. Kenelly, Head, Department of Mathematical Sciences

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

     Entering students are expected to have a background in linear algebra, differential equations, a computer language, and statistics.

     Students seeking the master's degree may choose a thesis or non-thesis option. Either prior to or during the program, the following general distribution requirements must be met: advanced calculus; modern algebra; probability and a subsequent applied statistics course; mathematical programming; an additional course in statistics or operations research; a numerical computer science course; a non-numerical computer science course; two core courses beyond advanced calculus and modern algebra; and an applied models course.

     In addition, six courses (to be approved by the advisory committee) must

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be selected from or to complement one of the following specialty areas: algebra, analysis, computer science, operations research, probability and statistics.

A minimum of 36 graduate hours is required for the master's degree.

Students are admitted to candidacy for the Ph.D. degree upon the successful completion of a written qualifying examination on the subject matter of the major and minor fields.

The Departments of Industrial Management and Mathematical Sciences jointly offer and administer a Ph.D. program in management science. It is described under Management Science in the College of Industrial Management and Textile Science.

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MATH 601   STATISTICAL THEORY AND METHODS I
3 cr. (3 and 0)

MATH 602   THEORY OF PROBABILITY
3 cr. (3 and 0)

MATH 603   STATISTICAL INFERENCE
3 cr. (3 and 0)

MATH 604   INTRODUCTION TO STOCHASTIC PROCESSES
3 cr. (3 and 0)

MATH 605   STATISTICAL THEORY AND METHODS II
3 cr. (3 and 0)

MATH 607   PARTIAL DIFFERENTIAL EQUATIONS
3 cr. (3 and 0)

MATH 608   TOPICS IN GEOMETRY
3 cr. (3 and 0)

MATH 609   STATISTICAL THEORY AND METHODS III
3 cr. (3 and 0)

MATH 611   LINEAR ALGEBRA
3 cr. (3 and 0)

MATH 612   INTRODUCTION TO MODERN ALGEBRA
3 cr. (3 and 0)

MATH 613   MODERN ALGEBRA
3 cr. (3 and 0)

MATH 615   INTRODUCTION TO TOPOLOGY
3 cr. (3 and 0)

MATH 617   MATHEMATICAL PROGRAMS
3 cr. (3 and 0)

MATH 619   APPLIED COMBINATORIAL ALGEBRA I
            3 cr. (3 and 0)

MATH 620   APPLIED COMBINATORIAL ALGEBRA II
            3 cr. (3 and 0)

MATH 628   NUMERICAL LINEAR ALGEBRA
            3 cr. (3 and 0)

MATH 629   NUMERICAL ANALYSIS
            3 cr. (3 and 0)

MATH 630   ACTUARIAL FINITE DIFFERENCES
            3 cr. (3 and 0)

MATH 631   THEORY OF INTEREST
            3 cr. (3 and 0)

MATH 635   COMPLEX VARIABLES
            3 cr. (3 and 0)

MATH 652   LINEAR PROGRAMMING
            3 cr. (3 and 0)

MATH 653   ADVANCED CALCULUS I
            3 cr. (3 and 0)

MATH 654   ADVANCED CALCULUS II
            3 cr. (3 and 0)

MATH 657   APPLIED MATHEMATICS I
            3 cr. (3 and 0)

MATH 658   APPLIED MATHEMATICS II
            3 cr. (3 and 0)

MATH 663   MATHEMATICAL ANALYSIS I
            3 cr. (3 and 0)

MATH 664   MATHEMATICAL ANALYSIS II
            3 cr. (3 and 0)

MATH 671   APPLIED STATISTICAL DECISION THEORY
            3 cr. (3 and 0)

MATH 673   INTRODUCTION TO NONLINEAR OPTIMIZATION
            3 cr. (3 and 0)

MATH 701   MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
            TEACHERS—NUMBER SYSTEMS I
            3 cr. (3 and 0)
            Sets and cardinal numbers; development of base ten number system, other

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ancient and modern number systems including other number bases; historical development of place value; importance of zero in number systems; arithmetic properties of whole numbers; construction of integers and rational numbers using sets; primes and composites; arithmetic properties of rationals, irrationals and incommensurables of Greeks; order properties of real number system; Dedekind cuts; density of real number system. Open to all graduate students in education except those majoring in secondary education.

MATH 702   MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
                TEACHERS—NUMBER SYSTEMS II
                3 cr. (3 and 0)
Continuation of MATH 701. Open to all graduate students in education expect those majoring in secondary education. **Prerequisite**: MATH 701.

MATH 703   MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
                TEACHERS—GEOMETRY
                3 cr. (3 and 0)
Concepts of geometry; informal geometry, measurement of geometric figures, metric measurements, deductive geometry, functions in geometry, coordinate and vector geometry. Open to all graduate students in education except those majoring in secondary education.

MATH 705   MODERN MATHEMATICS FOR ELEMENTARY SCHOOL
                TEACHERS—ALGEBRA, PROBABILITY, & STATISTICS
                3 cr. (3 and 0)
Fundamentals of elementary algebra, elementary probability, and descriptive statistics. Open to all graduate students in education except those majoring in secondary education.

MATH 712   MODERN ALGEBRAIC CONCEPTS
                3 cr. (3 and 0)
Topics may include groups, rings, Boolean algebras, integral domains, fields, Galois theory. Restricted to graduate students in secondary education.

MATH 721   MATRIX ALGEBRA I
                3 cr. (3 and 0)
Determinants, matrices, vectors, vector spaces, and linear transformations; introduction of matrices by systems of equations. Restricted to graduate students in secondary education.

MATH 722   MATRIX ALGEBRA II
                3 cr. (3 and 0)
Continuation of MATH 721; linear transformations, similarity, polynominals and polynominal matrices, and matrix analysis. Restricted to graduate students in secondary education.

MATH 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

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geometries, graphs, codes, Polya's theorem, recreational mathematics. Restricted to graduate students in secondary education.

MATH 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.

MATH 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.

MATH 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.

MATH 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.

MATH 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.

MATH 752   FUNDAMENTAL CONCEPTS OF CALCULUS II
         3 cr. (3 and 0)
Vector and Euclidean space, topology of Euclidean n-space, differential calculus of functions of several variables, integral calculus of functions of several variables. Restricted to graduate students in secondary education. **Prerequisite:** MATH 751.

MATH 761   PROBABILITY AND STATISTICS
         3 cr. (3 and 0)
Probability, conditional probability, descriptive statistics, random variables, probability functions, binomial distribution, normal distribution, sampling, estimation, decision making. Restricted to graduate students in secondary education.

MATH 771   NUMERICAL METHODS IN SECONDARY MATHEMATICS I
         3 cr. (3 and 0)
Update of traditional techniques for teaching high school mathematics

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through introduction of computer methods for investigation of processes and reinforcement of concepts; development of programs requiring participants to "invent" algorithms to solve problems in typical high school mathematics course; use of general purpose programming language; methods of teaching this language to high school students. Restricted to graduate students in secondary education.

MATH 772   NUMERICAL METHODS IN SECONDARY MATHEMATICS II
3 cr. (3 and 0)
Continuation of MATH 771. Restricted to graduate students in secondary education. **Prerequisite: MATH 771.**

MATH 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.

MATH 783   THEORY OF NUMBERS
3 cr. (3 and 0)
Properties of integers; divisors and prime numbers, fundamental properties of congruence, polynominal and primitive roots, quadratic residues. Restricted to graduate students in secondary education. **Prerequisite:** One year of calculus at college level.

MATH 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.

MATH 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:** MATH 403/603 and 411/611.

MATH 802   GENERAL LINEAR HYPOTHESIS II
3 cr. (3 and 0)
Continuation of MATH 801.

MATH 803   STOCHASTIC PROCESSES I
3 cr. (3 and 0)
Theory and analysis of time series, recurrent events, Markov chains, random walks, renewal theory, application to communication theory, and operation research. **Prerequisite: MATH 404/604.**

MATH 804   STOCHASTIC PROCESSES II
            3 cr. (3 and 0)
Continuation of MATH 803. Renewal theory; branching processes; Brownian motion. Special topics selected from: queuing theory, Markov decision processes, semi-Markov processes, point processes, applications to statistics, and others. **Prerequisite:** MATH 803.

MATH 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:** MATH 301, 402/602.

MATH 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:** MATH 402/602.

MATH 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:** MATH 402/602, 405/605, or equivalent.

MATH 811   NONLINEAR PROGRAMMING
            3 cr. (3 and 0)
Theoretical development of nonlinear optimization with applications; classical optimization, convex and concave functions, separable programming, quadratic programming, and gradient methods. **Prerequisites:** MATH 452/652, 453/653.

MATH 812   DYNAMIC PROGRAMMING
            3 cr. (3 and 0)
Deterministic and stochastic multistage decision processes; Mitten sufficiency, existence and uniqueness theorems, approximation in policy space, multistage games, Markovian decision processes, surveillance theory, and Pontryagin maximum principle. **Prerequisites:** MATH 452/652, 454/654.

MATH 813   ADVANCED LINEAR PROGRAMMING
            3 cr. (3 and 0)
Development of linear programming theory using inequality systems, convex cones, polyhedra and duality; solution algorithms and computational considerations for large scale and special structured problems using techniques of upper bounded variables, decomposition, partitioning and column generation; game theory; chance constraints; nonlinear representations. **Prerequisite:** MATH 452/652 or equivalent.

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MATH 814   NETWORK FLOWS AND INTEGER PROGRAMMING
3 cr. (3 and 0)
Max flow-min cut theorem, combinatorial applications, minimum cost flow problems (transportation, shortest path, transhipment), solution algorithms (including the out-of-kilter), integer programming including problems with network and special structure and general integer solution methods (branch and bound, cutting plane, group theoretic). **Prerequisite:** MATH 452/652 or equivalent.

MATH 815   DATA STRUCTURES
3 cr. (3 and 0)
Representation and transformation of information; formal descriptions of processes and data structures; tree and list structures, push-down stacks, string and formula manipulation, hashing techniques; interrelation between data structure and program structure; storage allocation methods. **Prerequisites:** Computational maturity and permission of instructor.

MATH 817   STOCHASTIC MODELS IN OPERATIONS RESEARCH I
3 cr. (3 and 0)
Stochastic control, structure of sequential decision processes; stochastic inventory models, recursive computation of optimal policies; discrete parameter finite Markov decision processes, various optimality criteria, computation by policy improvement and other methods, existence of optimal stationary policies, stopping-rule problems; examples from financial management, maintenance and reliability, search, queuing and shortest path. **Prerequisites:** MATH 402/602–404/604.

MATH 818   STOCHASTIC MODELS IN OPERATIONS RESEARCH II
3 cr. (3 and 0)
Introduction to queuing theory; Markovian queues, repairman problems, queues with an embedded Markov structure, the queue GI/G/1, queues with a large number of servers, decision making in queues; introduction to reliability theory; failure distributions, stochastic models for complex systems, maintenance and replacement policies, reliability properties of multi-component structures. **Prerequisites:** MATH 402/602, 803.

MATH 821   REAL ANALYSIS I
3 cr. (3 and 0)
Hausdorff and metric spaces, cardinal and ordinal numbers, rings and algebras of sets, exterior and interior measure, completion of measures, Borel and Lebesque measures in Euclidean n-space, integration theory associated with a measure, types of convergence, derivatives. **Prerequisite:** MATH 454/654.

MATH 822   REAL ANALYSIS II
3 cr. (3 and 0)
Continuation of MATH 821.

MATH 823   COMPLEX ANALYSIS I
3 cr. (3 and 0)
Topological concepts, complex integration, local and global properties of analytic functions, power series, representation theorems, calculus of residues. Designed for non-engineering majors. **Prerequisite:** MATH 464/664.

MATH 824   COMPLEX ANALYSIS II
            3 cr. (3 and 0)
Continuation of MATH 823 including introductory topological analysis.

MATH 825   ORDINARY DIFFERENTIAL EQUATIONS I
            3 cr. (3 and 0)
Existence and uniqueness theorems, dependence on initial conditions and parameters, linear differential equations, self adjoint eigenvalue problems, oscillation and comparison theorems. **Prerequisites:** MATH 454/654 and 411/611.

MATH 826   ORDINARY DIFFERENTIAL EQUATIONS II
            3 cr. (3 and 0)
Perturbations of systems having periodic solution, stability, Poincare-Bendixson theory, use of fixed point theorems, almost periodic solutions and integral manifolds. **Prerequisite:** MATH 825.

MATH 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, and semantic models. **Prerequisite:** COMP SC 428.

MATH 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 polynominals. **Prerequisite:** MATH 464/664.

MATH 833   OPERATIONAL MATHEMATICS
            3 cr. (3 and 0)
Operational properties of Laplace and other integral transforms; applications to problems in engineering and physics involving differential equations and boundary value problems in partial differential equations. **Prerequisite:** MATH 454/654.

MATH 837   CALCULUS OF VARIATIONS
            3 cr. (3 and 0)
Fundamental theory of the calculus of variations, variable end points, the parametric problem, the isoperimetric problem, fundamental sufficiency theorems. **Prerequisite:** MATH 454/654 or 464/664.

MATH 839   INTEGRAL EQUATIONS
            3 cr. (3 and 0)
Basic theory, relationships to linear differential initial value problems, Fredholm theory, linear Fredholm integral equations of the first and second kind, Hilbert-Schmidt theory, Volterra equations. **Prerequisite:** MATH 464/664.

MATH 841   APPLIED MATHEMATICS I
            3 cr. (3 and 0)
Linear spaces, spectral theory of operators, Green's function, eigenvalue problems of ordinary differential equations, partial differential equations. **Prerequisites:** MATH 464/664 and 853.

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MATH 842   APPLIED MATHEMATICS II
3 cr. (3 and 0)
Continuation of MATH 841.

MATH 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.

MATH 851   ABSTRACT ALGEBRA I
3 cr. (3 and 0)
Topics selected from fundamental theory of modern algebra; finite groups including permutation groups, p-groups, Sylow theorems and structure of finite abelian groups; groups with chain conditions, Krull-Schmidt and Jordan-Hölder theorems; solvable, nilpotent and free groups; Galois theory; finite fields; Wedderburn theorem.

MATH 852   ABSTRACT ALGEBRA II
3 cr. (3 and 0)
Continuation of MATH 851 including structure of rings and other algebraic systems.

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MATH 853   ADVANCED LINEAR ALGEBRA
3 cr. (3 and 0)
Properties of finite dimensional vector spaces; bases, dimensions, transformations, projections and orthogonality. **Prerequisites:** MATH 411/611, 412/612.

MATH 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.

MATH 855   COMBINATORIAL ANALYSIS
3 cr. (3 and 0)
Topics selected from combinations, permutations, permutations with restricted position, Polya's theorem, principle of inclusion and exclusion, partitions, recurrence relations, generating functions, Möbius inversion, enumeration techniques, Ramsey numbers, finite projective and affine geometrics, Latin rectangles, orthogonal arrays, block designs, error detecting and error correcting codes. **Prerequisite:** MATH 411/611.

MATH 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:** MATH 428/628, 429/629 and digital computer experience.

MATH 862   ADVANCED NUMERICAL ANALYSIS II
              3 cr. (3 and 0)
Continuation of MATH 861.

MATH 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:** MATH 411/611, 429/629, 453/653 and digital computer experience.

MATH 864   DIGITAL MODELS II
              3 cr. (3 and 0)
Continuation of MATH 863.

MATH 865   CALCULUS OF FINITE DIFFERENCES
              3 cr. (3 and 0)
Difference operators, summation formulas, functions important in calculus of finite differences, existence and uniqueness theorems of difference equations, orthogonal polynominals. **Prerequisite:** MATH 454/654.

MATH 867   SYSTEMS AND SOFTWARE
              3 cr. (3 and 0)
Systems organization and software design of the IBM 370; working knowledge of machine organization, basic assembler language, operating systems overview, program support facilities, job control language, data management, library management, interactive system concepts. **Prerequisites:** COMP SC 205 and MATH 411/611 or MATH 419/619.

MATH 868   AN INTRODUCTION TO NUMERICAL PROCESSES
              3 cr. (3 and 0)
Numerical solution of linear algebraic systems and systems of ordinary differential equations; computational problems in discrete event simulation. **Prerequisites:** MATH 208, 301, and 411/611.

MATH 871   GENERAL TOPOLOGY I
              3 cr. (3 and 0)
Definitions and elementary properties of topological space, subspaces, quotient and product spaces, Moore-Smith convergence, separation axioms and consequences, metrization theorems; homotopy theory uniformities and axiomatic boundedness. **Prerequisite:** MATH 454/654.

MATH 872   GENERAL TOPOLOGY II
              3 cr. (3 and 0)
Continuation of MATH 871.

MATH 881   HISTORY OF MATHEMATICS
              3 cr. (3 and 0)
Development of mathematics. Reference material supplements text, and class discussion is expected. **Prerequisite:** Permission of instructor.

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

MATH 901   PROBABILITY THEORY I
3 cr. (3 and 0)
Axiomatic theory of probabilities; general concepts and tools of probability theory developed to discuss sums of independent random variables and their limit properties; Cartesian product of infinity, many measurable spaces, Daniel-Kolmogoroff theorems, Borel-Cantelli lemma, monotone class theorem, modes of convergence, characteristic functions, infinitely divisible distributions, central limit theorems, law of large numbers, ergodic theorems. **Prerequisites:** MATH 402/602 and 822.

MATH 902   PROBABILITY THEORY II
3 cr. (3 and 0)
Continuation of MATH 901; conditioning and limit properties of sums of dependent random variables; conditioning, martingales, calculus in quadratic means.

MATH 905   DECISION THEORY I
3 cr. (3 and 0)
Classes of decision functions, estimators, properties of estimators, methods of deriving estimators, testing of hypotheses, uniformly most powerful tests, methods of deriving tests. **Prerequisites:** MATH 403/603 and 822.

MATH 906   DECISION THEORY II
3 cr. (3 and 0)
Continuation of MATH 905.

MATH 907   MULTIVARIATE ANALYSIS
3 cr. (3 and 0)
Multivariate normal distribution, Wishart distribution, Hotelling's T^2 distribution, estimation of parameters, test of hypotheses on vector means and covariance matrices. **Prerequisite:** MATH 802.

MATH 920   INTRODUCTION TO HARMONIC ANALYSIS
3 cr. (3 and 0)
Trigonometric functions and series, summability methods, convergence and summability of Fourier series, Fourier integrals, Fourier transforms, Banach algebra L^1 (R) and ideals in L^1. **Prerequisites:** MATH 822 and 824.

MATH 927   FUNCTIONAL ANALYSIS I
3 cr. (3 and 0)
Hilbert, normed and Banach spaces and topological linear operators in these spaces; Hahn-Banach, uniform boundedness, and closed graph-theorems, application to problems in analysis, spectral theory for linear operators. **Prerequisite:** MATH 821.

MATH 928   FUNCTIONAL ANALYSIS II
3 cr. (3 and 0)
Continuation of MATH 927.

MATH 956   FIELD THEORY
            3 cr. (3 and 0)
Fields; valuations, ideals, algebraic number fields, Dedekind fields, finite fields. **Prerequisites:** MATH 851 and 852.

MATH 957   SEMIGROUP THEORY
            3 cr. (3 and 0)
Algebraic theory of semigroups; elementary concepts, ideals and related concepts, minimal conditions, inverse semigroups, various representations, decompositions and extensions. **Prerequisite:** MATH 851 or permission of instructor.

MATH 980   SPECIAL TOPICS IN PROBABILITY
            1-3 cr. (1-3 and 0)
Advanced topics in probability from current problems of interest.

MATH 981   SPECIAL TOPICS IN MATHEMATICAL STATISTICS
            1-3 cr. (1-3 and 0)
Advanced topics in mathematical statistics from current problems of interest.

MATH 982   SPECIAL TOPICS IN ANALYSIS
            1-3 cr. (1-3 and 0)
Advanced analysis topics from current problems of interest.

MATH 983   SPECIAL TOPICS IN FUNCTIONAL ANALYSIS
            1-3 cr. (1-3 and 0)
Advanced topics in functional analysis from current problems of interest.

MATH 984   SPECIAL TOPICS IN APPLIED MATHEMATICS
            1-3 cr. (1-3 and 0)
Advanced topics in applied mathematics from current problems of interest.

MATH 985   SPECIAL TOPICS IN ALGEBRA
            1-3 cr. (1-3 and 0)
Advanced topics in algebra from current problems of interest.

MATH 986   SPECIAL TOPICS IN CONVEXITY
            1-3 cr. (1-3 and 0)
Advanced topics in convexity from current problems of interest.

MATH 987   SPECIAL TOPICS IN NUMERICAL PROCESSES
            1-3 cr. (1-3 and 0)
Advanced topics in numerical processes from current problems of interest.

MATH 988   SPECIAL TOPICS IN OPERATIONS RESEARCH
            1-3 cr. (1-3 and 0)
Advanced topics in operations research from current problems of interest.

MATH 989   SPECIAL TOPICS IN INFORMATION PROCESSING
            1-3 cr. (1-3 and 0)
Advanced topics in information processing from current problems of interest.

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MATH 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

The Department of Mathematical Sciences offers a computer science option in its M.S. and Ph.D. degree programs. In addition to courses in computer science, the student chooses courses from the core curriculum appropriate for this option.

COMP SC 609 INTRODUCTION TO NUMERICAL ANALYSIS I
3 cr. (3 and 0)

COMP SC 610 INTRODUCTION TO NUMERICAL ANALYSIS II
3 cr. (3 and 0)

COMP SC 623 INTRODUCTION TO OPERATING SYSTEMS
3 cr. (3 and 0)

COMP SC 628 STRUCTURE OF PROGRAMMING LANGUAGES
3 cr. (3 and 0)

COMP SC 629 TRANSLATION OF PROGRAMMING LANGUAGES
3 cr. (3 and 0)

COMP SC 640 INTRODUCTION TO DATA STRUCTURES
3 cr. (3 and 0)

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COMP SC 660 PERIPHERALS AND FILE DESIGN
3 cr. (3 and 0)

COMP SC 662 TELEPROCESSING AND DATA-BASE MANAGEMENT SYSTEMS
3 cr. (3 and 0)

MICROBIOLOGY

M. J. B. Paynter, Head, Department of Microbiology

Courses are offered leading to the Master of Science degree. The Doctor of Philosophy degree is offered in plant physiology with an emphasis in microbiology.

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

All students complete a basic core curriculum that includes general biochemistry, bacterial cytology and physiology, bacterial metabolism, current topics, and an advanced laboratory course in microbiological techniques. The remainder of the program is chosen by the student with the guidance and approval of an advisory committee. Each candidate must present and defend a thesis based upon original research.

Research disciplines include pathogenic, food, environmental, and

marine microbiology; microbial ecology; bacterial and plant virology; molecular biology; microbial genetics; microbial physiology and metabolism, and anaerobic microbiology.

In addition to the Master of Science degree in microbiology, the department participates in an interdepartmental program awarding the Doctor of Philosophy with a major in plant physiology. This program offers opportunities for doctoral research in microbiology. It is described under Plant Physiology in the College of Agricultural Sciences.

MICRO 600   PUBLIC HEALTH MICROBIOLOGY
              3 cr. (3 and 0) S

MICRO 601   ADVANCED BACTERIOLOGY
              4 cr. (2 and 6) F

MICRO 602   DAIRY MICROBIOLOGY
              3 cr. (2 and 3) S (even numbered years)

MICRO 603   MARINE MICROBIOLOGY
              3 cr. (2 and 3)

MICRO 604   FOOD MICROBIOLOGY
              3 cr. (2 and 3) S (odd numbered years)

MICRO 605   GENERAL MICROBIOLOGY
              4 cr. (3 and 3) F, S, SS

MICRO 610   SOIL MICROBIOLOGY
              3 cr. (2 and 3) S (even numbered years)

MICRO 611   PATHOGENIC BACTERIOLOGY
              4 cr. (3 and 3) S

MICRO 612   BACTERIAL PHYSIOLOGY
              4 cr. (3 and 3) S

MICRO 613   INDUSTRIAL MICROBIOLOGY
              3 cr. (2 and 3) F

MICRO 614   BASIC IMMUNOLOGY
              3 cr. (2 and 3) F

MICRO 615   MICROBIAL GENETICS
              4 cr. (3 and 3) S

MICRO 616   INTRODUCTORY VIROLOGY
              3 cr. (3 and 0) F

MICRO 802   BACTERIOLOGICAL TECHNIC
              4 cr. (2 and 6) F
   Analytical and experimental procedures used in bacteriology, including

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techniques for studying bacterial cytology, physiology, and metabolism. Designed to give students experience in more advanced methods of investigation.

MICRO 803   SPECIAL PROBLEMS IN MICROBIOLOGY
            Credit to be arranged.
Research not related to thesis.

MICRO 804   CURRENT TOPICS IN MICROBIOLOGY
            1 cr. (1 and 0)
Evaluation of current research literature in various areas of microbiology; critical evaluation of specific publications in terms of their merit. Required of all microbiology graduate students; may be repeated for credit.

MICRO 807   SEMINAR
            1 cr. (1 and 0)
Topics not covered in other courses. Students review literature, organize and present material; may be taken for credit twice.

MICRO 811   BACTERIAL CYTOLOGY AND PHYSIOLOGY
            4 cr. (4 and 0) S (odd numbered years)
Structure, chemistry and physiology of the various bacterial cell components; physiology of bacterial growth and reproduction in batch, continuous and synchronous cultures; economy of the bacterial cell, including endogenous metabolism and maintenance requirements; physiology of bacterial death; regulation of enzyme and nucleic acids syntheses. **Prerequisites:** MICRO 305/605; BIOCH 423/623 and 424/624 or concurrent registration in BIOCH 424/624; MATH 206, or permission of instructor.

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MICRO 812   BACTERIAL METABOLISM
            3 cr. (3 and 0) S (even numbered years)
Various biochemical pathways occurring in bacterial cells; fermentations of carbohydrates and related compounds and of nitrogenous organic compounds; anaerobic and aerobic respiration, including electron transport systems and oxidative phosphorylation; bacterial photosynthesis; nitrogen fixation; biosyntheses of amino acids, purines, pyrimidines, lipids, proteins, nucleic acids and polysaccharides. **Prerequisites:** MICRO 305/605; BIOCH 423/623 and 424/624 or concurrent registration in BIOCH 424/624; MATH 206 or permission of instructor.

MICRO 815   ADVANCED MICROBIAL GENETICS
            3 cr. (3 and 0) S (odd numbered years)
Current developments in microbial genetics; integration of genetics and biochemistry, analysis of genetic fine structure in microorganisms; nature of bacterial variation and expression of mutations; population dynamics; physio-chemical mechanisms of heredity; regulation of gene action in microorganisms; physiology and genetics of virulent and lysogenic bacteriophages. **Prerequisite:** MICRO 415/615.

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

MICRO 991   DOCTORAL DISSERTATION RESEARCH
            Credit to be arranged.

PHYSICS

J. P. McKelvey, Head, Department of Physics and Astronomy

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

For the Master of Science degree:

A student is admitted to candidacy for the M.S. degree upon completion of a written qualifying examination covering topics determined by the faculty. This examination must be completed one semester before the date on which the degree is expected.

It is usually recommended that students submit a thesis to fulfill the requirements for the M.S. degree; however a non-thesis option is available. In the non-thesis option, a minimum of 36 credit hours is required, including six credit hours of PHYS 890, Directed Activities in Applied Physics. A written report must be submitted in connection with this activity.

A final oral examination is required on the student's general area of study, and on the thesis or the directed activities report.

A program leading to the M.S. degree in physics with a concentration in health physics is available. A different selection of course work, including six credits of health physics or biophysics and nine credits of courses in biology, biochemistry, or chemistry is prescribed.

For the Doctor of Philosophy degree:

Students who enter with a bachelor's degree will take the qualifying examination for the M.S. degree. Students whose performance is satisfactory to the faculty may by-pass the master's degree. Otherwise, the M.S. degree must be awarded as an integral part of the doctoral program.

Students are admitted to candidacy for the Ph.D. degree upon the successful completion of a written qualifying examination on topics determined by the faculty. This examination must be completed at least one academic year prior to the date on which the degree is expected.

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

Teaching in undergraduate courses is an integral part of graduate study in physics and is required of all graduate students.

Astronomy

Students may specialize in astronomy or astrophysics, although their M.S. or Ph.D. degrees will be awarded in physics.

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)

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PHYS 621   MECHANICS I
3 cr. (3 and 0)

PHYS 622   MECHANICS II
3 cr. (3 and 0)

PHYS 625   EXPERIMENTAL PHYSICS I
4 cr. (2 and 6)

PHYS 626   EXPERIMENTAL PHYSICS II
4 cr. (2 and 6)

PHYS 632   PHYSICAL OPTICS AND INTRODUCTION TO SPECTROSCOPY
3 cr. (3 and 0)

PHYS 640   ELECTRICITY AND MAGNETISM I
3 cr. (3 and 0)

PHYS 641   ELECTRICITY AND MAGNETISM II
3 cr. (3 and 0)

PHYS 646   SOLID STATE PHYSICS
3 cr. (3 and 0)

PHYS 652   NUCLEAR AND PARTICLE PHYSICS
3 cr. (3 and 0)

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PHYS 655   QUANTUM PHYSICS I
3 cr. (3 and 0)

PHYS 656   QUANTUM PHYSICS II
3 cr. (3 and 0)

PHYS 657   BASIC HEALTH AND RADIOLOGICAL PHYSICS I
3 cr. (3 and 0)

PHYS 658   BASIC HEALTH AND RADIOLOGICAL PHYSICS II
3 cr. (3 and 0)

PHYS 660   CONTEMPORARY PHYSICS FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0)

PHYS 665   THERMODYNAMICS AND STATISTICAL MECHANICS
3 cr. (3 and 0)

PHYS 671   ELECTRON MICROSCOPY
3 cr. (2 and 3)

PHYS 673   X-RAY CRYSTALLOGRAPHY
3 cr. (2 and 3)

PHYS 700   PHYSICAL SCIENCE IN ELEMENTARY SCHOOL—PHYSICS
3 cr. (3 and 0)

Physical sciences as appropriate for teaching elementary school students; demonstrations and experiments that can be conducted with equipment available to elementary school teachers; topics mainly involve physics and astronomy. Restricted to students in elementary education.

PHYS 701   PHYSICS FOR HIGH SCHOOL TEACHERS I
4 cr. (3 and 3)
Fundamental ideas of time, space, and matter; motion; optics; waves. Laboratory experiments form an integral part of the course. Restricted to students in secondary education.

PHYS 702   PHYSICS FOR HIGH SCHOOL TEACHERS II
4 cr. (3 and 3)
Continuation of PHYS 701; Newton's laws of motion, universal gravitation, conservation laws, electricity and magnetism. Restricted to students in secondary education. **Prerequisite:** PHYS 701 or permission of instructor.

PHYS 703   MODERN PHYSICS FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0)
Rutherford model of the atom, molecular description of matter, quantum theory of matter, nuclear forces, radioactivity, special relativity. Restricted to students in secondary education.

PHYS 715   EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS I
4 cr. (2 and 4)
Experimental techniques employed in determination of fundamental quantities in classical and modern physics; experiments which may be demonstrated in the classroom and which broaden the concepts of physics. Restricted to students in secondary education.

PHYS 716   EXPERIMENTAL PHYSICS FOR HIGH SCHOOL TEACHERS II
4 cr. (2 and 4)
Continuation of PHYS 715. Restricted to students in secondary education.

PHYS 723   WEATHER SCIENCE FOR SCIENCE TEACHERS
3 cr. (3 and 0)
Meteorological phenomena emphasizing non-mathematical descriptions of atmospheric physics principles; solar and terrestrial radiation, adiabatic processes and cloud formation, local severe storms, global circulation patterns, air mass motions and fronts. Restricted to students in secondary education.

PHYS 811   METHODS OF THEORETICAL PHYSICS I
3 cr. (3 and 0)
Analytical methods and techniques used in theoretical physics; vector and tensor analysis as applied to physical problems, use of matrices and groups in classical and quantum mechanics, complex variables and partial differential equations of physics.

PHYS 812   METHODS OF THEORETICAL PHYSICS II
3 cr. (3 and 0)
Continuation of PHYS 811; use of integral transforms, integral equations,

special functions, calculus of variations and numerical approximations in solution of physical problems.

PHYS 813   ADVANCED THERMODYNAMICS AND STATISTICAL MECHANICS I
3 cr. (3 and 0)
Thermodynamics including thermodynamic potentials, phase transitions, and very low temperatures; Bortzmann integrodifferential equation and kinetic theory of gases and plasmas; classical statistical mechanics.

PHYS 814   ADVANCED THERMODYNAMICS AND STATISTICAL MECHANICS II
3 cr. (3 and 0)
Quantum statistical mechanics; microcanonical, canonical, and grand canonical ensemble theories; ideal Fermi gas and ideal Bose gas; special topics in advanced statistical mechanics.

PHYS 821   CLASSICAL MECHANICS I
3 cr. (3 and 0)
Dynamics of particles, variational principles and Lagrange's equations; two-body central force problems; dynamics of rigid bodies. Matrix formulations freely used.

PHYS 822   CLASSICAL MECHANICS II
3 cr. (3 and 0)
Special relativity in classical mechanics, Hamilton's equations, canonical transformations, Hamilton-Jacobi theory, small oscillations.

PHYS 841   ELECTRODYNAMICS I
3 cr. (3 and 0)
Field theory of electromagnetism; Maxwell's equations and their application to study of electromagnetic wave production and propagation, wave optics and theories of interference and diffraction.

PHYS 842   ELECTRODYNAMICS II
3 cr. (3 and 0)
Production and propagation of electromagnetic waves beginning with use of Maxwell's equations; discussions of wave guides, diffraction phenomenon, and boundary effects; theory of electrons and microscopic phenomena.

PHYS 845   SOLID STATE PHYSICS I
3 cr. (3 and 0)
Physical properties of crystalline solids; crystalline state determination by diffraction methods, theories of specific heat, properties of metallic lattices and alloys, lattice energy and ferroelectrics.

PHYS 846   SOLID STATE PHYSICS II
3 cr. (3 and 0)
Continuation of PHYS 845; electronic properties of solids; band theory of solids, physics of semiconductors, theories of magnetism and magnetic resonance phenomena.

PHYS 853   NUCLEAR PHYSICS
3 cr. (3 and 0)
Nuclear structure, nuclear forces and nuclear interaction processes; shell structure, spins, and magnetic moments of nuclear particles.

PHYS 875   SEMINAR IN CONTEMPORARY PHYSICS
1-3 cr. (1-3 and 0)
Students and interested faculty study areas of physics currently being extensively investigated.

PHYS 890   DIRECTED ACTIVITIES IN APPLIED PHYSICS
1-6 cr.
Training and work on practical problems. Activities are supervised by departmental faculty or by appropriate adjunct professor; written description of student's activities must be submitted to course supervisor at completion of activity. Maximum credit limits are six credit hours in a semester and three credit hours in a single summer session; graded on a pass-fail basis.

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

PHYS 951   QUANTUM MECHANICS I
3 cr. (3 and 0)
Review of wave mechanics; operator algebra and theory of representation; approximate methods for stationary problems; theory of scattering applied to atomic and nuclear problems.

PHYS 952   QUANTUM MECHANICS II
3 cr. (3 and 0)
Continuation of PHYS 951 including time dependent perturbations, radiation absorption and emission, relativistic quantum mechanics, introduction to quantum electrodynamics.

PHYS 955   ADVANCED MODERN PHYSICS I
3 cr. (3 and 0)
Application of quantum mechanics and relativity theory to selected topics of recent interest in physics; atomic and nuclear structure, radioactivity and nuclear stability, molecular structure, theory of solids.

PHYS 956   ADVANCED MODERN PHYSICS II
3 cr. (3 and 0)
Continuation of PHYS 955; topics of special interest to instructor and students.

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.

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PHYS 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

No degrees are offered in astronomy. Courses are offered to provide electives for students in other areas.

ASTR 607   INTRODUCTION TO ASTROPHYSICS
3 cr. (3 and 0)

ASTR 608   INTRODUCTION TO GALACTIC ASTRONOMY
3 cr. (3 and 0)

ASTR 612   SPHERICAL ASTRONOMY
3 cr. (3 and 0)

ASTR 621   INTRODUCTION TO RADIO ASTRONOMY
3 cr. (3 and 0)

ASTR 701   SOLAR SYSTEM ASTRONOMY FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0)
A lecture and observation course introducing concepts and descriptions basic to modern astronomy. The solar system is surveyed, with fundamental physical principles introduced as needed. Planetarium demonstrations and observing sessions are included. Restricted to students in secondary education.

ASTR 711   STELLAR ASTRONOMY FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0)
Lecture and observation course; stellar and galactic astronomy, energy sources, other topics of current interest. Planetarium programs and observing sessions are included. Restricted to students in secondary education.

ASTR 875   SEMINAR IN CONTEMPORARY ASTRONOMY
1-3 cr. (1-3 and 0)
Students and faculty study areas of astronomy of current interest.

ZOOLOGY

C. W. Helms, Head, Department of Zoology

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

Requirements for the M.S. degree include 24 semester hours of course work, six hours of research, an acceptable thesis, and satisfactory performance in a final oral examination.

Requirements for the Ph.D. degree include written qualifying and oral comprehensive examinations, research, a dissertation, and satisfactory performance in a final oral defense. While there are no required numbers of hours of course work for the doctorate beyond 18 semester hours of research, breadth and depth of preparation in the life sciences will be expected of each candidate.

ZOOL 603   PROTOZOOLOGY
            3 cr. (2 and 3) S

ZOOL 605   ANIMAL HISTOLOGY AND HISTOLOGY TECHNIQUES
            4 cr. (2 and 6)

ZOOL 610   LIMNOLOGY
            3 cr. (2 and 3) F

ZOOL 611   ANIMAL ECOLOGY
            4 cr. (3 and 3) F, S

ZOOL 612   AQUATIC ECOLOGY
            4 cr. (3 and 3)

ZOOL 615   INTRODUCTION TO MATHEMATICAL ECOLOGY
            3 cr. (3 and 0)

ZOOL 620   PRINCIPLES OF EVOLUTION
            3 cr. (3 and 0)

ZOOL 621   ADVANCED INVERTEBRATE ZOOLOGY
            4 cr. (3 and 3)

ZOOL 650   COMPARATIVE VERTEBRATE EMBRYOLOGY
            4 cr. (3 and 3)

ZOOL 656   PARASITOLOGY
            4 cr. (3 and 3) S

ZOOL 657   COMPARATIVE PHYSIOLOGY
            4 cr. (3 and 3)

ZOOL 658   CELL PHYSIOLOGY
            4 cr. (3 and 3)

ZOOL 659   SYSTEMS PHYSIOLOGY
            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   MAMMALOGY
            3 cr. (2 and 3) F

ZOOL 665   ORNITHOLOGY
            3 cr. (2 and 3) S

ZOOL 670   ANIMAL BEHAVIOR
            3 cr. (3 and 0)

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ZOOL 671   ANIMAL BEHAVIOR LABORATORY
1 cr. (0 and 3)

ZOOL 674   INVERTEBRATE ENDOCRINOLOGY
3 cr. (2 and 3) S

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 681   METHODS IN DEVELOPMENTAL BIOLOGY
2 cr. (0 and 6)

ZOOL 700   MODERN DEVELOPMENTS IN ZOOLOGY FOR HIGH SCHOOL TEACHERS
3 cr. (3 and 0) SS
Contemporary developments in zoology, advances in teaching methods and new equipment and technology. Restricted to graduate students in secondary education.

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ZOOL 701   MAN'S IMPACT ON ECOLOGY
3 cr. (3 and 0) SS
Fundamental relationship of man to his environment as it developed from prehistoric time to present; current overpopulation and pollution. Restricted to graduate students in secondary education.

ZOOL 702   FIELD METHODS IN ZOOLOGY FOR HIGH SCHOOL TEACHERS
3 cr. (2 and 3) SS
Non-technical lecture and field laboratory course designed to acquaint secondary teacher with local fauna. Collection, identification, and use in teaching laboratory stressed. Restricted to graduate students in secondary education.

ZOOL 803   POPULATION DYNAMICS
4 cr. (2 and 6) S (even numbered years)
Fundamental mechanisms basic to regulation of natural animal populations. Laboratory research project in population dynamics complements theory.

ZOOL 810   BEHAVIORAL ECOLOGY
3 cr. (3 and 0) F (odd numbered years)
Behavior of animals and the ecological context in which various behaviors are shown; empirical and theoretical aspects of behavioral ecology at individual, population and community levels. **Prerequisites:** ZOOL 411/611, 470/670, or permission of instructor.

ZOOL 812   SEMINAR
1 cr. (1 and 0) F, S, SS
Current literature on zoology.

ZOOL 813   EVOLUTION
             2 cr. (2 and 0)
Theoretical topics of current interest to evolutionary biologists. **Prerequisite:** ZOOL 420/620 or permission of instructor.

ZOOL 815   PHYSIOLOGICAL ECOLOGY
             4 cr. (3 and 3) F (even numbered years)
Physiological and biochemical adaptations of invertebrates and vertebrates toward various natural environmental parameters. Field trips acquaint student with natural macro- and micro-environments of individual species; field measurements of parameters of the environment will be undertaken and laboratory studies will furnish detailed knowledge of various physiological adaptations to these parameters.

ZOOL 816   ADVANCED ECOSYSTEM 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:** MATH 210 and 405/605, ZOOL 411/611 or BOT 441/641, ZOOL 415/615, or permission of instructor.

ZOOL 817   ADVANCED ECOSYSTEM ANALYSIS II
             4 cr. (3 and 3)
Thermodynamic principles that permit the persistence of ecosystems in time and space are examined based upon specific descriptions developed in ZOOL 816. Laboratory focuses on application of these stability theories to actual field and laboratory research problems. **Prerequisite:** ZOOL 816.

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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 tissues from various organisms at different phylogenetic levels will be stressed. **Prerequisite:** AN PH 801 or ZOOL 405/605, or permission of instructor.

ZOOL 845   ADVANCED CELL PHYSIOLOGY
             4 cr. (3 and 3)
Chemical and physical approach to problems of cell function including energetics, membrane transport, metabolic pathways, contractility and properties of excitable membranes. **Prerequisite:** ZOOL 458/658 or permission of instructor.

ZOOL 852   PRINCIPLES AND METHODS OF SYSTEMATIC ZOOLOGY
             2 cr. (2 and 0) F (even numbered years)
Problems confronting taxonomists in zoological sciences and conventional practices developed to handle them.

ZOOL 856   HELMINTHOLOGY
             3 cr. (2 and 3)
Symbiotic helminths emphasizing structure, life histories, ecology, physiology and biochemistry. **Prerequisite:** ZOOL 456/656 or permission of instructor.

ZOOL 861   SPECIAL TOPICS
1–4 cr. (1–4 and 0)
Current areas of active research interest in zoological sciences.

ZOOL 863   SPECIAL PROBLEMS
1–4 cr. F, S, SS
Research not related to thesis. **Prerequisite:** Permission of instructor.

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

ZOOL 991   DOCTORAL DISSERTATION RESEARCH
Credit to be arranged.

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DIRECTORY FOR CORRESPONDENCE

Mailing Address
Clemson University, Clemson, South Carolina 29631.

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(803)656–3311.

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The business and administrative offices of the University are open 8 a.m. to noon and 1 to 4:30 p.m. Monday through Friday for 12 months of the year except for official University holidays.

CLEMSON
UNIVERSITY

CLEMSON, SOUTH CAROLINA 29631