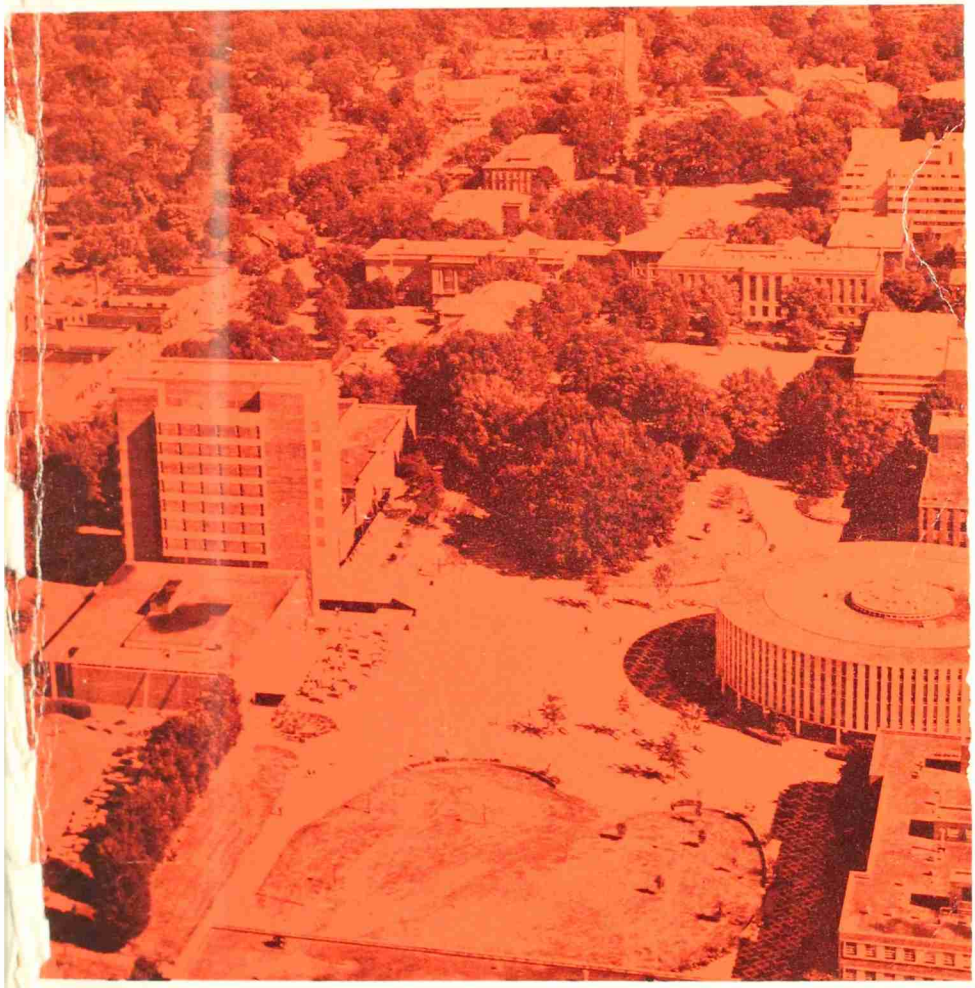
North Carolina State University Bulletin

1974-76



Graduate Catalog

December, 1973

Poe Hall, headquarters of the School of Education, is one of 120 buildings located on 596 acres which makes up the central campus of North Carolina State University.

NORTH CAROLINA STATE UNIVERSITY BULLETIN
VOLUME 73 DECEMBER 1973 NUMBER 4

Published four times a year in February, June, August and December by North Carolina State University, Department of Admissions, Peele Hall, P. O. Box 5126, Raleigh, N. C. 27607. Second class postage paid at Raleigh, N. C. 27611.

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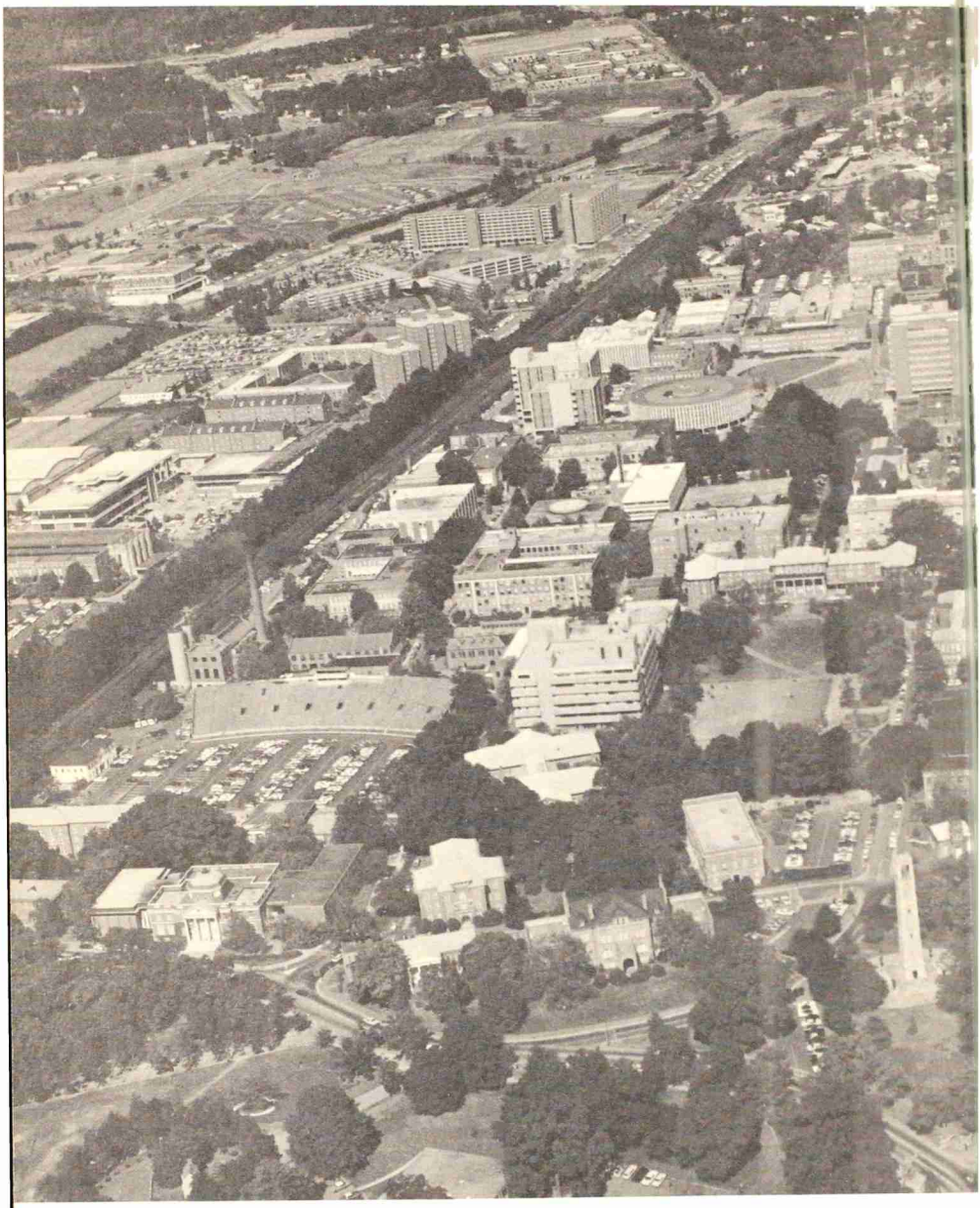
North Carolina State University

Raleigh, North Carolina

Graduate Catalog 1974-76

North Carolina State University



North Carolina State University ranges from this central campus in Raleigh to sites throughout the state, including research stations and forests, biology and ecology sites, nurseries, and coastal facilities. NCSU fulfills three major functions—research, extension and academic affairs.

The University of North Carolina

Sixteen Constituent Institutions

William Clyde Friday, B.S., LL.B., LL.D., *President*
Raymond Howard Dawson, B.A., M.A., Ph.D., *Vice President—Academic Affairs*
Harold Delaney, B.S., M.S., Ph.D., *Vice President—Student Services and Special Programs*
L. Felix Joyner, A.B., *Vice President—Finance*
John L. Sanders, A.B., J.D., *Vice President—Planning*
George Eldridge Bair, B.A., M.A., Ph.D., *Director of Educational Television*
James L. Jenkins Jr., A.B., *Assistant to the President*
Edgar Walton Jones, B.S., M.S., Ph.D., *Associate Vice President, Research and Public Service*
John P. Kennedy Jr., S.B., B.A., M.A., J.D., *Secretary of the University*
Arnold Kimsey King, A.B., A.M., Ph.D., *Assistant to the President*
Roscoe D. McMillan, Jr., B.S., *Assistant to the President for Governmental Affairs*
Richard H. Robinson Jr., A.B., LL.B., *Assistant to the President*
Alexander Hurlbutt Shepard Jr., M.A., *Assistant Vice President—Finance and Treasurer*
J. Lem Stokes II, A.B., M.Div., Ph.D., *Associate Vice President—Academic Affairs*
Robert W. Williams, A.B., M.A., Ph.D., *Associate Vice President—Academic Affairs*

The University of North Carolina was chartered in 1789 and opened its doors to students at its Chapel Hill campus in 1795. Throughout most of its history, it has been governed by a Board of Trustees chosen by the Legislature and presided over by the Governor. During the period 1917-1972, the Board consisted of 100 elected members and a varying number of ex-officio members.

By act of the General Assembly of 1931, without change of name, it was merged with The North Carolina College for Women at Greensboro and The North Carolina State College of Agriculture and Engineering at Raleigh to form a multicampus institution designated The University of North Carolina.

In 1963 the General Assembly changed the name of the campus at Chapel Hill to The University of North Carolina at Chapel Hill and that at Greensboro to The University of North Carolina at Greensboro and, in 1965, the name of the campus at Raleigh was changed to North Carolina State University at Raleigh.

Charlotte College was added as The University of North Carolina at Charlotte in 1965, and, in 1969, Asheville-Biltmore College and Wilmington College became The University of North Carolina at Asheville and The University of North Carolina at Wilmington respectively.

A revision of the North Carolina State Constitution adopted in November 1970 included the following: "The General Assembly shall maintain a public system of higher education, comprising The University of North Carolina and such other institutions of higher education as the General Assembly may deem wise. The General Assembly shall provide for the selection of trustees of The University of North Carolina . . . ." In slightly different language, this provision had been in the Constitution since 1868.

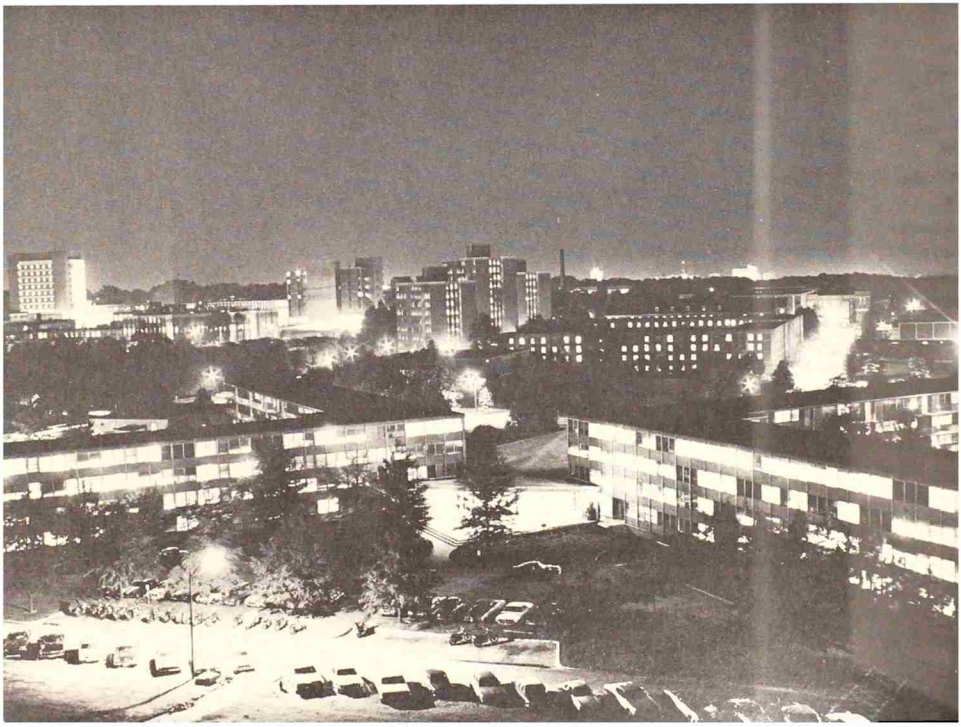
On October 30, 1971, the General Assembly in special session merged, without changing their names, the remaining 10 state-supported senior institutions into the University as follows: Appalachian State University, East Carolina University, Elizabeth City State University, Fayetteville State University, North Carolina Agricultural and Technical State University, North Carolina Central University, North Carolina School of the Arts, Pembroke State University, Western Carolina University, and Winston-Salem State University. This merger, which resulted in a statewide multi-campus university of 16 constituent institutions, became effective on July 1, 1972.

The constitutionally authorized Board of Trustees was designated the Board of Governors, and the number was reduced to 32 members elected by the General Assembly and with the authority to choose its own chairman and other officers. The Board is "responsible for the general determination, control, supervision, management, and governance of all affairs of the constituent institutions." However, each constituent institution has its own board of trustees of 13 members, eight of whom are appointed by the Board of Governors, four by the Governor, and one of whom, the elected president of the student body, serves *ex officio*. The principal powers of each institutional board are exercised under a delegation from the Board of Governors.

Each institution has its own faculty and student body, and each is headed by a chancellor as its chief administrative officer. Unified general policy and appropriate allocation of function are effected by the Board of Governors and by the President with the assistance of other administrative officers of the University. The General Administration office is located in Chapel Hill.

The chancellors of the constituent institutions are responsible to the President as the chief administrative and executive officer of The University of North Carolina.

Residence halls, in the foreground, are conveniently located near NCSU's central University Plaza where the D. H. Hill Library (far left) offers services.



CONTENTS

Dr. Walter J. Peterson
Dean of the Graduate School

The Graduate School of North Carolina State University has developed most significantly in both qualitative and quantitative dimensions in the last 17 years, during the tenure of Dean Peterson, dean of the Graduate School, 1957-1974. Some 60 masters and 40 doctoral programs are now offered. Graduate enrollment was 508 in 1957; in the fall of 1973 it reached 2,370. The development of the Graduate School has been a significant feature of the University's service. (Statement by Chancellor John T. Caldwell)

ADMINISTRATION

John T. Caldwell, *Chancellor*
Harry C. Kelly, *Vice Chancellor for Academic Affairs and Provost*
John D. Wright, *Vice Chancellor for Finance and Business*
Walter J. Peterson, *Dean, Graduate School*
Earl G. Droessler, *Administrative Dean for Research*
William L. Turner, *Vice Chancellor for Extension and Public Service*
Jackson A. Rigney, *Dean, International Programs*

Deans of Schools

James E. Legates, *Agriculture and Life Sciences*
Claude E. McKinney, *Design*
Carl J. Dolce, *Education*
Ralph E. Fadum, *Engineering*
Eric L. Ellwood, *Forest Resources*
Robert O. Tilman, *Liberal Arts*
Arthur C. Menius, *Physical and Mathematical Sciences*
David W. Chaney, *Textiles*

Graduate School—Administrative Office

Walter J. Peterson, *Dean*
Ralph J. Peeler, *Assistant Dean*
Patsy H. Lloyd, *Assistant to the Dean*

Graduate School—Administrative Board

	Term Expires
Walter J. Peterson, *Dean*	
Ralph J. Peeler, *Assistant Dean*	
Richard R. Wilkinson, *Prof. and Head Landscape Architecture*	May 1975
Howard M. Nahikian, *Prof. of Mathematics*	March 1975
William A. Jackson, *Reynolds Prof. of Soil Science*	July 1975
LeRoy C. Saylor, *Prof. of Genetics and Forestry, Assistant Dean Forest Resources*	July 1975
Wesley O. Doggett, *Prof. of Physics*	Sept. 1975
Durwin M. Hanson, *Prof. and Head Industrial and Technical Education*	Nov. 1975
Larry S. Champion, *Prof. and Head English*	Feb. 1976
Solomon P. Hersh, *Cannon Prof. of Textiles*	Sept. 1976
Carl F. Zorowski, *Reynolds Prof. of Mechanical Engineering and Head Mechanical and Aerospace Engineering*	March 1977
Philip A. Miller, *Prof. of Crop Science and Genetics*	Nov. 1977
Thomas S. Elleman, *Professor of Nuclear Engineering*	Dec. 1977

THE CALENDAR*

FALL SEMESTER, 1973

August 20-24	Mon.-Fri.	Opening days (counseling, advising, late orientation, etc.).
August 27	Mon.	General faculty meeting. Registration day —all students complete registration.
August 28	Tues.	Change day. (Late registration, drop/add.)
August 29	Wed.	First day of classes.
September 3	Mon.	Holiday.
September 5	Wed.	Last day to add a course. *Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in December, 1973.*
September 12	Wed.	Last day to withdraw or drop a course with refund.
October 19	Fri.	Mid-term reports due.
November 2	Fri.	Last day to drop a course without a grade.
November 9	Fri.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in December, 1973. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
November 21	Wed.	Thanksgiving holidays begin at 1 p.m.
November 26	Mon.	Classes resume at 8 a.m.
December 7	Fri.	Last day of classes.
December 8-9	Sat.-Sun.	Reading days.
December 10-19	Mon.-Sat. Mon.-Wed.	Final examinations.

SPRING SEMESTER, 1974

January 7	Mon.	Opening day (counseling, advising, new student orientation, etc.). Registration day —all students complete registration.
January 8	Tues.	Change day. (Late registration, drop/add.)
January 9	Wed.	First day of classes.
January 16	Wed.	Last day to add a course. *Last day for filing applications for admission to candidacy for*

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

* The calendar is tentative, subject to approval or change by the Board of Trustees.

		students expecting to complete requirements for the master's degree in May and July, 1974.
January 23	Wed.	Last day to withdraw or drop a course with refund.
March 1	Fri.	Mid-term reports due. Spring vacation begins at 10 p.m.
March 11	Mon.	Classes resume at 8 a.m.
March 15	Fri.	Last day to drop a course without a grade.
March 29	Fri.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in May, 1974. Last day for taking final oral examination by candidates for master's degrees not requiring theses.*
April 15	Mon.	Holiday.
April 26	Fri.	Last day of classes.
April 27-28	Sat.-Sun.	Reading days.
April 29-May 8	Mon.-Sat. Mon.-Wed.	Final examinations.
May 11	Sat.	Commencement.

SUMMER SESSIONS, 1974

First Session

May 20	Mon.	Registration day — all students complete registration.
May 21	Tues.	First day of classes.
May 24	Fri.	Last day to register; last day to withdraw or drop a course with refund.
May 28	Tues.	*Deadline for submission of theses in final form to the Graduate School by candidates for master's and doctoral degrees in July, 1974. Last day for taking final oral examinations by candidates for master's degrees not requiring theses. Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in August, 1974.*
June 6	Thurs.	Last day to drop a course without a grade.
June 24	Mon.	Last day of classes.
June 25	Tues.	Final examinations.

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students a least one semester before the anticipated date for scheduling the final oral examination.

Second Session

July 1	Mon.	Registration day — all students complete registration.
July 2	Tues.	First day of classes.
July 4	Thurs.	Holiday.
July 8	Mon.	Last day to register, last day to withdraw or drop a course with refund.
July 10	Wed.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in August, 1974. Last day for taking final oral examinations by candidates for the master's degree not requiring theses.*
July 19	Fri.	Last day to drop a course without a grade.
August 6	Tues.	Last day of classes.
August 7	Wed.	Final examinations.

FALL SEMESTER, 1974

August 19-23	Mon.-Fri.	Opening days (counseling, advising, late orientation, etc.).
August 26	Mon.	General faculty meeting. All students complete registration.
August 27	Tues.	Change day (late registration, drop/add).
August 28	Wed.	First day of classes.
September 2	Mon.	Holiday.
September 4	Wed.	Last day to add a course. *Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in December, 1974.*
September 11	Wed.	Last day to withdraw or drop a course with refund.
October 18	Fri.	Mid-term reports due.
November 1	Fri.	Last day to drop a course without a grade.
November 8	Fri.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in December, 1974. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
November 27	Wed.	Thanksgiving vacation begins at 1 p.m.
December 2	Mon.	Classes resume at 8 a.m.

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

December 6	Fri.	Last day of classes.
December 7-8	Sat.-Sun.	Reading days.
December 9-18	Mon.-Sat. Mon.-Wed.	Final examinations.

SPRING SEMESTER, 1975

January 13	Mon.	Opening day (counseling, advising, new student orientation, etc.). Registration day—all students complete registration.
January 14	Tues.	Change day (late registration, drop/add).
January 15	Wed.	First day of classes.
January 22	Wed.	Last day to add a course. *Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in May and July, 1975.*
January 29	Wed.	Last day to withdraw (or drop a course) with refund.
March 7	Fri.	Mid-term reports due; spring vacation begins at 10 p.m.
March 17	Mon.	Classes resume at 8 a.m.
March 21	Fri.	Last day to drop a course without a grade.
March 31	Mon.	Holiday.
April 4	Fri.	*Deadline for submission of theses in final form to the Graduate School by candidates for master's and doctoral degrees in May 1975. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
May 2	Fri.	Last day of classes.
May 3-4	Sat.-Sun.	Reading days.
May 5-14	Mon.-Sat. Mon.-Wed.	Final examinations.
May 17	Sat.	Commencement.

SUMMER SESSIONS, 1975 *

First Session

May 20	Tues.	Registration day—all students complete registration.
May 21	Wed.	First day of classes.
May 26	Mon.	Last day to register; last day to withdraw or drop a course with refund.

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

* Tentative calendar, subject to change.

May 27	Tues.	*Deadline for submission of theses in final form to the Graduate School by candidates for master's and doctoral degrees in July, 1975. Last day for taking final oral examinations by candidates for master's degrees not requiring theses. Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in August 1975.*
June 6	Fri.	Last day to drop a course without a grade.
June 24	Tues.	Last day of classes.
June 25	Wed.	Final examinations.

Second Session

June 30	Mon.	Registration day—all students complete registration.
July 1	Tues.	First day of classes.
July 3	Thurs.	Last day to register; last day to withdraw or drop a course with refund.
July 4	Fri.	Holiday.
July 9	Wed.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in August, 1975. Last day for taking final oral examinations by candidates for the master's degree not requiring theses.*
July 18	Fri.	Last day to drop a course without a grade.
August 5	Tues.	Last day of classes.
August 6	Wed.	Final examinations.

FALL SEMESTER, 1975

August 18-22	Mon.-Fri.	Opening days (counseling, advising, orientation, etc.).
August 25	Mon.	General faculty meeting. All students complete registration.
August 26	Tues.	Change day (late registration, drop/add).
August 27	Wed.	First day of classes.
September 1	Mon.	Holiday.
September 3	Wed.	Last day to add a course. *Last day for filing application for admission to candidacy for students expecting to complete require-*

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

		ments for the master's degree in December, 1975.
September 10	Wed.	Last day to withdraw or drop a course with refund.
October 17	Fri.	Mid-term reports due.
October 31	Fri.	Last day to drop a course without a grade.
November 7	Fri.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degrees in December, 1975. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
November 26	Wed.	Thanksgiving vacation begins at 1 p.m.
December 1	Mon.	Classes resume at 8 a.m.
December 5	Fri.	Last day of classes.
December 6-7	Sat.-Sun.	Reading days.
December 8-17	Mon.-Sat. Mon.-Wed.	Final examinations.

SPRING SEMESTER, 1976

January 12	Mon.	Opening day (counseling, advising, new student orientation, etc.). All students complete registration.
January 13	Tues.	Change day (late registration, drop/add).
January 14	Wed.	First day of classes.
January 21	Wed.	Last day to add a course. *Last day for filing applications for admission to candidacy for students expecting to complete requirements for the master's degree in May and July, 1976.*
January 28	Wed.	Last day to withdraw or drop a course with refund.
March 5	Fri.	Mid-term reports due; spring vacation begins at 10 p.m.
March 15	Mon.	Classes resume at 8 a.m.
March 19	Fri.	Last day to drop a course without a grade.
April 2	Fri.	*Deadline for submission of theses in final form to Graduate School by candidates for the master's and doctoral degrees in December, 1976. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
April 19	Mon.	Holiday.
April 30	Fri.	Last day of classes.

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

May 1-2	Sat.-Sun.	Reading days.
May 3-12	Mon.-Sat. Mon.-Wed.	Final examinations.
May 15	Sat.	Commencement.

SUMMER SESSIONS, 1976*

First Session

May 18	Tues.	Registration day—all students complete registration.
May 19	Wed.	First day of classes.
May 24	Mon.	Last day to register; last day to withdraw or drop a course with refund.
May 26	Wed.	*Deadline for submission of theses in final form to Graduate School by candidates for the master's and doctoral degrees in July 1976. Last day for taking final oral examination by candidates for master's degrees not requiring theses. Last day for filing application for admission to candidacy for students expecting to complete requirements for the master's degree in August 1976.*
June 4	Fri.	Last day to withdraw or drop a course without a grade.
June 22	Tues.	Last day of classes.
June 23	Wed.	Final examinations.

Second Session

June 28	Mon.	Registration day—all students complete registration.
June 29	Tues.	First day of classes.
July 2	Fri.	Last day to register; last day to withdraw or drop a course with refund.
July 5	Mon.	Holiday.
July 7	Wed.	*Deadline for submission of theses in final form to the Graduate School by candidates for the master's and doctoral degree in August 1976. Last day for taking final oral examinations by candidates for master's degrees not requiring theses.*
July 16	Fri.	Last day to withdraw or drop a course without a grade.
Aug 3	Tues.	Last day of classes.
August 4	Wed.	Final examinations.

NOTE: Chairmen of doctoral advisory committees are reminded to schedule preliminary examinations for their students at least one semester before the anticipated date for scheduling the final oral examination.

* Tentative calendar, subject to change.

The D. H. Hill Library, facing University Plaza, houses a 650,000-volume collection which serves graduate students in educational and research programs.

NORTH CAROLINA STATE UNIVERSITY

North Carolina State University is a large and complex state university, one of the major state universities of the nation.

It shares the distinctive character of Land-Grant state universities nationally—broad academic offerings, extensive public involvement, national and international activities, and large-scale extension and research programs.

State was founded as a Land-Grant state university under terms of the famed federal Morrill Act of 1862 which provided for public land endowments to support a public institution in each state.

The Land-Grant heritage of fulfilling three major functions—research, extension and academic affairs—is reflected in the large dimensions of these functions at North Carolina State University.

The rich and varied academic program of the University is comprised of some 70 bachelors of arts and science programs, 67 master's degree fields and 45 doctoral degrees. The University offers about 2,300 courses.

Its research activities span a broad spectrum of about 700 scientific, technologic and scholarly endeavors, with a budget of about $20 million annually.

Extension programs of the University are similarly diverse and include urban affairs, marine sciences, environmental protection, engineering, industrial and textiles extension, agricultural extension and many others.

The annual University budget is about $80 million. The University has 4,600-plus employees. There are 1,621 faculty and professional staff and 157 adjunct and federal agency faculty, including 974 graduate faculty.

There are 120 campus buildings with an estimated value of about $120,000,000. The central campus is 596 acres, though the University has 88,000 acres, including one research and endowment forest of 78,000 acres. Research farms; biology and ecology sites; genetics, and horticulture, and floriculture nurseries; and Carter Stadium areas near the main campus comprise about 2,500 acres.

Principal operational locations for the University in North Carolina are the Marine Sciences Center at Wilmington, the Fisheries Laboratory at Hatteras, the Minerals Research Laboratory at Asheville, the Pamlico Marine Laboratory at Aurora, and the 20 agricultural research stations and forests.

North Carolina State University is one of the three Research Triangle Universities along with Duke University and the University of North Carolina at Chapel Hill. In the 30-mile triangle formed by the three Universities is the 5,000-acre Research Triangle Park, the Research Triangle Institute, a Universities' subsidiary, and the Triangle Universities Computation Center, a central facility for the extensive computing centers of the institutions.

The University's total enrollment is about 14,200. There are 11,640 undergraduates, 2,375 graduate students and about 200 special and other students. Students at State come from all 50 states and some 50 other countries. The international enrollment is a distinctive feature of the institution since its 430 international students give it a decidedly cosmopolitan aura.

North Carolina State University is organized in eight schools and the Graduate School. The eight schools are Agriculture and Life Sciences, Design, Education, Engineering, Forest Resources, Liberal Arts, Physical and Mathematical Sciences and Textiles. In addition a complex of divisions and programs provide for a wide range of special programs in academic affairs, research and extension.

State is one of 118 recognized members of the National Association of State Universities and Land-Grant Colleges. It is also a member of the American Council on Education, the College Entrance Examination Board, the Council of Graduate Schools in the United States, the National Commission on Accrediting, the Oak Ridge Institute of Nuclear Studies and the Southern Association of Colleges and Schools.

The University is accredited by national and regional accrediting agencies applicable to the University and its numerous professional fields.

THE GRADUATE SCHOOL

The Graduate School at North Carolina State University offers programs leading to master of science degrees in 53 fields of study, masters of arts degrees in four, 10 "master of" degrees, the Doctor of Philosophy in 39 and the Doctor of Education in six. The Graduate School includes 974 faculty.

Graduate instruction at North Carolina State University is organized to provide opportunity and facilities for advanced study and research in the fields of agriculture and life sciences, design, education, engineering, forestry, liberal arts, physical and mathematical sciences, technological education and textiles. The purpose of these graduate programs is to develop in advanced students a more adequate comprehension of the requirements and responsibilities essential for independent research investigation. In all the graduate programs emphasis is placed upon a high level of scholarship rather than upon the satisfaction of specific course or credit requirements.

Exceptional facilities for graduate study are provided at North Carolina State University. New buildings furnish modern well-equipped laboratories for graduate study in specialized scientific and technological areas.

A high degree of cooperation and coordination exists between the graduate programs of the University of North Carolina at Chapel Hill, the University of North Carolina at Greensboro and North Carolina State University. This coordination is effected through the Graduate Executive Council of the Consolidated University, composed of representatives of the administrative boards of these three institutions and the academic vice-president of the statewide University of North Carolina system.

The D. H. Hill Library

Library facilities at North Carolina State University include the main D. H. Hill Library and special libraries for the Schools of Design, Textiles, and Forest Resources. The collections, totaling more than 650,000 volumes, have been carefully assembled to serve the educational and research programs of the University.

The D. H. Hill Library contains particularly strong research holdings in the biological and physical sciences, in all fields of engineering, agriculture and forestry. The 6,000 volume Friedrich F. Tippmann collection in the field of entomology and related biological sciences is one of the outstanding collections in the country. The collection of books and journals in the humanities and social sciences is especially helpful to undergraduate students.

The library's comprehensive collection of scientific journals emphasizes the major teaching and research interests at State; approximately 7,000 journals are received regularly. A large collection of state and federal government publications further strengthens the library's research material. The D. H. Hill Library is a

depository for publications of the Atomic Energy Commission and the Food and Agricultural Organization of the United Nations, and has been a depository for U. S. federal documents since 1923.

The Textiles Library, located in Nelson Textile Building, contains holdings in the field of textiles and textile chemistry. It is regarded as one of the best textile libraries in the country. The School of Design Library, in Brooks Hall, has a fine collection of books, journals and slides in the areas of architecture, landscape architecture and product design. The Forest Resources Library which contains a limited collection of specialized literature is located in Biltmore Hall.

As a further aid to graduate and faculty research, the library participates in an interlibrary loan program with the University of North Carolina at Chapel Hill, Duke University Research Triangle Institute, IBM, Chemstrand, the Division of Environmental Health Services and the N. C. State Library in downtown Raleigh. A bus, arriving at North Carolina State University daily Monday through Friday, makes resources from these seven libraries available to State students and faculty. Among the materials available are approximately 14,000 scientific periodicals.

The D. H. Hill Library building has been expanded and remodeled for additional library seating and open shelf collections. An 11-story addition provides bookstacks for a 1,000,000-volume book collection and greatly expanded research facilities, including carrels and study areas.

Among the many services offered by the library are orientation tours for faculty and graduate students and also lectures on library use to all new students. Coprehensive reference service is available almost all the hours the library is open. A variety of microtext readers and printers in the library and an extensive microfilm collection provide access to much important research material. A music listening room is equipped with listening machines for playing taped recordings. One of the most widely used services in the library is the photocopy service. Coin-operated machines plus two machines operated by staff provide a wide variety of photocopy service, including copy from microfilm. Machines may be used all hours the library is open.

The Curriculum Materials Center, administered by the School of Education, is located in Poe Hall. The Center contains an outstanding collection of elementary and secondary school curriculum materials in various fields ranging from films and slides to audio tapes and simulation games. Audiovisual equipment is available to preview materials in the Center.

Institutes

INSTITUTE OF STATISTICS

The Institute of Statistics is composed of two sections, one at Raleigh and the other at Chapel Hill. At North Carolina State University, the Institute provides statistical consulting services to all branches of the institution, sponsors research in statistical theory and methodology, and coordinates the teaching of statistics at

the undergraduate and graduate levels. The instructional and other academic functions are performed by the Department of Statistics, which forms a part of the Institute.

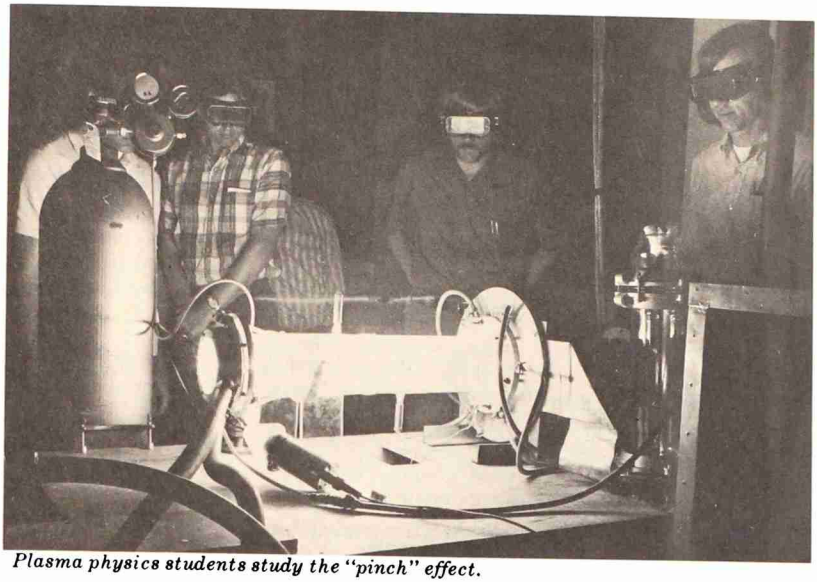
WATER RESOURCES RESEARCH INSTITUTE

The Water Resources Research Institute is a unit of the University of North Carolina System and is located on the campus of North Carolina State University. The deans of the Graduate School, School of Engineering and School of Agriculture and Life Sciences at North Carolina State University and two faculty members from the University of North Carolina at Chapel Hill serve as a board of directors. The Institute was established to promote a multidisciplinary attack on water problems, to develop and support research in response to the needs of North Carolina, to encourage strengthened educational programs in water resources, to coordinate research and educational programs dealing with water resources, and to provide a link between the state and federal water resources agencies and related interests in the University.

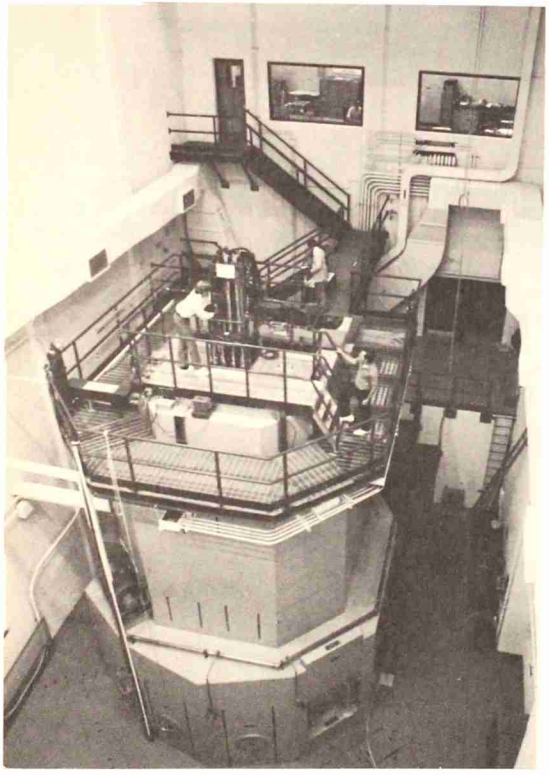
Research and educational activities are conducted through established departments and schools of the University System. All senior colleges and universities of North Carolina are eligible to participate in the Institute's research program. Applications for research grants must be received by September 1 for the Matching Grants Program and February 1 for the Annual Allotment Program preceding the fiscal year for which funds are requested. Basic support for the Institute's program is provided by the Office of Water Resources Research, U. S. Department of the Interior, under the Water Resources Research Act of 1964 and appropriations from the State of North Carolina.

The Institute has sponsored a graduate minor in water resources which offers a strong water resources program with the major in any of the basic disciplines contributing to water resources planning, conservation, development and management. This capitalizes on the combined training resources of the Raleigh and Chapel Hill campuses of the University System and offers these in an organized way to graduate students seeking interdisciplinary training in this field. Additional information concerning the program is presented elsewhere in this catalog.

The Institute sponsors research and educational symposia and seminars, encourages the development of specialized training opportunities, and provides a means for the continuing evaluation and strengthening of the University System's total water resources program.



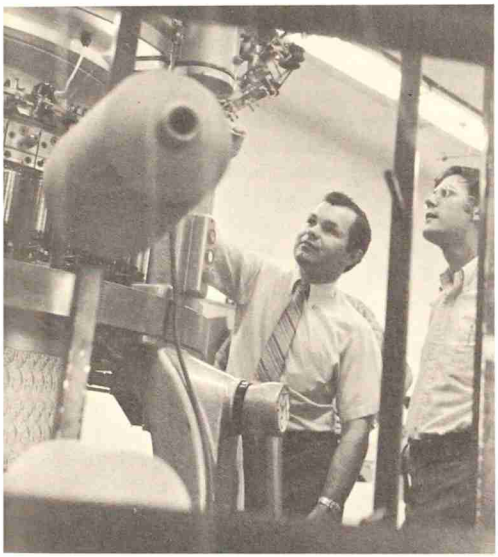
Plasma physics students study the "pinch" effect.

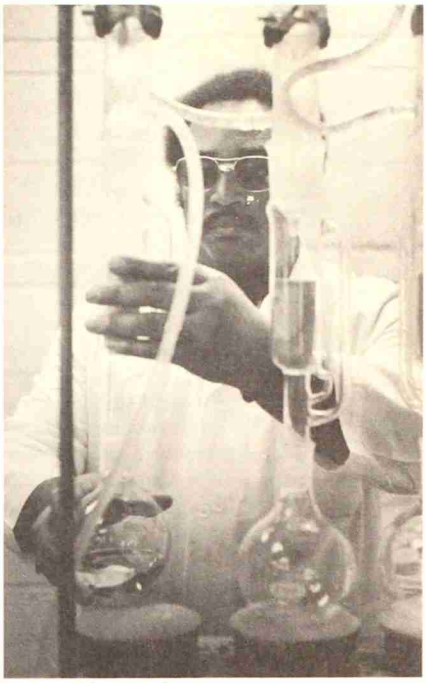


This one-megawatt PULSTAR reactor is used for teaching, research and service on behalf of the university.

Minute objects can be studied utilizing the electron microscope.

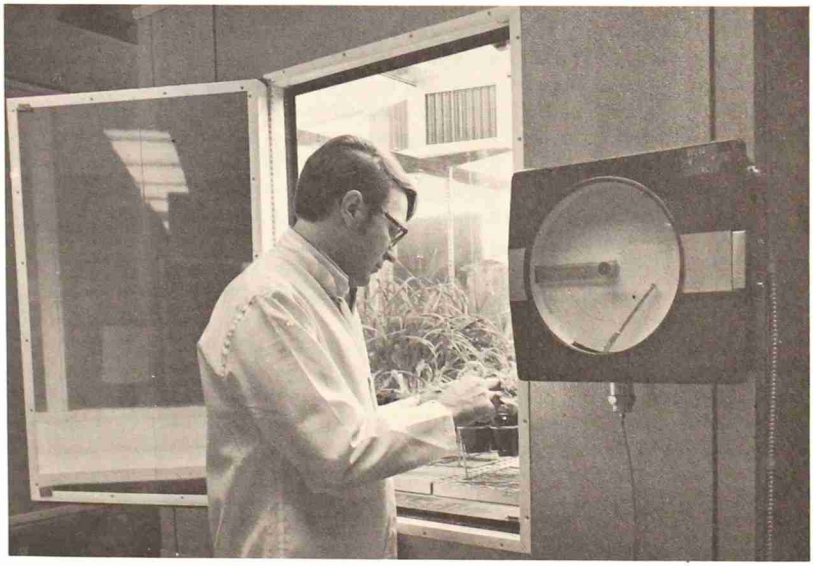
Physical resources of the School of Textiles allow demonstrations of machines and equipment used in the processing of natural and man-made fibers.





Pesticide residues research on animals, plants, soils, water and other entities is undertaken in the Pesticide Residue Research Laboratory by graduate students and members of cooperating departments.

The Phytotron is a controlled environmental facility which makes possible a variety of plant experiments.



Special Laboratories and Facilities

ADULT LEARNING CENTER

The Adult Learning Center is an organizational unit in the School of Education at North Carolina State University and is an integral part of the research and development program of the School of Education.

Established in 1967, the Center is committed to seeking new ways and means for facilitating the intellectual growth and development of adults. Among the objectives of the Center is the provision of national leadership in the development and implementation of experimental and demonstration projects which give promise of materially improving adult education programs.

The Center maintains on the campus of North Carolina State University an adult learning laboratory, the primary purpose of which is to further the use of programmed instructional materials with undereducated adults. Continuing research is conducted in the laboratory to determine the capacity of programmed instructional materials to raise effectively and efficiently the general educational level of marginally literate adults.

BIOLOGY FIELD LABORATORY

The Biology Field Laboratory is located eight miles from the University campus and comprises a 20-acre pond, 180 acres of extremely varied vegetation types and a modern laboratory building. The latter contains two laboratories, one for class use and another principally for research, and quarters for a married graduate student who serves as custodian of the property. The many unique ecological situations found in this area make it ideal for use by advanced classes of most biological science departments. Likewise, the area is well adapted to a variety of research projects by faculty, graduate students and undergraduates because of its habitat diversity. The laboratory facility makes possible many types of behavioral, physiological, ecological, taxonomic and limnological studies that could be accomplished only with great difficulty at other locations. Since the site is close to the campus and readily accessible, those investigators with campus duties may carry out long-term studies there even though frequent observations must be made.

COMPUTING FACILITIES

North Carolina State University, Duke University and the University of North Carolina at Chapel Hill jointly own the Triangle Universities Computation Center (TUCC). This center is equipped with a large computer (IBM System 370, Model 165) and is located in the Research Triangle Park, about 15 miles from the North Carolina State University campus. Data is transmitted to and from the TUCC computer primarily by electronic means. A variety of input/output facilities are avail-

able in convenient campus locations. The Computing Center's main facility contains an IBM System 360, Model 40 (256K bytes of storage with a 2314 disk facility and two nine-track tape drives plus a high resolution plotter) capable of simultaneously transmitting work to and from TUCC and processing work locally. There are also medium-speed terminals located in the Schools of Physical and Mathematical Sciences and Engineering. Many low-speed, keyboard terminals are located throughout the campus. A number of special-purpose computing facilities also exist. These are employed for research purposes in the Schools of Education, Engineering, Physical and Mathematical Sciences and Agriculture and Life Sciences.

One of the principal reasons for the extensive computing facilities is to take care of the heavy graduate student training and research requirements. The present configuration provides for a wide range of computing needs in all disciplines. Courses in the use of computers are offered by the Department of Computer Science.

ELECTRON MICROSCOPE CENTER

The facilities of the Electron Microscope Center are available to all graduate students and faculty within the University for research purposes and to those students who wish only to obtain a general knowledge of electron microscopy techniques. A charge is assessed when the Center is used for research by faculty and graduate students.

The Center is located in Gardner Hall in a suite of rooms designed specifically for electron microscopy. The Center currently provides two transmission electron microscopes, a Siemens Elmskop 1A and a Hitachi HS-8-B, a specimen preparatory laboratory and a completely equipped darkroom.

Formal instruction is provided in electron microscopic cytological techniques, use of transmission and scanning electron microscopes, photographic techniques and interpretation of electron micrographs. Instructional tours are available for secondary education groups.

HIGHLANDS BIOLOGICAL STATION

North Carolina State University is an institutional member of the Highlands Biological Station, Inc., an inland biological field station located at Highlands, North Carolina. The town of Highlands is in the heart of the Southern Appalachians at an elevation of 3,823 feet. The area has an extremely diverse and interesting biota and the highest rainfall in the eastern United States. The facilities are available throughout the year for pre- and post-doctoral research in botany, zoology, soils and geology. The laboratory building with research rooms and cubicles and the library are well equipped for pursuit of field research problems. Also, four cottages and a dining hall are located on the edge of a six-acre lake. In addition to 16 acres surrounding the lake, the station owns several tracts of undisturbed forested land available for research. Research grants are available from the station; the stipends are adequate to cover room, board and research expenses.

NUCLEAR SERVICE FACILITIES

Specialized nuclear service facilities are available to the University faculty, students and industry. The purpose of these facilities is to further the use of nuclear energy in engineering research and in scientific and public service programs. The facilities include: a 1 megawatt steady-state and pulse, pool-type, research reactor (PULSTAR) with a variety of test facilities; a 30,000 curie multi-purpose cobalt-60 gamma irradiation source which includes a controlled envirnoment support unit; intermediate hot laboratories with hoods, junior caves and glove boxes; a neutron activation analysis and radioisotope laboratory; NaI and solid-state detectors; counting and photographic rooms. In addition, a new 50,000 sq. ft. Burlington Engineering Laboratories complex houses the Department of Nuclear Engineering and the Engineering Research Services Division with their associated offices and laboratories. All of the facilities including the reactor are on the North Carolina State University campus.

CENTER FOR OCCUPATIONAL EDUCATION

Administered by the School of Education, the Center for Research, Development, and Training in Occupational Education is a national research and development center, the mission of which is to improve through research and related activity the quality and quantity of occupational education for all persons and groups. The total program is focused on problems underlying the development of adequate programs of occupational education.

The program of the Center includes research, developmental, and action projects directed by senior members of the faculty. One of the special features of the Center is its Research Intern Program for those who are interested in preparing for positions as research specialists in occupational education or related fields, and who have completed all course requirements for the doctorate.

PESTICIDE RESIDUE RESEARCH LABORATORY

The Pesticide Residue Research Laboratory is a facility in the School of Agriculture and Life Sciences devoted to research on pesticide residues in animals, plants, soils, water and other entities of the environment of man. Although the laboratory is administered through the Department of Entomology, it serves the total needs of the school in cooperative research projects requiring assistance on pesticide residue analyses.

The laboratory functions as a focal point for residue research involving interdepartmental cooperation, but faculty in the laboratory also conduct separate research of their own interest on persistence and decomposition of pesticides in soils and plants, absorption and translocation in plants, distribution in environment, and contamination of streams, estuaries and ground water.

The modern laboratory is equipped with the latest analytical instruments. Grad-

uate study can be undertaken in any aspect of pesticide residues either in the Pesticide Residue Laboratory or in one of the cooperating departments.

REPRODUCTIVE PHYSIOLOGY RESEARCH LABORATORY

The Reproductive Physiology Research Laboratory administered through the Department of Animal Science includes four environmental control rooms designed to provide constant levels of air temperature, humidity and light for animals involved in studies on reproduction. Facilities and equipment are available for surgery, in vitro growth of embryos, isotope labeling in embryo metabolism and transfer of embryos between females.

Support for research at both the master's and the doctoral levels is available. Students may elect a comparative approach to a specific problem in mammalian reproduction, working with several species, or they may choose to work with a single species. Generally students select a problem associated with the identification of factors influencing early prenatal development, the endocrine control of ovarian function or some aspect of elucidation and control of aberrations in mammalian reproduction.

Cooperative research is possible between the laboratory and the Medical School or the Enviornmental Health Sciences Center at the University of North Carolina at Chapel Hill for those students desiring a broader training in the general area of reproductive physiology.

Students whose work is concentrated in reproductive physiology can major in either animal science or physiology with a minor in related disciplines.

SOUTHEASTERN PLANT ENVIRONMENT LABORATORIES

The Southeastern Plant Environment Laboratories operate as a cooperative association between North Carolina State University and Duke University with one unit, commonly called a phytotron, located on each campus. The laboratory is especially designed for research dealing with the response of biological organisms to their environment, and the high degree of control makes it possible to duplicate any climate from tropical rain forest to arid desert or arctic cold.

Research in the North Carolina State unit concentrates on agricultural problems encountered in the southeastern United States. However, the ability to control all phases of the environment allows inclusion of research dealing with space, pollution and tropical agriculture as well as basic physiological and biochemical investigations.

The facilities are available to the resident research staff, participants in North Carolina State's graduate research program and to domestic and foreign visiting scientists.

TRIANGLE UNIVERSITIES NUCLEAR LABORATORY

TUNL is a laboratory for research in nuclear structure. It is located on the campus of Duke University in Durham and it is staffed by faculty members and graduate students in the Departments of Physics of Duke University, the University of North Carolina at Chapel Hill and North Carolina State University. The principal

tools of the laboratory are particle accelerators used to bombard target nuclei with an assortment of ions of accurately controlled energy and small energy spread. For example, protons can be accelerated to desired energies between a few hundred thousand electron volts and a bit over 30 million electron volts energy. The accelerators are a 3 MeV and a 4 MeV Van de Graaff generator and a 15 MeV tandem Van de Graaff generator injected by a 15 MeV AVF cyclotron normally accelerating negative ions. An on-line computer is used for data collection and analysis.

Personnel from NCSU are participating partners in the maintenance and use of the laboratory. Collaboration with personnel from the other two participating universities is encouraged.

This laboratory is the first to combine a cyclotron and tandem Van de Graaff generator—the "Cyclo-Graaff." Successful operation began on December 28, 1968. The unusual physical facilities and the collaboration of personnel from the three universities make this an excellent laboratory.

Special Training Programs

INSECT PEST MANAGEMENT

Food production, control of disease and abatement of pollution are problems of national and international concern. Adequate food for burgeoning populations is a problem of increasing urgency, and insect pests comprise an important limiting factor. Insect control is also of strategic importance in combating arthropod-borne diseases of man as well as of his cultivated plants and domesticated animals. Pollution, a companion problem of food production and disease control, is increasing at an alarming rate, partly as a result of inadvisable pest control practices.

If a viable and aesthetically desirable environment is to be maintained, the materials and methods of pest control must be used carefully under the guidance of personnel possessing a thorough understanding of ecological principles. A program to train such personnel as pest management specialists, including assistantships, is available for graduate students with an adequate background in biological sciences, chemistry and mathematics. Ecology is fundamental to the pest management concept since populations, communities and ecosystems are of primary concern in this approach to the regulation of pest numbers.

Trainees will major in entomology but may choose from a wide selection of minors such as statistics, biomathematics, genetics, microbiology, zoology and ecology. Faculty with competencies in these and related disciplines are available as advisers.

RESEARCH PROGRAM AT THE OAK RIDGE ASSOCIATED UNIVERSITIES

North Carolina State University is one of the sponsoring institutions of the Oak Ridge Associated Universities at Oak Ridge, Tennessee. Through this cooperative association, North Carolina State's graduate research program has at its disposal the facilities and research staff at Oak Ridge National Laboratory. Extensive research programs are under way there on physical and biological effects of radiation, radio-

isotope utilization and many other areas of nuclear science and engineering. When master's and doctoral candidates have completed their resident work, it may be possible, by special arrangment, for them to do their thesis research at Oak Ridge National Laboratory. In addition, it is possible for the staff members of this University to go to Oak Ridge for advanced study in their particular fields.

Other Programs

THE TRIANGLE UNIVERSITIES CONSORTIUM ON AIR POLLUTION

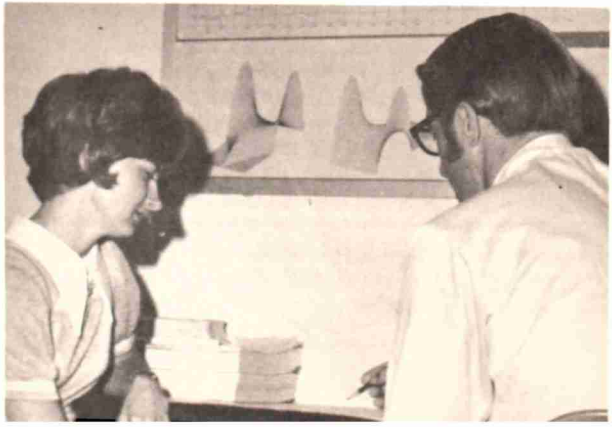
Controlling the quality of the air we breathe is clearly recognized as one of the major problems facing man in the decades ahead. This concern has been expressed as a statement of national policy.

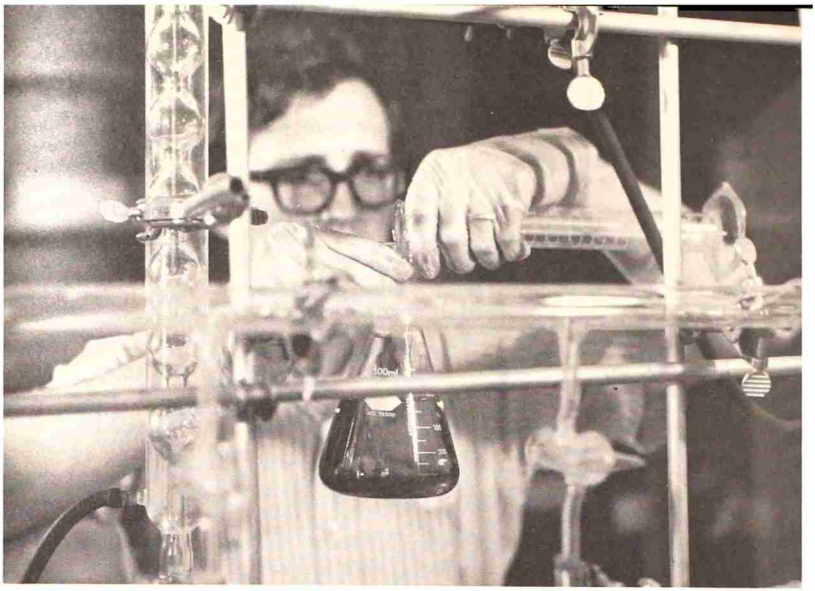
The Triangle Universities (North Carolina State University at Raleigh, University of North Carolina at Chapel Hill and Duke University at Durham) took a major step in 1970 to make North Carolina an international center for research and training in air pollution control with the creation of the Triangle Universities Consortium on Air Pollution (TUCAP). Adding focus to their effort was the proximity of the two national agencies most immediately concerned—the Office of Air Programs of the Environmental Protection Agency and the National Institute of Environmental Health Sciences. Both are located within the Research Triangle.

The Consortium is the first of its kind in the country. It has brought together institutions with long experience in working together on common problems and interests. A pool of talent and resources that could cover all facets of the national problem has been made available. From biology to ecology, from law to medicine, from engineering to economics, specialized knowledge has been brought together to provide the research and training needed by both the state and the nation.

TUCAP has already sponsored several conferences and symposia, developed joint instructional programs and stimulated considerable faculty involvement in air pollution related research on the three campuses. Significant funding for TUCAP has been provided through EPA.

Assistance in computer programming is offered students of statistics or biomathematics.





Major fields of specialization for chemistry majors are analytic, inorganic, organic, nuclear and physical chemistry.

GENERAL INFORMATION

Admissions

Students of all races and sexes are equally welcome at North Carolina State University. All people may apply for and accept admission, confident that the policy and regular practices of the University will be administered without discrimination.

Graduate School admission may be to full, provisional or unclassified status. Applications for admission to the Graduate School at North Carolina State University must be accompanied by official transcripts from all colleges or universities previously attended and should be received no later than one month before the start of the session in which enrollment is planned.

A non-refundable application fee of $10 must be submitted with the application for admission to the Graduate School.

Since the Graduate Catalog is prepared to cover a two-year period, changes may occur during this period which are not included herein. In the event of such changes, the schools and departments concerned will communicate with applicants at the time that the application forms are received.

It is the prerogative of each school or department to require evidence of academic potential beyond those stated specifically in the catalog.

Judgments concerning admission or denial to particular degree programs and the criteria used for admission are initiated in the individual departments and schools. These criteria and judgments vary according to departments and schools and re-

flect not only estimates of ability of students to do graduate work but also the ability of the department to absorb additional graduate students.

When application forms, transcripts and reference forms arrive in the Graduate Office they are forwarded, as they arrive, to the department indicated as that in which the student hopes to major. Departments vary in the mechanisms used for evaluating an applicant's chances for success in graduate work, but in most cases the final decision rests with an "admissions committee." In due course a department forwards its recommendation to the Graduate Office. Most departments act on applications as received but some departments accumulate applications and make their decisions as to admission at certain fixed times during the year, such as March 1 or April 1.

Application forms, transcripts and reference forms should be directed to Dean of the Graduate School, 104 Peele Hall, North Carolina State University, Raleigh, N. C. 27607.

FULL GRADUATE STANDING

For admission in this category a student must have a bachelor's degree from a recognized college or university regarded as standard by a regional or general accrediting agency, and must have at least a "B" grade average in his undergraduate major.

PROVISIONAL ADMISSION

Provisional admission may be granted to applicants who lack undergraduate work considered essential for graduate study in the major field. Course work, without graduate credit, will be required to make up such deficiencies before admission to full graduate status can be granted.

Graduates from nonaccredited institutions may be granted provisional admission when their academic records warrant this status. Additional course work will be required of such students when deficiencies in their previous training are apparent.

Graduates from accredited institutions whose scholastic records are below the standards for admission to full graduate standing may be admitted provisionally when unavoidable extenuating circumstances affected their undergraduate averages or when progressive improvement in their undergraduate programs warrants provisional admission. All such students are required to take the Graduate Record Examination and to submit scores to the Graduate School office in support of their application.* The National Teacher Examination may be substituted for the Graduate Record Examination if recommended by the department head. Information as to the dates on which the Graduate Record and the National Teacher Examinations are given may be obtained at the Graduate School office.

Many departments, although not normally requiring GRE scores, may in special instances require their submission as additional information to assist in making a

* Most of the advanced degree-granting departments in the University strongly encourage submission of Graduate Record Examination scores. The following departments will not act on an application unless it is accompanied by GRE scores: biomathematics, English, entomology, fiber and polymer science, guidance and personnel services, history, industrial and technical education (vocational industrial education and industrial arts education), mathematics, plant pathology, politics, psychology (requires the Advanced Test and Miller Analogies as well), sociology, textile chemistry (aptitude and advanced test in chemistry), textile technology (aptitude only) and zoology.

judgment as to a student's chances of success in a graduate program.

Although some departments in the School of Education might consider the results of the National Teacher Examination as a basis for admission to the master's degree program, the Graduate Record Examination scores are required in all departments in the School of Education in the case of applicants for admission to doctoral programs.

Graduate students admitted to provisional status are not eligible for appointment to graduate assistantships or fellowships. They may attain full graduate standing when the deficiencies responsible for their provisional status are corrected. They also must have maintained a satisfactory academic record in all course work taken as part of their graduate program. Change from provisional to full graduate standing is effected only on written recommendation from the department in which the student is seeking his degree.

UNCLASSIFIED GRADUATE STUDENTS

Unclassified graduate students are not candidates for graduate degrees. They may take courses for graduate credit but may not apply more than 10 credits earned while in the unclassified status to any program leading to an advanced degree at this institution. Unclassified graduate students are expected to meet the same admissions requirements that apply to graduate students in full standing.

Applications for admission to the Graduate School should be on file in the Graduate School office at least 30 days in advance of the registration date for the term in which the student wishes to enroll in the Graduate School.

GRADUATE-CERTIFICATE RENEWAL

Public school personnel (primary teachers, secondary teachers or administrators) registering at North Carolina State for the first time who are interested primarily in "Certification Credit" may enroll as graduate students for a maximum of six semester hours without forwarding official transcripts of previous work to the Graduate Office. If, however, application is not made through normal channels for graduate credit in the session in which the course or courses are taken, the student will not be permitted to apply the credit toward an advanced degree at North Carolina State, or elsewhere.

In all cases where the teacher's interest is primarily in approval for certification credit, the School of Education will be responsible for assessing the adequacy of the teacher's qualifications for enrollment in the University in the particular course or courses. The School of Education will also be responsible for advising all such students early in each school session that if they wish their credits to be applied in due course to a higher degree at North Carolina State, or elsewhere, normal admission procedures will be required.

All teachers who have previously attended North Carolina State University and earned six semester hours of credit and wish to enroll for additional courses for graduate credit will be required to make application for admission to the Graduate School in the usual manner.

In all cases a "B" level of academic performance or better is required.

GRADUATE-SPECIAL

This classification is used primarily for individuals located in the Raleigh area who may be considering pursuing a graduate degree in due course but who have, as yet, not been admitted to a graduate program.

The following rules apply to students registered as graduate-special:

1. All must have at least a baccalaureate degree from an accredited institution of higher learning;
2. Official transcripts need not be submitted to the Graduate Office for enrollment in this classification but instructors are expected to make certain that students have adequate preparation for the course(s) contemplated. Students are encouraged to seek advisement from the appropriate department before registering;
3. Placement in this classification carries with it no implication that students will be admitted to the Graduate School in any of the other classifications;
4. Graduate credit will be allowed, not to exceed six hours (or nine hours under special circumstances) of course work at the 500- or 600-level;
5. If the student is in due course admitted to the Graduate School, graduate credit obtained under this classification may apply to an advanced degree, if in the judgment of the advisory committee the course(s) is germane to the particular program of work, and performance was at an adequate level;
6. Students who have received as many as six hours of graduate credit under this classification must make application for admission to the Graduate School before permission will be granted to enroll for additional graduate work. (Permission may be granted to take a third course if recommended by the graduate administrator of the department in which the student plans to major.)

Registration

The Office of Registration must have written authorization from the dean of the Graduate School before any graduate student will be given a permit to register. This authorization will be sent to the Office of Registration by the graduate dean at the time the student is notified of his acceptance.

REGISTRATION FOR COURSES AT OTHER CAMPUSES OF THE CONSOLIDATED UNIVERSITY

Graduate students working toward an advanced degree at North Carolina State University may find it desirable to enroll for certain courses in one of the other campuses of the University (see page 17). The following principles and procedures apply in such cases:

1. A graduate student shall be considered to remain in the Graduate School of the campus of the University to which admitted for a specific degree program, to be under the control of his department, to be advised by his department and to be enrolled by that Graduate School for any graduate work

which he may take for credit in his own campus or any other campus of the University.

2. A graduate student at one campus of the University who is taking work at some other campus of the University for credit toward his degree at the University campus to which he has been admitted shall be enrolled for all courses, including those at the other campus of the University, in his home Graduate School. This Graduate School shall consider courses taken at the other campus of the University as a part of the student's normal load and shall use such enrollment in computing the total billing which the home University will make to the student.
3. A student at one campus of the University who is by this method enrolled in one or more graduate courses at some other campus of the University will be admitted to these courses, provided space exists in these classes, by the Graduate School of the other campus upon normal notification by the Graduate School of the student's campus that the student has been properly enrolled for these courses and has the approval of the home campus for this program of study.
4. During the summer sessions, approval of the courses to be taken shall be asked, but the billing procedures shall be those regularly used for visiting students.
5. No student enrolled as a regular graduate student in any campus of the University shall be admitted to courses at another campus of the University without the presentation by the student of written permission from the Graduate School of the campus to which the student was originally admitted.
6. The graduate programs of students enrolled at North Carolina State University are under the jurisdiction of the Graduate School of North Carolina State University.

PHYSICAL EXAMINATIONS

All regularly enrolled graduate students must take a physical examination preferably given by the family physician, with the results recorded on forms provided by the University. When this is not done the examination may be given by the North Carolina State physician during registration for a fee of $10.

COURSE LOAD

A full-time graduate load is considered to be nine to 15 credits per semester (including audits). This course load restriction is made so that graduate students may have time for reading and contemplation well beyond the limits set for satisfactory undergraduate work. In exceptional cases one or two additional credit hours may be added to the roster if necessary in order to get prerequisite work not taught in subsequent terms, provided the corresponding adjustment in course load is made in the other terms. Rosters with additional credit hours beyond 15 should be accompanied by a special note from the head of the major department indicating the reasons for the additional work.

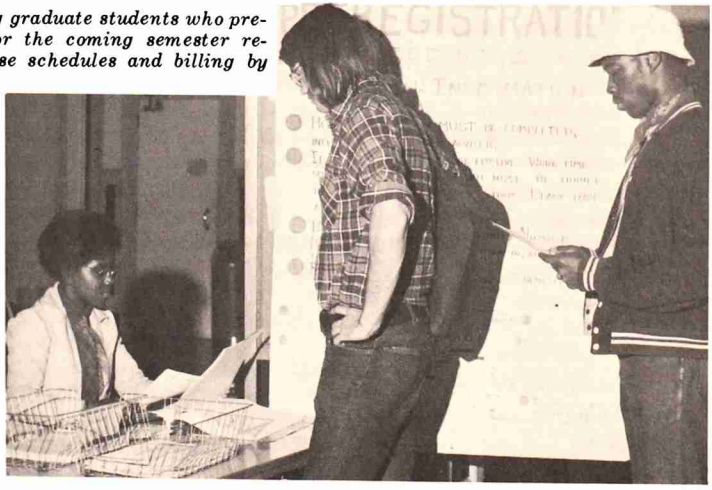
Full-time faculty of instructor rank and above and other full-time employees of the University who hold membership in the Teachers' and State Employees' Retirement System may register for credit or audit one course in each semester and one course during one of the two summer sessions. A maximum of eight semester hours may be taken during the academic year.

Employees having academic rank higher than that of instructor may register for graduate work for credit to be transferred to other institutions, but they may not undertake programs for graduate degrees at North Carolina State University.

Graduate assistants on half-time appointments are permitted a maximum course load of nine credits per semester unless corresponding adjustments are made in their service obligations during the same semester. If the appointment is for the academic year of nine months, half-time assistants are restricted to a maximum of 18 credit hours of work during the nine months of their appointment. Half-time graduate assistants whose appointments are for 12 months may not exceed a total of 24 credits during the 12-month period of their appointment. Three-quarter time graduate assistants whose appointments are for 12 months may register for a total of 16 credits during the calendar year. A total of six credits is the maximum load in a regular semester.

A member of the North Carolina State senior class may, upon approval of the dean of the Graduate School, register for courses in the 500 group for graduate credit to fill a roster of studies not to exceed 15 credits in any semester. No more than six hours of graduate credit may be acquired by an undergraduate student and the credits associated with courses approved for graduate credit may not apply toward the requirements for the bachelor's degree. Courses listed with numbers in the 600 series are not ordinarily open to undergraduates. Occasional exceptions may be made for "honor" students.

Continuing graduate students who preregister for the coming semester receive course schedules and billing by mail.



Tuition and Fees

SEMESTER RATES

For Academic Year 1973-74 and 1974-75

RESIDENTS OF NORTH CAROLINA				NONRESIDENTS			
HOURS	TUITION	REQUIRED FEES	TOTAL	HOURS	TUITION	REQUIRED FEES	TOTAL
1-3	$ 40.00	$114.75	$154.75	1-3	$300.00	$114.75	$ 414.75
4-6	80.00	114.75	194.75	4-6	600.00	114.75	714.75
7 or more	120.00	114.75	234.75	7 or more	900.00	114.75	1,014.75

REQUIRED FEES

General Academic	$ 38.00
Medical	15.00
Athletic	10.00
Special	51.75
	$114.75

Eligibility of a non-resident for reduced tuition rates. Under certain conditions, students who have been solicited for a "special talent" and have been offered an assistantship, traineeship, or fellowship, may be eligible for reduced tuition.

Application fee. A nonrefundable application fee of $10 dollars is required to accompany each application for admission.

SPECIAL REGISTRATIONS AND FEES

Thesis Preparation Only: (GR 598 or GR 698)
- In-Residence ($20.25 plus $114.75 fees) $135.00
- Not-In-Residence ($20.25 plus $7.00 registration fee) 27.25

Dissertation Research: (GR 697)
- In-Residence ($20.25 plus $114.75 fees) 135.00
- Not-In-Residence ($20.75 plus $7.00 registration fee) 27.25

Examination Only: (GR 597)
- In-Residence ($10.75 plus $114.75 fees) 125.50
- Not-In-Residence ($10.75 plus $7.00 registration fee) 17.75

Audits: Registered and paying for other course work—one audit free
Not registered for other course work—rates same as for credit

Full-time Faculty or Staff 7.00

Microfilming Doctoral Dissertation 21.00

Incidental fees and charges are levied for purposes and services available to all graduate students whether or not the student takes advantage of them.

The full amount of incidental fees and charges will be collected, notwithstanding the number of semester hours of credit for which the student may enroll.

In cases of occasional or part-time graduate students not in residence, application for cancellation of nonacademic fees may be made if it is clear that the student could not use the services covered. Application forms are available in the Graduate School and the Office of Business Affairs.

Full-time faculty of instructor rank and above and other full-time employees of the University who hold membership in the Teachers' and State Employees' Retirement System may register for credit or audit one course in each semester and one course during one of the two summer terms with free tuition privileges. Free tuition privileges apply only during the period of one's employment and do not include other charges such as registration, laboratory or other appropriate fees. Thus, a nine-month employee is not entitled to free tuition privileges in summer terms unless employed during the session for which free tuition is sought. Each applicant for free tuition privileges must complete and submit through regular administration channels a form provided by the University.

Faculty members on less than full-time appointments will be permitted to take more than one course per semester upon the recommendation of their dean and the approval of the dean of the Graduate School. In these cases, tuition and fees will be the same as those for part-time graduate students computed at resident rates.

Maximum permissible course loads for graduate students holding part-time appointments are as follows: three-quarters time, six hours; half-time, nine hours; quarter-time, twelve hours.

Students wishing to visit classes without participation in class discussions, quizzes or examinations must register for this privilege as auditors. Visiting classes without registration is not permitted. Graduate students may register for one course as an audit in any semester without charge when the audit is certified by the dean of the Graduate School as a part of course work for which tuition charges are made (this does not apply in the summer sessions).

Graduate students often mistakenly assume that registration for an audit carries with it the privilege of irregular or infrequent attendance. This is not correct. When audits are recommended by departmental advisers or appear on the student's plan of work, regular attendance is expected as in courses taken for credit. Failure to attend on a regular basis will be so noted on the student's permanent record.

Audits in subjects in which the student has had no previous experience will be evaluated at full credit value in determining course loads. Audits taken as repetition of work previously accomplished are considered at one-half their credit value in calculating course loads. With the single exception of foreign language audits, all audit registrations must fall within the maximum permissible course loads. Audits are not permitted for students registering for thesis preparation. While audit registrations are evaluated for purposes of determining permissive course loads in terms of the above regulations of the Graduate School, the Office of Business Affairs considers all audits excepting the one permitted free of charge, in terms of full credit value in calculating the graduate student's tuition.

Dissertation Research: A Ph.D. student whose program of work specifies no formal courses during a given semester or summer session, who has successfully passed his preliminary examinations, completed at least six hours of departmental

research on his Ph.D. program and who is devoting full time to his dissertation research shall register for "dissertation research" or an appropriate research course offered by the department. A graduate student so registered will be classified as a full-time student. "Dissertation research" as is the case for "thesis preparation" will have no credit hour designation. Tuition and fee charges for "dissertation research" are the same as those for "thesis preparation."

Thesis Preparation: Graduate students who have completed all course work, research and residence requirements and who are writing a thesis or dissertation may register for "thesis preparation." The tuition charge for this registration is $20.25. Students registering for thesis preparation will pay, in addition, fees of $114.75 per semester. When not in residence these charges will be $20.25 plus $7.00 registration fee or $27.25.

Examination Only: Graduate students in master's programs not requiring a thesis, who have completed all requirements except the final oral examination by the beginning of the semester in which the degree is to be awarded, will be required to register for "examination only." The tuition charge for this registration is $10.75. Students registering for "examination only" will pay, in addition, fees of $114.75 per semester. When not in residence these charges will be $10.75 plus $7.00 registration fee or $17.75.

Other Fees: A fee of $21.00 is charged all doctoral candidates for microfilming their dissertations.

Anyone who feels a mistake has been made in his bill may discuss the matter with the Office of Business Affairs. Any further appeals should be made to the Committee on Refund of Fees. Forms for this appeal may be obtained from the Office of Business Affairs.

All tuition charges and fees are subject to change without notice.

TUITION AND FEES FOR PART-TIME STUDENTS*—SEMESTER RATE 1973-74

RESIDENTS OF NORTH CAROLINA

HOURS	TUITION	REQUIRED FEES	TOTAL
1-3	$40.00	$12.50	$ 52.50
4-6	80.00	25.00	105.00
7 or more	Cannot be classified as part-time if enrolled for more than six (6) hours.		

NONRESIDENTS

HOURS	TUITION	REQUIRED FEES	TOTAL
1-3	$300.00	$12.50	$312.50
4-6	600.00	25.00	625.00
7 or more	Cannot be classified as part-time if enrolled for more than six (6) hours.		

* Part-time students are defined as persons who are primarily employed (full-time and permanent), registered for not more than six (6) hours during the regular semester as incidental students. Part-time students must complete an "Application for Cancellation of Nonacademic Fees" form each semester to qualify for the reduced rates.

FEES FOR SUMMER SCHOOL

	1973	1974
Registration Fee	$27.00	$35.00
Tuition (in-state students per credit hour)	10.00	10.75
Tuition (out-of-state students per credit hour)	50.50	50.50
Audits (same as for credit)		

REFUND OF TUITION AND FEES

A student who withdraws from school on or before the first two weeks of a semester will receive a refund of the full amount paid less an enrollment fee. After the period specified, refunds may be obtained only by submitting a petition to the Refund of Fees Committee, which endeavors to protect the rights of the student and the University. The committee is empowered to approve a petition when the withdrawal is caused by extensive illness and upon the advice of a physician, military orders, or when circumstances justify waiving the rules. For information, contact William R. Styons, Director of Student Accounts, "B" Holladay Hall, North Carolina State University, Raleigh, N.C. 27607.

RESIDENCE STATUS

Until May of 1973, determination of a student's residence status for tuition purposes rested upon the easily administered statutory requirement that "a legal resident must have maintained his domicile in North Carolina for at least 12 months next preceding the date of enrollment or re-enrollment in an institution of higher education in this State," with the express proviso that "student status in an institution of higher learning in this State shall not constitute eligibility for residence to qualify said student for in-state tuition" (G.S. 116-143.1, 1971) (emphasis added). The administrative consequence of this law was to make necessary, in most cases, only one inquiry concerning residence status for each student, at the outset of the higher education experience, since time spent enrolled as a student could not be counted in satisfaction of the 12-month eligibility requirement.

The 1973 Session of the General Assembly amended the applicable law, so as to read in pertinent part as follows:

"(b) To qualify for in-state tuition a legal resident must have maintained his domicile in North Carolina for at least the 12 months immediately prior to his classification as a resident for tuition purposes. In order to be eligible for such classification, the individual must establish that his or her presence in the State during such 12-month period was for purposes of maintaining a bona fide domicile rather than for purposes of merely temporary residence incident to enrollment in an institution of higher education; further, (1) if the parents (or court-appointed legal guardian) of the individual seeking resident classification are (is) bona fide domicilaries of this State, this fact shall be prima facie evidence of domiciliary status of the individual applicant and (2) if such parents or guardian are not bona fide domiciliaries of this State, this fact shall be prima facie evidence of non-domiciliary status of the individual." (University regulations concerning the classification of students by residence, for purposes of applicable tuition differentials, are set forth in detail in *A Manual to Assist The Public Higher Education Institutions of North Carolina in the Matter of*

Student Residence Classification for Tuition Purposes. Each enrolled student is responsible for knowing the contents of that *Manual,* which is the controlling administrative statement of policy on this subject. Copies of the *Manual* are available on request at the Admissions Office, 112 Peele Hall, North Carolina State University.)

The essential change effected by the 1973 amendment to this statute is that a person who is an enrolled student is no longer necessarily precluded from demonstrating during the period of his enrollment that he in fact has become a legal resident of North Carolina entitled to the in-state tuition rate. The administrative consequences of this modification of the law are substantial. Two inquiries are mandated by the statute. First, has the applicant for classification as a legal resident in fact resided in North Carolina for a minimum period of twelve months immediately prior to the proposed effective date of his classification as a resident for tuition purposes? Second, during the twelve-month period in question, did the applicant's presence in the State constitute legal residence? Thus, a carefully detailed inquiry must be made in each such case concerning the residential status of the applicant, as measured by established legal principles which control the disposition of questions about the place of legal residence of an individual.

CLASSIFICATION PROCEDURES

A. *Initial Classification*—A student admitted to initial enrollment in an institution (or permitted to re-enroll following an absence from the institutional program which involved a formal withdrawal from enrollment) shall be classified by the admitting institution either as a resident or as a nonresident, for tuition purposes, prior to actual matriculation. Particular officials or offices of the institution shall be designated to evaluate all such initial classification cases and to assign an appropriate classification consistent with the requirements of State law and the provisions of this manual. Basic data on which such assignment shall be based shall be collected in accordance with the common informational form prescribed herein (see Appendix B of Residence Manual, 1973, NCSU); additional data or documentation deemed essential to a reliable determination may be elicited from the student, as deemed appropriate by the responsible official or office.

B. Subsequent Classification Inquiries: Reclassification—A residential classification once assigned (and confirmed pursuant to any appellate process invoked) may be changed thereafter only at intervals corresponding with the established primary divisions of the academic calendar of the institution, viz., at the beginning of a semester, quarter, or otherwise denominated basic interval of the academic calendar. No change in residential status for tuition purposes (and thus no change in applicable billing rates) shall be effected during such a semester, quarter, or term, with resulting increases or decreases in the tuition obligation on a pro rata basis for a portion of such semester, quarter, or term.

The institution shall provide to each student at the time of and in connection with the transmission to him of each periodic bill for tuition charges a notice of the circumstances under which and the time at which a change in classification may occur. The notice shall be of the type prescribed in Appendix C of the Residence Manual, July 1973, NCSU.

Fellowships and Graduate Assistantships

FELLOWSHIPS

Graduate fellowships and traineeships provide funds to graduate students to assist in the support of their programs of advanced study. Holders of fellowships have no service obligation to the University and may devote full time to their graduate programs.

Some of the agencies sponsoring fellowships at North Carolina State University are the Agency for International Development, Aluminum Company of America, the Atomic Energy Commission, Chemstrand, Douglas Aircraft Company, Dow Chemical Company, DuPont Company, E. Sigurd Johnson, Eastman Kodak Company, Ford Foundation, General Electric Foundation, General Food Corporation, Goodyear Tire and Rubber Company, Honor Society of Phi Kappa Phi, International Institute of Education, Kellogg, National Aeronautics and Space Administration, National Institutes of Health, National Lumber Manufacturing Association, National Science Foundation, North Carolina Chapter of the Soil Conservation Society of America (Hugh Hammond Bennett Fellowship), North Carolina Grange (E. G. Moss Fellowship), North Carolina Textile Foundation, Office of Education (Department of Health, Education and Welfare), Phillips Petroleum Company, Public Health Service (U.S.), R. J. Reynolds Tobacco Company, Research Corporation, Rockefeller Foundation, Scholler Foundation, Shell Companies Foundation, U.S. Office of Education and Wachovia Bank and Trust Company.

Information relative to stipends, areas of research study supported by specific fellowships and application forms may be obtained from the Graduate School or from the heads of the appropriate departments.

ASSISTANTSHIPS

Graduate assistantships are granted to selected students who normally devote half time to service duties for the University. Teaching assistantships carry stipends ranging from $2,900 to $4,600 for the academic year, depending on experience, and permit the holder to enroll for 60 percent of a full course load. The stipends for research assistantships range to $5,200 for a calendar year appointment, depending on experience.

The University offers 823 assistantships requiring a service obligation in either teaching or research. Some of these are supported by funds granted by the following agencies: the Agency for International Development, Air Force Cambridge Research Laboratories, Air Force Office of Scientific Research, Akzona, Amerikan Enka, the American Museum of Natural History, Amos Johnson Grant, Army Missile Command, Army Research Office (Durham), the Atomic Energy Commission, Best Foods, Bureau of Commercial Fisheries, Campbell Soup Company, the Chilean Nitrate Education Bureau, Inc., Cotton, Inc., Eastman Kodak, Gerber Products Company, Graham Manufacturing Company, Hercules Powder Company, Department of Labor, the Lilliston Implement Company, The Lilly Company, National Aeronautics and Space Administration, E. I. DuPont de Nemours and Company.

National Institutes of Health, National Knitwear Manufacturers Association, National Science Foundation, North Carolina Agricultural Foundation, North Caro-

lina Board of Science and Technology, North Carolina Dairy Foundation, North Carolina Milk Commission, North Carolina Motor Carriers Association, North Carolina Soybean Producers Association, Owens-Corning Fiberglass Corporation, Pacific Coast Borax Company, Peanut Growers Association, the Petroleum Research Fund of the American Chemical Society, Pulp and Paper Foundation, Inc., R. J. Reynolds Tobacco Company, the Ralston-Purina Company, the Solvay Process Division of Allied Chemical Company, Sherwin-Williams Foundations, Southeastern Association of Game and Fish Commissions, the Tennessee Corporation, Southern Forest Institute, The Union Camp Corporation, U.S. Department of the Interior, U.S. Office of Education, U.S. Public Health Service, and the Water Resources Research Institute.

Students interested in applying for a fellowship or assistantship may indicate their interest on the application forms submitted.

Other Financial Aid

NATIONAL DIRECT STUDENT LOANS
(Formerly National Defense Student Loans)

Graduate students who are American citizens may apply to the Financial Aid Office for consideration for long term, low interest loans. To qualify for loans students must be making satisfactory academic progress and must show financial need. Students are expected to apply for and to accept any available assistantships before applying for loans.

Graduate students may borrow up to $10,000 inclusive of any undergraduate National Direct Student (National Defense Student) Loans. There is no interest on the loan while the borrower is a full- or half-time student at an institution of higher education. Nine months after ceasing to be at least a half-time student, interest begins at three percent per year. The repayment period begins at the same time. A ten year repayment period is possible for large indebtedness; however, a minimum payment of $30 per month is required. Interest does not accrue and repayment installments may be postponed during any period not in excess of three years during which the borrower is a member of the Armed Forces of the United States or is a Peace Corps or Vista volunteer. Reduction of obligations to repay may result from teaching in schools with high concentrations of low income families or from teaching handicapped children. Military service qualifies for cancellation as follows: If, after June 30, 1972, the loan maker serves as a member of the Armed Forces of the United States, up to 50 per cent of the principal amount of this loan shall be reduced at the rate of 12½ per cent of the total principal amount of the loan, plus interest thereon, for each complete year of service in an area of hostilities that qualifies for special pay under section 310 of Title 37, United States Code.

Institutional Long Term Loans: These loans are made from University funds. Institutional loans are made and are to be repaid under the same terms as the National Direct Student Loans except that there are no forgiveness features.

Insured Loan Program: This program provides loans from private lenders. Procedures are different in each state. Information and applications for available

loans may be obtained in the Financial Aid Office. Interest is at seven percent per year with the Federal Government paying the interest during the in-school period for students who qualify because of the financial circumstances of their families.

North Carolina legal residents enrolled full-time may borrow through College Foundation up to $1,250 per semester for a total of $2,500 per academic year for an aggregate of $10,000 for all enrollment including Graduate School. College Foundation Loans are insured by the North Carolina Education Assistance Authority or the United States Office of Education and under certain conditions the Office of Education pays the seven percent interest during the in-school and grace periods. Students from other states may obtain information about similar plans.

PART-TIME JOBS

The College Work Study Program is a federal program designed to guarantee part-time jobs to students who show need of financial assistance. The same application is used to apply for loans and jobs. Effort is made to assign students to jobs in keeping with their special interests and skills.

Other jobs not based on need are listed at the Financial Aid Office, and are open to all students.

SHORT-TERM EMERGENCY LOANS

Loans, usually in amounts of $100 or less, to meet emergency expenses may be obtained on short notice at the Financial Aid Office. Repayment periods are from 30 to 60 days.

Military Education and Training

The Reserve Officers' Training Corps (ROTC) selects interested University students who are to be enrolled in Military Science (Army ROTC) or in Aerospace Studies (Air Force ROTC) for officer education and training leading toward a commission.

The Army and Air Force ROTC departments educate and train University students, graduate and undergraduate, for a commission in their respective military services. These students must have four full semesters (undergraduate or graduate) remaining at the time they enter the ROTC program. Uniforms for Army and Air Force ROTC are provided by the University from funds made available by the Federal Government. Transfer credit is allowed for work at other institutions having an ROTC unit.

Qualified male graduate students may elect either a two-year or four-year program of Army ROTC studies. Female participation is currently limited to the four-year program. Additional information concerning either program can be obtained at the Department of Military Science in Room 154 of the Reynolds Coliseum.

To enroll for the two years of the AFROTC program, students must qualify on the Air Force Officer Qualification Test, meet physical requirements, and complete a six-week field training course during the summer just prior to entry into the program. This training is conducted at one of several Air Force bases in the United States. There he or she will receive the education and training comparable

to those students who have been in the four-year program. The student must complete the program and obtain a commission before reaching the 30th birthday.

Those students who will be under 26½ years of age upon commissioning and can pass physical and mental exams may elect to enter the AFROTC program as pilot or navigator candidates. Students selected for pilot training receive 35 hours of flying instruction and ground school education which can lead to a FAA Private Pilot's License *before* commissioning. Details can be obtained from the Aerospace Studies Department in Reynolds Coliseum, Room 145.

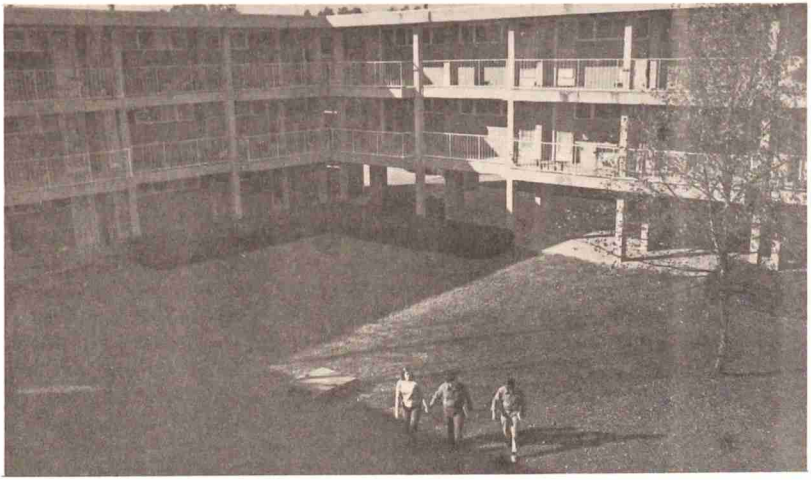
For those graduate students qualifying for admission to the Advanced ROTC course of instruction, a monthly subsistence allowance of $100 will be paid during the fall and spring semester. A limited number of students may be selected for ROTC scholarships. These scholarships pay all tuition, fees, costs of required textbooks and a tax-free subsistence allowance of $100 per month paid during regular semesters to *all* students in the last two years of the program.

Housing

North Carolina State University strives to provide suitable accommodations for its students. The University operates 16 residence halls, two of which are coeducational, with a housing capacity of 4,093 men and 1,479 women. In addition, 300 apartments are available for married students.

The residence halls are operated to provide opportunities through group living experiences which will complement and expand the educational experiences of the residents. Each hall is staffed with selected students, both graduate and undergraduate, who are responsible directly to professionally trained people in their area and to the Director of Residence Life. The staff members are available to help students

McKimmon Village for married students includes 300 apartments ranging from these efficiencies to one- and two-bedroom apartments.



initiate programs and activities and to advise and assist residents in any way possible.

Living arrangements in buildings vary. Six high-rise buildings are arranged in suites of four or five rooms sharing a bath; the other buildings have rooms opening on to a central corridor. The rooms are furnished but the residents must provide bed linen, pillows and towels.

ROOM RENTALS

The rental fee per semester is $147 for men and $158 for women. Reservations are made in the order of applications received so long as space is available. Application dates are announced by the Housing Rental Office. These dates are set to allow continuing students to reserve rooms in advance for each semester. Failure to vacate a room and/or complete check-out procedure at the end of a rental period or on withdrawal from the University will result in a penalty fee.

ROOM CHANGES

Once room assignments are made, no room changes will be permitted until the beginning of the second week of classes. Room changes are permitted as follows:

Student request: Approval of the Housing Rental Office is needed and there is a $5 room change fee. Residents transferring to other University housing (McKimmon Village, fraternities, greenhouses, or dairy units) will be refunded the rental fee paid less the $10 processing fee and a prorated daily charge from the opening day of the residence halls until the room is vacated *and* the keys returned.

Administratively initiated: No fees are charged.

REFUND OF ROOM RENT

A room assignment must be cancelled IN PERSON or IN WRITING at the Department of Residence Life in Leazar Hall. The effective date of cancellation is the date the notification is received in that office.

The amount of refund, if any, will be determined in accordance with the Refund Policy for Residence Halls as stated below:

1. *If the Room Assignment is Cancelled on or Before the Following Dates:*

First Summer Session:	May 17, 1974
Second Summer Session:	July 28, 1974
Fall Semester:	July 1, 1974
Spring Semester:	December 15, 1974

   The rental fee paid will be refunded less the $10 processing fee.

2. *If the Room Assignment is Cancelled After the Above Dates:*

   A. A refund will be given only if the space is reassigned to a new resident. The refund will be the rental fee paid less a $10 processing fee and a prorated daily charge from the opening day of the residence halls until the space is occupied by the NEW resident. (New resident is defined as a student who is a non-resident of a residence hall prior to being assigned to the vacated space.)

   B. If a resident *officially withdraws* from the University because of *Medical* reasons or *Military Orders*, the refund will be the rental fee paid less the $10 processing fee and a prorated daily charge from the opening day of the residence halls until the space is vacated and the keys returned. (It

is *not* necessary for the space to be occupied in order that a refund of room rent may be authorized.)

ROOM KEYS

A room key and mailbox key are issued to each student. No deposit is required; however, failure to return keys to the floor assistant upon vacating will result in a $2.50 charge for each key. Replacement for a lost key will be issued at the Housing Rental Office for $2.50. Duplication of a University key is illegal.

MARRIED STUDENT HOUSING

Efficiency, one-bedroom, and two-bedroom apartments are available in the married student housing complex. Rent of $50.50, $61.00, and $72.50 respectively does not include utilities except in the efficiencies. The University does not operate a trailer park, but there are privately owned parks within reasonable distance of campus. For more information contact the Housing Rental Office, Box 5505, N. C. State University, Raleigh, N. C. 27607.

FOOD SERVICES

Food service is provided at the University Student Center. Cost depends on the individual's requirements and the selection of food. A typical student, paying cash for each meal, will spend approximately $600 per academic year.

The Students Supply Stores operate soda fountain snack bars for the convenience of resident students in five areas. There is an additional snack bar located in the Nelson Textile Building.

LINEN RENTAL SERVICE

The linen service provides for the initial issue of two sheets, one pillow case and three towels. The student may exchange his linen weekly at a cost of $28 per year. Pillows may be rented for $1.50 per year. A regular blanket may be purchased for $5; the N.C. State monogrammed blanket, $7. These services are available to both campus and off-campus students. Application may be made in the Auxiliary Services Office in Holladay Hall.

The Instructional Materials Production Center in the School of Education is used for videotaping mock counseling conferences so students can study and improve guidance techniques.

GRADUATE DEGREES

Admission to the Graduate School does not constitute admission to candidacy for a graduate degree. Application for admission to candidacy for graduate degrees must be submitted to the Administrative Board of the Graduate School. Applications of students preparing for the master's degree may not be filed before the satisfactory completion of one full semester of graduate study and must be presented before the end of the first week of the last semester in residence. Approval of the application will be determined by the quality of the scholastic record and on the certification by the major department that the student is qualified to continue advanced work. Admission to candidacy for the doctorate is granted upon satisfactory completion of the qualifying or preliminary examinations.

The Graduate School at North Carolina State University offers work leading to the Master of Science degree and the Professional Master's degree in certain specialized fields in the Schools of Agriculture and Life Sciences, Design, Education, Engineering, Forest Resources, Physical and Mathematical Sciences and Textiles; and the Doctor of Philosophy degree in certain fields of agriculture and life sciences, engineering, forest resources, physical and mathematical sciences and textiles. The Doctor of Education degree, providing majors in Adult and Community College Education, Curriculum and Instruction, Educational Administration and Supervision, Guidance and Personnel Services, Industrial Arts Education and Occupational Education is offered in the School of Education. Work leading to the Master of Arts degree is offered in economics, English, history and politics.

A graduate student is expected to familiarize oneself with the requirements for the degree for which one is a candidate and is held responsible for the fulfillment of these requirements. This applies to the last dates on which theses may be accepted, the dates for examinations, the proper form of theses and all other matters regarding requirements for degrees.

Master of Science and Master of Arts Degrees

The Master of Science degree is awarded by North Carolina State University after a student has completed a course of study in a specialized field in agriculture and life sciences, education, engineering, forest resources, physical and mathematical sciences or textiles, has completed a satisfactory thesis and has taken comprehensive examinations in the chosen field of study.

A Master of Arts degree is awarded in economics, English, history and politics. Candidates for Master of Science or Master of Arts degrees are expected to achieve high levels of scholarship. Graduate study is distinguished from undergraduate work by its emphasis upon independent research. The graduate student is more interested in the significance of facts than in the accumulation of data. He is con-

cerned with the materials of learning and the organization and interpretation of these materials.

A graduate student's program of study is planned so as to provide a comprehensive view of some major field of interest and to furnish the training essential for successful research in this field and related areas of knowledge. As great a latitude is permitted in the selection of courses as is compatible with a well-defined major interest. The program of course work is selected with the object of making possible a reasonable mastery of the subject matter in a specialized field. Training in research is provided to familiarize the student with the methods, ideals and goals of independent investigation. Since there are many possible combinations of courses, the administration of graduate programs calls for personal supervision of each student's plan of work by a special advisory committee of the graduate faculty. The program of course work to be followed by the student as part of the requirements for the master's degree, and the thesis problem selected, must be approved by the student's advisory committee, the head of the department and the dean of the Graduate School.

Students are generally discouraged from seeking duplicate graduate degrees.

CREDITS

1. For the Master of Science degree or the Master of Arts degree a minimum of 30 semester hours is required.
2. No more than six of the academic credits required for the degree will be accepted from other institutions.
3. No graduate credit will be awarded for excess undergraduate credit from another institution.
4. All work credited toward a master's degree must be completed within six calendar years.
5. No graduate credit is allowed for courses taken by correspondence.

Normally, a maximum of six semester credits may be obtained in extension study in the field of education, provided the extension courses are taught by a member of the graduate faculty and provided the courses are given graduate ranking by the Graduate School. If a student has been admitted to the Graduate School and an approved program of work has been submitted, then six *additional* semester credits may be attained in off-campus graduate courses to apply to a minimal 30-hour master's program. Credit for extension courses reduces the amount of credit that may be transferred from other institutions.

The 30 semester hour requirement for the master's degree represents the minimum quantity of work acceptable. The credit hours required of graduate students usually exceed the minimum requirements. Inadequate preparation and thesis research frequently make additional work necessary.

COURSES OF STUDY

In a typical minimal program of 30 hours, at least 20 semester hours must come from the 500- and 600-level group with no less than six hours being at the 600 level. The program of the student may include no more than six hours of research

nor more than two hours of departmental seminar unless the total program planned exceeds 30 hours. Courses at the 400-level counted toward the minimal 30-hour requirement may not ordinarily come from the major field.

During the first term in residence an advisory committee of at least three faculty members, one representing the minor field, will be appointed by the dean, after consultation with the head of the major department, for each student engaged in a program of work leading to the master's degree. The advisory committee will meet with the student and prepare a program of course work to meet the requirements of the student's graduate objectives. Four copies of the program, prepared on forms provided for this purpose, must be approved by each member of the committee, by the head of the major department and by the dean of the Graduate School. After approval in the Graduate Office, three copies will be returned to the department head—one for his files, one for the chairman of the advisory committee and one for the student.

The courses taken by a graduate student shall constitute a well-rounded but unified plan of study. This means that the program of research and course work shall be divided between a major and a minor field. While there are no inflexible rules which govern the number of credit hours that must constitute the major and minor, in general, it is expected that approximately two-thirds of the course work will fall in the major and one-third in the minor. The detailed course requirements for each graduate student program are left to the judgment of the advisory committee.

RESIDENCE

Students engaged in a course of study leading to the Master of Science or Master of Arts degree are required to be in residence, pursuing graduate work, one full academic year.

CLASS WORK

A graduate student is expected to show greater initiative in exploring the possibilities of the subject matter presented in the courses he takes than is the undergraduate. He is also expected to recognize the significance of facts and to assume a responsibility for relating data to theoretical concepts. In preparation, attendance and in all the routine of class work the graduate student is subject to the regulations observed in other divisions of the University.

GRADES

A minimum grade of "C" must be made on all formal course work to obtain graduate credit. An average of "B" must be obtained on all course work taken as part of the student's graduate program. Failure to maintain a "B" average will place the student on probation. Any student whose academic record fails to meet the "B" average requirement for two consecutive terms will not be permitted to continue a graduate program without the written approval of the graduate dean.

Grades in research, seminar and special problems courses are given in terms of "S" (satisfactory) or "U" (unsatisfactory) in place of the symbols used for formal course work.

"S" and "U" grades in graduate courses are not used in computing GPA. However, in the case of a "U" grade, the student's advisory committee is notified imme-

diately and asked to make recommendations. It may recommend (1) a repeat of the course, (2) the substitution of another course (with an "S," "A," or "B" grade required), or (3) if the course is not needed to fulfill degree requirements and if the student has otherwise completed an adequate program, the committee may request that no corrective action be taken in the way of course addition or substitution. The "U" grade will, however, remain on the record.

The grade *incomplete* may be used in research and laboratory courses when circumstances beyond the control of the student have prevented completion of the work by the end of the academic term. A grade of *incomplete* may be given only after approval of the graduate dean and must be converted to one of the usual symbols before the end of the next academic term in which the student is registered.

LANGUAGE REQUIREMENTS

Since this catalog is prepared for a two-year period covering the calendar years 1974-76 some departments may seek a modification of their language requirements during that period. Thus, a student would be well advised to inquire about this matter from the department in which he plans to work toward an advanced degree.

A reading knowledge of at least one modern foreign language (Germanic, Romance or Slavic) is presently required of candidates for the Master of Arts degree in English, history or politics, and by some departments for the Master of Science degree. Departments having this requirement are: biomathematics, chemistry, entomology and statistics. The School of Forest Resources and the Departments of Guidance and Personnel Services, Sociology and Soil Science leave the decision to the student's advisory committee.

In those instances where the language is required, the requirement must be satisfied before a student can be admitted to candidacy.

Proficiency in languages is determined by the Department of Modern Languages:

1. By traditional reading knowledge examination at any time requested by the student.
2. By taking course work (audit) especially designed for graduate students who have no previous knowledge of a foreign language or who wish to refresh their knowledge. The Department offers one special course in each of the three major languages: MLF 401, MLG 401, MLS 401. These courses are normally scheduled in the fall. In them, students are asked to learn a basic vocabulary and are taught to recognize the structural patterns necessary for an understanding of the written language. As the course develops, students will get practice in translation based on materials drawn from various sources reflecting student interest. In the final examination, students will be tested on their ability to translate accurately and correctly. A passing grade in the course will certify students in the language chosen. Both the course and the examination concentrate exclusively on the ability to understand the written word, and do not provide instruction or testing in speaking nor in original composition.

Students whose native language is other than English may meet the foreign language requirement by demonstrating a satisfactory mastery of English. Examinations in English are conducted by the Department of Modern Languages.

When only one language is required in a student's program, certification for that language must occur on this campus.

THESIS

A candidate for the Master of Science or Master of Arts degree must prepare a thesis representing an original investigation. The subject of the thesis must be approved by the head of the department in which the major work is done and by the student's advisory committee. Three copies of the thesis in final form, and five copies of the abstract, must be filed in the Graduate Office at least one month before the end of the term in which the degree is awarded. Detailed instructions as to form and organization of the thesis may be obtained at the Graduate Office.

EXAMINATIONS

All candidates for the Master of Science or Master of Arts degree must pass, with a grade of "A," "B" or "C," all formal course work specified as part of the requirements for the degree. Graduate credit for research, seminar and special problems courses is granted when a grade of "S" is recorded in the Registration Office. In addition, the candidate must pass a comprehensive oral examination that is held to satisfy the examining committee that the candidate possesses a reasonable mastery of knowledge in the major and minor fields and that this knowledge can be used with promptness and accuracy. This examination may not be held until all other requirements, except completing the course work of the last semester, are satisfied. Application for the comprehensive oral examination must be filed with the graduate dean by the chairman of the advisory committee at least two weeks prior to the date on which the examination is to be held.

The oral examination will be conducted by an examining committee appointed by the graduate dean. The chairman of the examining committee will be the chairman of the student's advisory committee. At least two additional members will be appointed to represent the major and minor fields. The comprehensive oral examination is open to all graduate faculty members who care to attend but the decision as to the candidate's fitness rests solely with the examining committee.

At the discretion of the examining committee, written examinations covering the subject matter in the major and minor fields also may be required of the candidate. Written examinations, when required, normally should not be held earlier than the end of the first month of the last semester in residence and not later than one week before the comprehensive oral examination. Information as to when written examinations are scheduled should be obtained from the appropriate departments. See Summary of Procedures for the Master's Degree, pages 53-54.

Master's Degree in a Designated Field

This degree differs from the Master of Arts or Master of Science degree primarily in that course work is substituted for the thesis requirement. Very often this degree is sought by students who are interested in a wider variety of courses than can be

chosen by a student who wishes research training at the master's level. A student may develop a program of study which terminates at the master's level or which may lead to further study toward the doctorate degree.

Following is a listing of the types of degrees that may be awarded upon completion of the course of study in a designated field.

Master of Education (Adult and Community College Education)
Master of Agriculture
Master of Education (Agricultural Education)
Master of Architecture
Master of Biological and Agricultural Engineering
Master of Biomathematics
Master of Chemical Engineering
Master of Civil Engineering
Master of Economics
Master of Education (Curriculum and Instruction)
Master of Education (Educational Administration and Supervision)
Master of Electrical Engineering
Master of Engineering Mechanics
Master of Forestry
Master of Education (Guidance and Personnel Services)
Master of Education (Industrial Arts Education)
Master of Industrial Engineering
Master of Technology for International Development
Master of Landscape Architecture
Master of Life Sciences
Master of Education (Mathematics Education)
Master of Mechanical Engineering
Master of Education (Occupational Education)
Master of Product Design
Master of Public Affairs
Master of Recreation Resources
Master of Education (Science Education)
Master of Sociology
Master of Education (Special Education)
Master of Statistics
Master of Textile Technology
Master of Urban Design
Master of Education (Vocational Industrial Education)
Master of Wildlife Biology
Master of Wood and Paper Science

LANGUAGE REQUIREMENTS

The candidate for a master's degree in a designated field is exempt from the requirement of a reading knowledge of a modern foreign language.

THESIS REQUIREMENTS

In the School of Education the thesis requirement for the master's degree in each of the specialized fields may be waived by the department in which the degree is

sought. When the thesis requirement is waived the student must complete the course "Introduction to Educational Research" or a departmental course in research, and a problem report.

OTHER REQUIREMENTS

Some of these master's programs have special requirements that differ from and sometimes exceed minimum requirements of Master of Arts or Master of Science degrees. Students are advised to obtain full particulars from the appropriate departments. In the main, however, requirements are the same as those for the Master of Arts and Master of Science degrees.

Master of Agriculture Degree and Master of Life Sciences Degree

The requirements for either of these degrees are as follows:

1. A total of 36 semester hours is required.
2. A minimum of four semester hours in special problems is required. Not more than six semester hours in special problems will be allowed. This work replaces the research thesis requirement for the Master of Science or Master of Arts degree.
3. There are no specific requirements as to courses in the 600 group.
4. A reading knowledge of a modern foreign language is not required.

In all other respects the requirements for the Master of Agriculture or the Master of Life Sciences degree are the same as those for the Master of Science degree.

Summary of Procedures for the Master's Degree In a Designated Field

1. Letter of inquiry from prospective student to Graduate School or department head.
2. Mailing of proper forms to student by Graduate School.
3. Receipt of application forms and transcripts by Graduate School.
4. Application with transcript sent to department head for study.
5. Department head recommends acceptance of prospective student stating curriculum in which he will work and the degree sought.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate School. When the student's academic record fails to meet the minimum scholastic standards of the Graduate School, provisional admission may be granted upon submission by the student of evidence of a satisfactory performance on the Graduate Record Examination or National Teacher Examination. The National Teacher Examination is accepted only when approved by the department head and the graduate dean.
7. Permit to register is sent by the Graduate School to the registrar.

8. Student arrives, reports to the department head, is assigned an adviser and makes out a roster of courses in consultation with the departmental adviser.
9. Advisory committee of three or more faculty members, one of whom represents the minor field, appointed before the end of the first semester of graduate study by the Graduate School after consultation with the department head. If departmental written examinations are required by the major department, there may be a minimum of two members on the advisory committee (one from the major field and one from the minor).
10. Plan of work prepared by the advisory committee and submitted in quadruplicate to the Graduate School by the end of the first semester in residence.
11. Plan of work approved by the graduate dean and three copies returned to the department head. One copy is kept in department files, one goes to the adviser and one is given to the student. Students preparing themselves for the professional degree in specialized fields of education should consult the chairmen of their committees with reference to their problem report.
12. Student applies for admission to candidacy for the master's degree. Application must be filed before the end of the first week of the last semester in residence.
13. Application is reviewed by the head of the major department and by the graduate dean and, if approved, the student becomes a candidate for the degree.
14. At the discretion of the advisory committee, written examinations in the major and/or minor fields may be required of the candidate. Written examinations, when required, normally should not be held earlier than the end of the first month of the last semester in residence and not later than one week before the oral examination.
15. Permission for the candidate to take the final oral examination is requested of the Graduate School at least two weeks before the examination.
16. Permission is granted by the graduate dean, date is set and examining committee appointed. The report on the final examination should be filed with the Graduate School as soon as the examination has been completed.
17. Graduate School certifies to the Registration Office and to the Administrative Board of the Graduate School that all requirements for the degree have been met and recommends the awarding of the degree.
18. All requirements must be completed within six calendar years.
19. Student must be registered in semester or session in which degree is to be awarded unless one has completed all requirements for the degree, including the passing of the final oral examination, by the first day of classes in the term in which the degree is to be awarded.

Summary of Procedures for the Master of Science Degree and the Master of Arts Degree

1. Letter of inquiry from prospective student to Graduate School or department head.
2. Mailing of proper forms to student by Graduate School.
3. Receipt of application form and transcript by Graduate School.
4. Application with transcript sent to department head for study.
5. Department head recommends acceptance of prospective student stating curriculum in which he will work and the degree sought.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate School. When the student's academic record fails to meet the minimum scholastic standards of the Graduate School, provisional admission may be granted upon submission by the student of evidence of a satisfactory performance on the Graduate Record Examination or National Teacher Examination. The National Teacher Examination is accepted only when approved by the department head and the graduate dean.
7. Permit to register is sent by the Graduate School to the registrar.
8. Student arrives, reports to the department head, is assigned an adviser and makes out a roster of courses in consultation with department adviser.
9. Advisory committee of three or more faculty members, one of whom represents the minor field, appointed before the end of the first semester of graduate study by the Graduate School after consultation with the department head.
10. A thesis subject is selected and an outline of the proposed research submitted to the department head and to the student's advisory committee.
11. Plan of work prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate School by the end of the first semester in residence.
12. Plan of work approved by the graduate dean and three copies returned to the department head. One copy is kept in department files, one goes to the adviser and one is given to the student.
13. Student passes language examination (if required by the major department). The language requirement must be satisfied before admission to candidacy can be granted.
14. Student applies for admission to candidacy for the master's degree. Application must be filed before the end of the first week of the last semester in residence and may not be filed before the language requirement is satisfied.
15. Application is reviewed by the head of the major department and by the graduate dean and, if approved, the student becomes a candidate for the degree.
16. At the discretion of the advisory committee, written examinations in the major and/or minor fields may be required of the candidate. Written exami-

nations, when required, normally should not be held earlier than the end of the first month of the last semester in residence and not later than one week before the oral examination.

17. A copy of a preliminary draft of the thesis is submitted to the chairman of the student's committee for criticism.
18. At least two weeks prior to the final oral examination, the chairman of the student's advisory committee submits a corrected draft of the dissertation to members for review.
19. Permission for the candidate to take the final oral examination is requested of the Graduate School at least two weeks before the examination, and must be accompanied by a certification that the thesis is complete except for such revisions as may be necessary as a result of the final examination.
20. Permission is granted by the graduate dean, date is set and examining committee appointed. The report on the final examination should be filed with the Graduate School as soon as the examination has been completed.
21. Three copies of the thesis in final form signed by each member of the student's advisory committee and the adviser must be submitted to the Graduate School at least four weeks before the end of the semester or summer session in which the degree is to be conferred.
22. Graduate School certifies to the Registration Office and to the general faculty that all requirements for the degree have been met and recommends the awarding of the degree.
23. All requirements must be completed within six calendar years.
24. Student must be registered in term in which degree is to be awarded unless he has completed all requirements for the degree, including submission of the thesis in final form to the Graduate School, by the first day of classes in the term in which the degree is to be awarded.

Doctor of Philosophy Degree

The degree of Doctor of Philosophy is offered by North Carolina State University in the following fields of study:

Animal Science
Applied Mathematics
Biochemistry
Biological and Agricultural Engineering
Biomathematics
Botany
Chemical Engineering
Chemistry
Civil Engineering
Crop Science
Economics
Electrical Engineering
Engineering Mechanics
Entomology
Fiber and Polymer Science
Food Science
Forestry
Genetics
Horticultural Science
Industrial Engineering
Marine Sciences
Materials Engineering
Mathematics

Mathematics Education
Mechanical Engineering
Microbiology
Nuclear Engineering
Nutrition
Operations Research
Physics
Physiology
Plant Pathology
Psychology
Science Education
Sociology
Soil Science
Statistics
Wood and Paper Science
Zoology

The doctor's degree symbolizes the fact that the recipient is capable of undertaking original research and scholarly work at the highest levels without supervision. Therefore, the Doctor of Philosophy degree is not granted on the basis of successful completion of a given amount of course work, but rather upon the demonstration by a candidate of a comprehensive knowledge and high attainment in scholarship and research in a specialized field of study. These attainments are determined by the quality of the dissertation which the candidate prepares to report the results of original investigations and by passing successfully a series of rigorous and comprehensive examinations on the special and related fields of study.

COURSE OF STUDY

At the time of admission the student should, with the advice of the chairman of the department, elect a major field. During the student's first semester in residence, an advisory committee of at least four members will be appointed by the graduate dean, after consultation with the department head, to prepare with the student a plan of graduate work. Four copies of the program, signed by all members of the advisory committee and the department head or graduate administrator, are referred to the graduate dean for approval. When approved, three copies are returned to the department head, one being retained in the department files, a second copy is given to the chairman of the advisory committee and the third copy is given to the student. The subject of the dissertation must appear on the plan of work and any subsequent changes in the subject of the thesis or in the plan of graduate work must be reported to the Graduate School for approval.

There are no definite requirements in credit hours for the doctor's degree.

Major and Minor Fields The Ph.D. degree is never granted for a program of miscellaneous studies. The program of work as a whole must be rationally unified and all constituent parts must contribute to an organized program of study and research. Courses must be selected from groups embracing one principal subject of concentration, called the major; and from cognate fields, called the minor. The minor program of study may be either a specific minor or interdisciplinary minor.

Specific Minor Supplementary to his major study a candidate is required to offer a minor in a single discipline or field which, in the judgment of the student's advisory committee, provides relevant cognate support to the major field.

Interdisciplinary Minor When an advisory committee finds that the needs of a doctoral student will be best served by preparation not available as a depart-

mental minor, it has the alternative of developing a special program in lieu of the usual minor. To meet the requirements of this option a student may be required to complete courses in two or more departments outside his major, in related courses selected for their relevance to his particular area of concentration. Thus an appropriate program for a major in genetics might include courses in statistics, biochemistry and physiology. In the case of a split minor the two pertinent disciplines may be so identified on the "program of work" forms.

RESIDENCE

For the Doctor of Philosophy degree and the Doctor of Education degree, the student is expected to be registered for graduate work for at least six semesters beyond the bachelor's degree at some accredited graduate school. The amount of work from other institutions credited to the fulfillment of degree requirements will be determined by the dean after consultation with the student's advisory committee at the time the plan of graduate work is filed.

At least two residence credits, as defined below, must be secured in continuous residence (registration in consecutive semesters) as a graduate student at North Carolina State University. Failure to take work during the summer does not break the continuity; however, summer school work can be used to fulfill this requirement.

Residence credit is based on the number of credits of graduate work beyond the bachelor's degree carried in a given term. During a regular semester, residence credit is calculated in the following manner:

Semester Credits	*Residence Credits*
9 or more	1
6-8	⅔
less than six*	⅓

The residence credit for a six-week summer term is only one-half the corresponding amount for a regular semester; i.e., six semester hours carry one-third residence credit and less than six credits, one-sixth residence credit.

The candidate must complete all requirements for the degree, including the final examination on his dissertation and submission of the dissertation in final form to the Graduate School, within a period of seven calendar years from the date of admission to candidacy for the degree.

LANGUAGES

A reading knowledge of scientific literature in at least one modern foreign language is required by most departments for the Doctor of Philosophy degree.** The programs in chemistry, entomology, and mathematics require a reading knowledge of two foreign languages or a comprehension in depth of one language. For the Doctor of Education degree the decision as to whether or not there will be a requirement is left with the student's advisory committee.

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* Including registration for thesis preparation on campus.

** The foreign language requirements for particular degree programs may be modified subsequent to the publication of this catalog. A student would be well advised to check with the department in which he hopes to be working toward an advanced degree.

Comprehension in depth is to be interpreted as a proven ability in the oral and composition elements of a particular language as well as the reading knowledge normally required. Ph.D. students desiring to offer one language in depth should consult with the head of the Department of Modern Languages as to the specific courses to be followed to achieve this comprehension. Specific arrangements may differ, depending upon the student's previous background in the language. It is emphasized that students choosing to achieve competence in depth in one language will generally find this alternative more rigorous than proof of reading ability in two languages.

If the student elects to work in two languages, the languages may be a combination of Romance and Slavic, Romance and Germanic, or Slavic and Germanic.

Students whose native tongue is some language other than English may use English as one of the two languages when two are required for the Doctor of Philosophy degree. When English is submitted in partial fulfillment of the language requirements, the native language may not be used to satisfy one of the language requirements.

When only one language is required in a student's program, certification for that language must occur on this campus.

THE DISSERTATION

The doctoral dissertation presents the results of the candidate's original investigations in the field of his major interest. It must represent a contribution to knowledge, adequately supported by data and written in a manner consistent with high standards of excellence in scholarship. Detailed instructions relating to the thesis may be obtained from the Graduate Office.

Publication of the results obtained in the thesis investigation is expected. Each copy of the thesis must be accompanied by an abstract of approximately 500 words.

The dissertation will be examined by all members of the examining committee and must receive their approval to be acceptable to the Graduate Office.

Two copies of the dissertation in final form, signed by all members of the student's advisory committee, and five copies of the abstract must be presented to the Graduate School not later than four weeks before the date on which the degree is to be awarded.

North Carolina State now has an agreement with University Microfilms, Inc., of Ann Arbor, Michigan, by which all doctoral dissertations are microfilmed and abstracts of the dissertations are published in "Dissertation Abstracts." (See "Other Fees," page 36, under Tuition and Fees.)

EXAMINATIONS

Not earlier than the end of the second year of graduate study and not later than one semester (or its equivalent) before the final orals can be scheduled, each doctoral student is required to pass general comprehensive examinations (known as the qualifying or preliminary examinations). The examinations are given by an examining committee of graduate faculty members appointed by the graduate dean after consultation with the head of the department in which the student's major work has been taken. The examining committee usually consists of the student's advisory committee and a representative of the Graduate School, but may include other

members of the graduate faculty. The examinations are open to all members of the graduate faculty who care to attend.

Authorization for the qualifying examination is requested of the Graduate School by the chairman of the student's advisory committee when the major part of the student's program of course work has been completed and when, in the judgment of the committee, the student is prepared to devote the greater part of his time to the prosecution of his research study. Members of the examining committee will be notified of their appointment by the Graduate Office. Official printed forms will be supplied to the chairman of the examining committee for a report of the results of the examination.

The examination consists of two parts—written examinations and an oral examination held before the entire examining committee. When, in the judgment of the chairman of the student's advisory committee, the student is ready for the written examinations, arrangements may be made. Two approaches are acceptable. In the first, the chairman requests examination questions from each member of the examining committee. Each set of questions is given to the student by the chairman in any order that may seem appropriate. The questions, together with the student's answers, are then returned to the members of the committee for grading. This procedure is still used by departments having a relatively small number of doctoral candidates. Many of the larger departments, however, have found it impractical to have separate written examinations prepared by each student's committee and have instituted departmental written examinations to be used for all candidates. These examinations are given several times during the year and scheduled dates are announced well in advance. Where written departmental examinations of this kind are made available, the student majoring or minoring in the field of the department will be expected to make arrangements for taking these examinations. Questions on written examinations may cover any phase of the course work taken by the student during the period of his graduate study or any subject logically related and basic to an understanding of the subject matter of the major and minor areas of study. They should be designed to measure the student's mastery of these subject matter fields and the adequacy of his preparation for research investigations.

Upon satisfactory completion of the written examinations the student must pass an oral examination before the entire examining committee. This examination is usually held within two weeks after the chairman of the examining committee has certified to the Graduate School that the student has completed satisfactorily the written examinations. The members of the examining committee will be notified by the Graduate School of the time and place arranged for the oral examination. The oral examination is designed to test the student's ability to relate factual knowledge to specific circumstances. In the oral examination the student is expected to use his knowledge with accuracy and promptness and to demonstrate that his thinking is not limited to the facts learned in course work.

A unanimous vote of approval is required for passing the preliminary examination. Approval may be conditioned, however, upon the completion of additional work in some particular field to the satisfaction of the committee. In case a single dissenting vote is cast, the course of action to be taken will become a matter for decision by the Administrative Board. Upon receiving the approval of the examin-

ing committee the student is admitted to candidacy for the doctorate.

A final oral examination is also required. An interval of at least one semester or its equivalent must elapse between admission to candidacy and the final oral examination.

This examination is held after the dissertation has been completed and consists of a defense by the candidate of the methods used and the conclusions reached in his research study. The examination is conducted by an examining committee. The examining committee usually includes the student's advisory committee, plus a representative of the Graduate School, although this procedure is not always adopted. The examining committee is appointed by the graduate dean after consultation with the head of the student's major department.

Failure of a student to pass either the preliminary or the final examination terminates his graduate work at this institution unless otherwise recommended by the examining committee. No reexamination may be given until at least one full semester has elapsed since the first examination. Only one reexamination is permitted.

See Summary of Procedures for Doctor of Philosophy and Doctor of Education Degrees below.

ADMISSION TO CANDIDACY

A student is admitted to candidacy after he has successfully passed the preliminary examinations. The language requirements must be fulfilled before permission to take the preliminary examination is granted.

Doctor of Education Degree

The School of Education offers graduate programs leading to the Ed.D. degree for majors in Adult and Community College Education, Curriculum and Instruction, Educational Administration and Supervision, Guidance and Personnel Services, Industrial Arts Education and Occupational Education. Details are presented on page 114. The philosophy and requirements for the Ed.D. degrees are the same as those expressed herein for the Doctor of Philosophy degree except for the language requirement.

ADDITIONAL INFORMATION

A booklet containing detailed instructions about the form of the dissertation may be obtained from the Graduate School.

Further information concerning graduate work at North Carolina State University may be secured from Dr. Walter J. Peterson, Dean of the Graduate School, North Carolina State University, Raleigh, North Carolina 27607.

Summary of Procedures for the Doctor of Philosophy and Doctor of Education Degrees

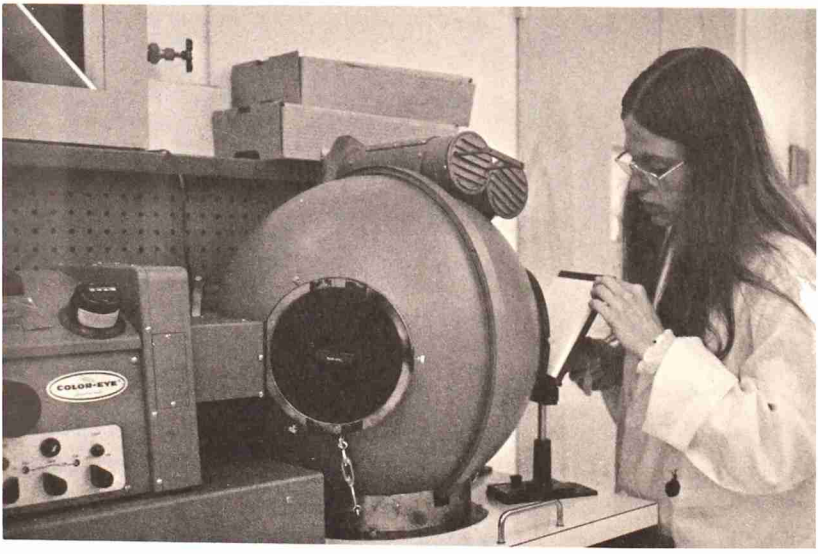
1. Letter of inquiry from prospective student to Graduate School or department head.
2. Mailing of proper forms to student by Graduate School.

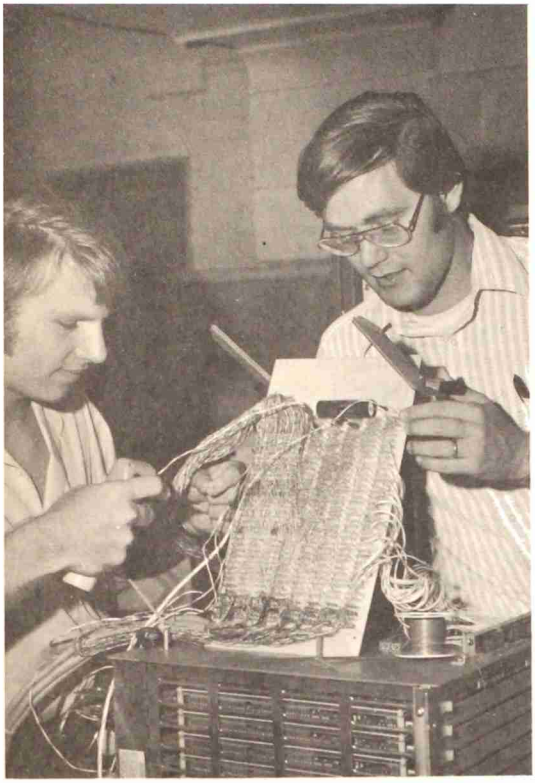
3. Receipt of application forms by Graduate School.
4. Application with transcript sent to department head for study.
5. Department head recommends acceptance of prospective student stating curriculum in which he will work.
6. Assuming the prospective student meets the minimum scholastic standards, notice of acceptance is mailed to him by the Graduate School.
7. Permit to register is sent by Graduate School to the registrar.
8. Student arrives, reports to the department head, is assigned an adviser and makes out a roster of courses in consultation with departmental adviser.
9. Advisory committee of at least four members is appointed in the first term of graduate study by the graduate dean after consultation with the department head.
10. Plan of work is prepared by the advisory committee in consultation with the student and submitted in quadruplicate to the Graduate School by the end of the first semester in residence.
11. Plan of work is approved by the graduate dean and three copies returned to the department head. One copy is kept in department files, one goes to the adviser and one is given to the student.
12. A dissertation subject is selected and an outline of the proposed research submitted to the department head and the student's advisory committee.
13. Student passes language examination(s). (See page 56.)
14. When the student has completed satisfactorily all the courses in the minor field on his plan of work, he may, with the consent of the chairman of his committee, take the written qualifying examination in the field of his minor. If desirable, this examination may be taken if all but one of the courses in the minor field have been completed and the student is taking the last such course during the semester in which the examination is held. The results of this examination will be reported to the Graduate School. The examination in the minor field may be combined with the examination in the major field.
15. The written examination in the major field may be scheduled upon approval of the dean of the Graduate School not earlier than the end of the second year of graduate study and not later than one semester before the final oral examination would be scheduled. The results of this examination will be reported to the Graduate School.
16. When all written examinations have been completed satisfactorily, the oral qualifying examination may be held. The Graduate School is notified two weeks in advance of the time and place of this examination. The report of the examination is sent to the Graduate School. If the report is favorable, the student is admitted to candidacy.
17. A copy of the preliminary draft of the dissertation is submitted to the chairman of the student's committee for criticism.
18. At least two weeks prior to the final oral examination, the chairman of the

student's advisory committee submits a corrected draft of the dissertation to members for review.

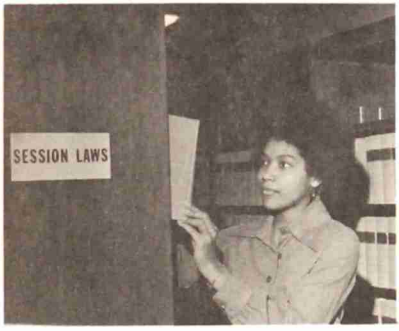
19. One semester after admission to candidacy or later, permission for the candidate to take the final oral examination is requested of the Graduate School by the chairman of the candidate's advisory committee. Requests should be filed at least two weeks before the date of the examination and must be accompanied by a certification that the thesis is complete except for such revisions as may be necessary as a result of the final examination.
20. Permission is granted by the graduate dean if the student's record is in order. A date is set and examining committee appointed. The report on the examination should be filed with the Graduate School as soon as the examination has been completed.
21. Two copies of the thesis in final form and five copies of the abstract must be submitted to the Graduate School not later than four weeks before the end of the term in which the degree is to be awarded. It must carry the signatures of all members of the advisory committee.
22. The Graduate School certifies to the Registration Office and to the general faculty that all requirements for the degree have been met and recommends the awarding of the degree.
23. All requirements must be completed within seven calendar years from date of admission to candidacy for the doctoral degree.
24. The student must be registered in the term in which the degree is to be awarded unless he has completed all requirements for the degree, including submission of the thesis in final form to the Graduate School, by the first day of classes in the term in which the degree is to be awarded.

The color of objects is measured in Textiles utilizing a "color eye."

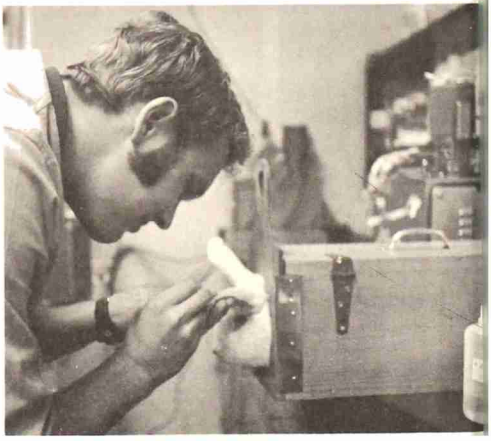




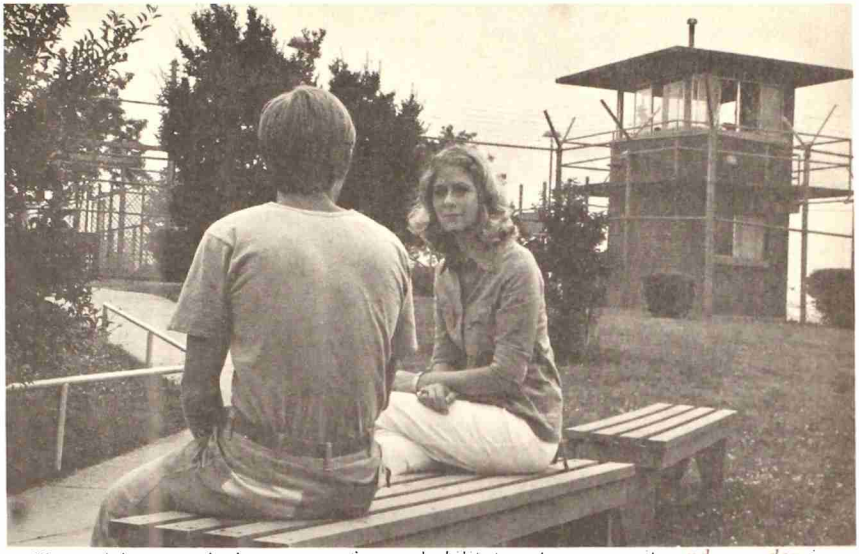
Electrical engineering students engage in such activities as designing and building computer graphics equipment.



NCSU politics students observe and utilize the resources unique to a state capital. American political institutions and processes, administration and comparative political development are politics concentrations.



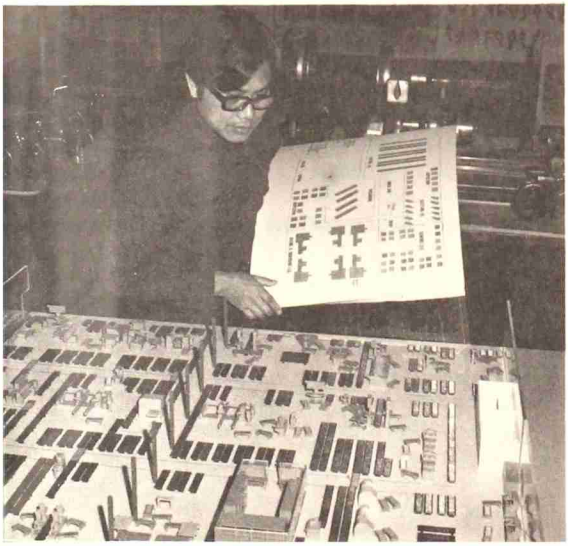
Antibody formation later detectable in plant protein is this microbiology student's research project.



The sociology curriculum ranges from rehabilitation to community and area development. Here a sociology major counsels a Polk Youth Center inmate.

The laboratory digester in the School of Forest Resources is filled with wood chips in preparation for pulping studies on odor abatement.

This industrial engineering student is assemblying a plant layout in an engineering shop.



Design students are encouraged to present plans before juries of fellow students and professors.

FIELDS OF INSTRUCTION

The course descriptions are planned for the academic years 1974-1975 and 1975-1976, unless indicated otherwise. Specific courses may not be offered, however, if registration for a course is too low, or if faculty or facilities are not available.

Courses in the 500 series are open to seniors and graduate students. All courses in this series carry full graduate credit. Courses in the 600 series are open to graduate students only. Master's programs must include not less than 20 semester hours from courses in the 500 and 600 series.

In a typical course description, the semester hours of credit, the number of actual lecture and laboratory hours of meeting per week, and the term or terms in which the course is offered are shown in this manner: 2(1-2) F,S,Sum. or 1-3 F,S,Sum.

The 2 indicates the number of semester hours credit given for satisfactory completion of the course. The (1-2) indicates that the course meets for one hour of lecture and for two hours of laboratory work each week. The 1-3 indicates that a maximum of three and a minimum of one semester hours credit can be earned. This is to be arranged with the instructor. The F designates that the course is to be given in the fall semester. Likewise the S designates spring and the Sum., summer.

For 400-level course descriptions, see the Undergraduate Catalog.

Adult and Community College Education

GRADUATE FACULTY

Professor E. J. Boone, *Head*

Professor: C. Trent; *Extension Professor:* J. D. George; *Visiting Professor:* I. E. Ready; *Adjunct Professor:* B. E. Fountain; *Associate Professors:* W. L. Carpenter, W. L. Gragg, R. W. Shearon; *Assistant Professors:* J. C. Glass Jr., G. E. Parsons, K. B. Segner III; *Extension Assistant Professor:* Estelle E. White; *Visiting Assistant Professor:* D. B. Lumsden; *Adjunct Assistant Professor:* C. J. Law Jr.

The department is a component of both the School of Education and the School of Agriculture and Life Sciences. It offers programs of study leading to the Master of Education, Master of Science and Doctor of Education degrees with a major in adult and community college education. The program is directed toward administrators, supervisors and teachers in university and cooperative extension and community colleges and other adult education agencies.

The curriculum of the department is interdisciplinary. It is specifically designed to help students acquire an integrated conceptual and theoretical framework derived from the behavioral agencies, social sciences and education that will equip them to plan, administer and effect viable and relevant programs of change with individual learners, groups and larger societal aggregates in both formal and informal settings.

Further, the curriculum provides opportunities for students to acquire a high level of competence in identifying and diagnosing problematic situations and proposing alternative courses of action and strategies in seeking solutions to problems. Cognate fields of study include anthropology, economics, politics, psychology and sociology.

The department is housed in Ricks Hall and Poe Hall. Graduate students on assistantships and internships are provided office space and equipment. Other graduate students are provided study space when possible.

For descriptions of the adult and community college education courses listed below, see page 122 to 134.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 500 The Community College System. 3(3-0) F,S,Sum.

ED 501 (SOC 501) Leadership. 3(3-0) F,S. (See sociology, page 243.)

ED 502 (PS 502) Public Administration. 3(3-0) F,S. (See politics, page 226.)

ED 503 The Programming Process in Adult and Community College Education. 3(3-0) F,S,Sum.

ED 510 Adult Education: History, Philosophy, Contemporary Nature. 3(3-0) F,S,Sum.

ED 513 (SOC 513) Community Organization. 3(3-0) F.

ED 537 The Extension and Public Service Function in Higher Education. 3(3-0) S,Sum.

ED 538 Instructional Strategies in Adult and Community College Education. 3(3-0) F,Sum.

ED 559 Learning Concepts and Theories Applied to Adult and Community College Education. 3(3-0) S,Sum.

ED 596 Topical Problems in Adult Education. Credits Arranged. F,S,Sum.

ED 598 Concepts and Strategies of Understanding, Motivating and Teaching Disadvantaged Adults. 3(3-0) S,Sum.

FOR GRADUATES ONLY

ED 600 Organizational Concepts and Theories Applied to Adult and Community College Education. 3(3-0) F,Sum.

ED 601 Administrative Concepts and Theories Applied to Adult and Community College Education. 3(3-0) S,Sum.

ED 696 Seminar in Adult and Community College Education. 1-3. F,S,Sum.

Agricultural Education

(For a listing of graduate faculty and departmental information, see Education. page 115.)

Air Conservation

The air conservation faculty includes some 50 faculty members representing 20 departments in four schools. It is the intent of this faculty and the associated program to provide training for students in the many disciplines related to air conservation. Such areas as air sampling, biological effects, air quality management, sources, meteorology, law and economics are all important aspects covered by course offerings and research projects.

A graduate student desiring to minor in Air Conservation will have on his committee a member of the Air Conservation faculty from outside his major department, representing this minor field. While there are no restrictions on the major, students minoring in Air Conservation should have a strong background in the life sciences, the physical sciences or engineering. The minor program will normally consist of 10 or more credits for the master's degree, 16 or more for the doctorate.

A variety of courses bearing on different aspects of the air-conservation problem may be taken on this campus (under the auspices of the Triangle Universities Consortium on Air Pollution) or at UNC-Chapel Hill or Duke. The listing below shows courses available at North Carolina State University. For courses at Duke and Chapel Hill see appropriate catalogs.

Air Pollutants and Their Sources

CE	576	Atmospheric Pollution.

Meteorology and Pollutant Transport

MY	512	Micrometeorology.
MY	555	Meteorology of the Biosphere.
MY	556	Air Pollution Meteorology.
MY	627	Atmospheric Turbulence and Diffusion.

Air Sampling and Analysis

ST	511	Experimental Statistics for Biological Sciences, I.
CH	517	Physical Methods of Elemental Trace Analysis.
FOR	353	Air Photo Interpretation.

Effects on Human, Animal, and Plant Receptors

BO (ZO)	360	Introduction to Ecology.
BO	480	Air Pollution Biology.
ZO	400	Biological Basis of Man's Environment.
BO	561	Physiological Ecology.
TOX	515	Environmental Toxicology.

Air-Quality Management

CE	472	Elements of Air Quality Management.
CHE	535	Engineering Economy in Air-Pollution Control Systems.
MAE	409	Particulate Control in Industrial Atmospheric Pollution.
MAE	510	Theory of Particulate Collection in Air Pollution Control.
WPS	525	Pollution Abatement in Forest Products Industries.

Air-Quality Law and Institutions

PS (ED)	502	Public Administration.
UNI	495	Special Topics in University Studies (Environment and Law).

Air-Conservation Economics

EC	401	Economic Analysis for Non-Majors.
EC	515	Water Resources Economics.
EC	550	Mathematical Models in Economics.
OR	501	Introduction to Operations Research.

Communications concerning the Air Conservation program, including inquiries from students wishing to minor in Air Conservation, should be directed to: Chairman, Air Conservation Committee, Department of Chemical Engineering, 103 Riddick, North Carolina State University, Raleigh, North Carolina 27607

Animal Science

GRADUATE FACULTY

Professor I. D. PORTERFIELD, *Head*

Professors: E. R. BARRICK, E. G. BATTE, A. J. CLAWSON, E. J. EISEN, L. GOODE, G. HYATT JR., J. M. LEATHERWOOD, J. G. LECCE, J. E. LEGATES—*Dean, School of Agriculture and Life Sciences,* B. T. MCDANIEL, R. D. MOCHRIE, A. H. RAKES, H. A. RAMSEY, H. A. SCHNEIDER, L. C. ULBERG, G. H. WISE;

Professors Emeriti: F. H. SMITH, H. A. STEWART; *Extension Professor:* R. F. BEHLOW; *Associate Professors:* E. V. CARUOLO, D. G. DAVENPORT, E. U. DILLARD, H. J. GOLD, R. W. HARVEY, E. E. JONES, J. J. MCNEILL, D. J. MONCOL, R. M. MYERS, O. W. ROBISON, J. C. WILK; *Extension Associate Professors:* J. R. JONES, F. D. SARGENT; *Assistant Professors:* J. A. COALSON, B. H. JOHNSON, W. L. JOHNSON

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: C. H. HILL, G. MATRONE, S. B. TOVE

The Department of Animal Science offers programs leading to the degrees of Master of Science and Doctor of Philosophy with majors in six different disciplines. Animal science traditionally has been oriented toward the study of domestic animals. Although the problems of the livestock industry have not all been solved, the overall approach to research in the general area of animal science has changed and will continue to change in the future. In order to obtain added insight into the underlying problems currently facing animal science, students are trained in those disciplines which provide a basic understanding of the processes of life.

The Department of Animal Science offers a unique opportunity for students to obtain advanced training in a diversity of basic sciences and to integrate this experience into the framework of a living system. Students in this department may obtain degrees in the disciplines of biochemistry, genetics, microbiology, nutrition and physiology as well as a major in animal science. Students with a major in animal science specialize in one or more of the basic biological disciplines or in the more applied areas such as economics and management. This major also provides for the student who desires to achieve a multi-disciplinary experience. Students who desire a major in one of the disciplines develop a program strong in the basic sciences. At the successful termination of such a program they are qualified to compete with students trained in that discipline, but also have the added capabilities of integrating basic knowledge into a complete living system; i.e., the domestic animal. The student may minor in any one of the above areas or may choose as a minor such areas as statistics, economics, chemistry or other biological sciences. One's research experiences can be with a specific species or with a variety of species from cattle to mice.

The availability of a variety of modern laboratories, specialized equipment and many different species which serve as biological models enables the student to become familiar with research tools and their use in expanding knowledge in the several segments which go to make up the field of animal science. The required list of courses and the research program is developed for the individual student. The objective of the program is to provide the student with a challenging program offering one an opportunity to develop creative ability to such an extent that one will have the knowledge and motivation to contribute significantly to a chosen discipline.

FOR ADVANCED UNDERGRADUATES

ANS 401 Reproductive Physiology. Prerequisite: ZO 421. 3(2-3) S.

ANS 402 **Beef Cattle Management.** Prerequisite: ANS 204. 3(2-3) S.

ANS 403 **Swine Management.** Prerequisite: ANS 204. 3(2-3) S.

ANS 404 **Dairy Cattle Management.** Prerequisite: ANS 204. 3(2-3) S.

ANS 405 **Lactation.** Prerequisite: ZO 421. 3(2-3) F.

ANS 406 **Sheep Management.** Prerequisite: ANS 204. 3(2-3) F.

ANS 409 (FS 409) **Meat and Meat Products.** 3(2-3) S. (See food science, page 152.)

ANS 410 **Horse Management.** 3(2-2) F.

ANS 411 **Breeding and Improvement of Domestic Animals.** Prerequisite: GN 411. 3(2-2) F.

ANS 415 (PO 415, NTR 415) **Comparative Nutrition.** Prerequisite: CH 220 or CH 221. 3(3-0) F.

ANS 416 (NTR 416) **Quantitative Nutrition.** Prerequisite: BCH 351. 3(1-6) F.

ANS 490 **Animal Science Seminar.** 1(1-0) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ANS 502 (PHY 502) **Reproductive Physiology of Vertebrates.** Prerequisite: ZO 421 or consent of instructor. 3(3-0) S. Emphasis will be placed on discussions of mechanisms which control the reproductive processes. Mechanisms which are species limited will be compared with those which are shared by all species. Current knowledge of some subsystems will be investigated in detail while others will be referred to in reviews of well-documented research findings. Ulberg

ANS 505 **Diseases of Farm Animals.** Prerequisites: CH 101, CH 103. 3(3-0) F. The pathology of bacterial, viral, parasitic, nutritional, thermal and mechanical disease processes. Batte

ANS 508 (GN 508) **Genetics of Animal Improvement.** Prerequisites: GN 411, ST 511. 3(3-0) S. Emphasis is placed on the utilization of basic principles of population and quantitative genetics in animal improvement. Factors affecting genic and genotypic frequencies and methods of estimating genetic and nongenetic variance, heritabilities and breeding values are presented. The roles of mating systems and selection procedures in producing superior genetic populations are examined. Robison

BCH 551 **General Biochemistry.** 3(3-0) F. (See biochemistry, page 74.)

MB 551 **Immunology and Serology.** 2(1-2) S. (See microbiology, page 203.)

ANS 580 (PHY 580) **Mammalian Endocrine Physiology.** Prerequisites: BCH 351, ZO 421. 3(3-0) F. The course provides detailed discussions of the mammalian endocrine system with emphasis on the functional aspect, chemistry, and mode of action of specific hormones secreted from major endocrine glands. Modern biochemical and physiological principles of hormonal integrations and neuroendocrine integration are examined. B. H. Johnson

ANS 590 Topical Problems in Animal Science. Maximum 6 F,S. Special problems may be selected or assigned in various phases of animal science. Graduate Staff

FOR GRADUATES ONLY

ANS 603 (GN 603) Population Genetics in Animal Improvement. Prerequisites: ST 512, GN 506. 3(3-0) F. A study of the forces influencing gene frequencies, inbreeding and its effects, and alternative breeding plans. Eisen

ANS 604 (PHY 604) Experimental Animal Physiology. Prerequisite: ZO 513 (PHY 513) or equivalent. A study of the theories and techniques involved in the use of animals in physiological investigation with special emphasis on the diversity of physiological applications on this campus. Caruolo

NTR 608 Energy Metabolism. 3(3-0) F. (See nutrition, page 209.)

ANS 622 (ST 622) Principles of Biological Assays. Prerequisites: BCH 551, ST 512. 3(3-0) S. Techniques and designs of biological assays. The interrelationship of logical principles, designs and analyses is emphasized. Graduate Staff

ANS 653 (BCH 653) Mineral Metabolism. 3(3-0) F. (See biochemistry, page 75.)

ANS 690 Seminar in Animal Nutrition. Prerequisite: Consent of seminar leaders. 1(1-0) F,S. Orientation in philosophy of research, preparation for research and general research methodology. Graduate Staff

ANS 699 Research in Animal Science. Credits Arranged. A maximum of six hours is allowed toward the master's degree; no limitation on credits in doctorate program. Graduate Staff

Anthropology

(For anthropology courses, see sociology.)

Architecture

GRADUATE FACULTY

Professor R. P. BURNS JR., *Head*

Professors: J. H. COX, C. E. MCKINNEY—*Dean, School of Design*, D. R. STUART; *Professors Emeriti:* H. H. HARRIS, H. L. KAMPHOEFNER; *Associate Professors:* P. BATCHELOR, G. L. BIRELINE, R. H. CLARK, J. P. REUER, H. SANOFF, V. F. SHOGREN; *Assistant Professors:* D. W. BARNES, E. P. BRANTLY

The Department of Architecture offers programs of study leading to the Master of Architecture degree. While designed primarily as the concluding two-year professional component to follow the four-year undergraduate Bachelor of Environmental Design curriculum in the total six-year program, the graduate program also provides courses of study for graduates holding the five-year Bachelor of Architecture degree. In addition, applicants with undergraduate degrees in fields other than architecture may be accepted as graduate students, and extended programs of study leading to the Master of Architecture degree will be designed

to build on their previous academic experience. This program normally requires three to four years in residence. A group of core courses has been developed to provide in the first semester an intensive orientation to current concepts and activities in the environmental design field for entering graduate students who come from non-design backgrounds.

The nature and complexity of the tasks which confront the architect make it paramount that the master's program be broadly based and diversified. Flexibility is provided so that each student can structure a program of study in accordance with expressed interests and demonstrated capabilities. Essentially, master's candidates are afforded concentrated education in depth so that they can prepare themselves for significant professional involvement in the environmental design field as practitioners, teachers, researchers, or in other more specialized areas.

The advanced architectural design studio provides an arena for graduate students to address both real-life problems of immediate concern as well as theoretical issues having implications for long-range development. Of special interest are those problems at the frontiers of the architectural profession, which have inherent potential for research, innovation and for the development of emergent roles for new professionals. In response to these objectives, the graduate program in architecture has developed three major studio options—*building systems, community development* and *urban design.* The student normally selects one of the three options but may call on other faculty expertise to support his individualized development program with the possibility of self-directed, independent studies during the final two semesters.

The program requires of all students undertaking the normal two-year master's program a minimum of 48 credit hours of course work of which 75 percent will be in the major field; the remainder, constituting the minor field, will be selected to reinforce the student's individual abilities and long-range career goals. While it is conceivable that almost any relevant field of study could be explored, it is assumed that the following interdisciplinary areas of investigation would most frequently be chosen: construction management; environmental policy planning; housing systems; environmental psychology; human behavior; urban physical systems; urban technology; facilities planning—educational, health care, etc.; environmental technology; design theory and philosophy; and visual communication.

FOR ADVANCED UNDERGRADUATES

ARC 400 Intermediate Architectural Design (Series). Prerequisite: DN 202 or equivalent or consent of department. 4(1-9) F,S.

ARC 415 (CE 415) Architectural Structures I. Prerequisite: ARC 316 (EM 316). Not open to CE students. 3(2-3) F.

ARC 416 (CE 416) Architectural Structures II. Prerequisite: ARC 415 (CE 415). Not open to CE students. 3(2-3) S.

ARC 431 Industrialized Systems Building. Prerequisite: ARC 331. 2(1-3) F,S.

ARC 432 Climate Control Systems and Design. Prerequisite: ARC 332. 2(1-3) F.

ARC 433 Illumination Design. Prerequisite: ARC 332. 2(1-3) S.

ARC 441 Design Methods. 2(2-0) F,S.

ARC 491 Special Projects in Architecture. Prerequisite: Junior standing. 1-4 F,S.

ARC 495 Special Problems in Architecture. Prerequisite: Junior standing. 1-3 F,S.

ARC 499 Architecture Seminar. Prerequisite: Departmental approval. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ARC 501, 502 Advanced Architectural Design I, II. Prerequisites: (501) 16 credits of ARC 400 or equivalent; (502) ARC 501. 6(3-9) F,S. Advanced studies in architectural design which investigates large-scale architectural problems having complex functional, social and economic implications; special emphasis is given to problem identification, program formulation and application of advanced design methods.

ARC 511 Professional Practice I. Prerequisite: Fourth year standing. 2(2-0) F. The evolution of architecture as a modern practical profession; obligations of the profession to society and to itself; the legal and ethical position of the architect in practice; comparative study of documents; the architect's working organization; emerging techniques of office practice.

ARC 512 Professional Practice II. Prerequisite: Fourth year standing. 2(2-0) S. Continuing study of standard documents and emerging techniques of practice, with emphasis on the principles and improved techniques of writing construction specifications; interrelationship of The Contract Documents; comparative study of techniques for controlling competitive bidding.

ARC 521, 522 Advanced Architectural Structures I, II. Prerequisites: (521) ARC 416 (CE 416); (522) ARC 521. 3(3-0) F,S. Gravity and non-gravity loads on structures; comparative behavior of structural materials; comparative behavior of simple structural systems; approximate and exact analysis procedures as applied to systems; principles of approximate exact design in timber, steel and reinforced concrete; architectural/structural/mechanical compatibility in systems; basic principles of foundation analyses and design.

ARC 531, 532 Advanced Building Technology I, II. Prerequisites: ARC 331, 332. 2(1-3) F,S. A synthesis of studies in building science undertaken in previous courses. Material assemblies in practical applications, dimensional characteristics of mechanical and construction systems for buildings, and special projects in selected areas of building science.

ARC 551 Research Methods in Architecture. Prerequisite: Graduate standing. 2(2-0) F,S. Seminar on the quantitative methods from various disciplines towards the scientific inquiry of knowledge. Analysis of techniques and instruments appropriate in solving problems involving scaling, measurement, modeling and gaming within the scope of the physical environment.

ARC 591, 592 Advanced Topics in Architecture I, II. Prerequisite: Advanced or graduate standing in School of Design or departmental approval. 1-4 F,S. Investigation of advanced topics in specialized aspects of architecture for interested advanced undergraduate and graduate students in the School of Design.

FOR GRADUATES ONLY

ARC 601, 602 Advanced Architectural Design III, IV. Prerequisites: (601) ARC

502; (602) ARC 601. 6(3-9) F,S. Continuing advanced studies in architectural design in which are synthesized all previous design experience through in-depth investigations of significant environmental problems. Consultation with planners and environmental specialists is extensive. A terminal project is developed in the spring semester.

ARC 621, 622 Advanced Architectural Structures III, IV. Prerequisites: (621) ARC 522; (622) ARC 621. 2(1-3) F,S. Special projects in the study of complex structural systems: cable structures, membranes, thin shells, folded plates, arches, vaults, space frames; studies of construction techniques, prefabrication, structural behavior and stress analysis through model work and simplified calculation procedures.

ARC 691, 692 Special Topics in Architecture. Prerequisite: Graduate standing. 1-6 F,S. An investigation of special topics in architecture of particular interest to advanced students under the direction of a faculty member on a tutorial basis. Credits and content will vary with the needs of students.

Biochemistry

GRADUATE FACULTY

Professor G. MATRONE, *Head*

Professors: F. B. ARMSTRONG, H. R. HORTON, J. S. KAHN, I. S. LONGMUIR, A. R. MAIN, S. B. TOVE; *Associate Professor:* E. C. SISLER; *Assistant Professors:* J. A. KNOPP, ELIZABETH C. THEIL

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: L. W. AURAND, S. G. LEVINE, W. P. TUCKER; *Associate Professors:* J. BORDNER, E. E. JONES

The field of biochemistry applies and extends the concepts of chemistry and physics to the investigation of biological problems. The Department of Biochemistry offers courses of study leading to the Master of Science and Doctor of Philosophy degrees.

A student entering into graduate study in biochemistry should have a bachelor's degree in chemistry or in a biological science. The undergraduate program of studies should include a minimum of two semesters of organic chemistry, two semesters of physical chemistry, one semester of quantitative analytical chemistry and one semester of qualitative organic analysis. Students who lack undergraduate courses considered essential for graduate study in biochemistry may be admitted to the graduate program, provided the deficiencies are corrected early in their graduate work.

Courses in General and Experimental Biochemistry and in Intermediary Metabolism are required as part of programs leading to advanced degrees in biochemistry. In addition to completing a program of study approved by one's advisory committee, a candidate for an advanced degree is expected to participate regularly in seminars throughout one's graduate residence and to engage in

independent research leading to the completion of a scholarly thesis. Research programs are currently being conducted in biochemical genetics, enzyme structure and mechanisms, enzyme kinetics, biochemical aspects of toxicology, regulatory mechanisms, photosynthesis and electron transport, lipid metabolism, metabolism and function of transition elements, plant growth and development, physical biochemistry of macromolecules, oxygen transport mechanisms, and regulation during development.

FOR ADVANCED UNDERGRADUATES

BCH 452 Experimental Biochemistry. Prerequisite: BCH 351, or corequisite BCH 551; quantitative chemical analysis recommended. 3(1-6) F. An introduction to fundamental techniques of biochemistry and molecular biology involving experimental study of carbohydrates, proteins, enzymes, nucleic acids, lipids, metabolism and metabolic controls. Designed to accompany BCH 551. Theil, Knopp

BCH 453 Quantitative Problems in Experimental Biochemistry. Corequisite: BCH 452. 1(0-1) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BCH 551 General Biochemistry. Prerequisites: Three years of chemistry including CH 223 or equivalent; CH 331 or CH 431 strongly recommended. 3(3-0) F. Principles of modern biochemistry including a study of structural and metabolic relationships of carbohydrates, lipids, proteins, nucleic acids, enzymes and metabolic regulation. Jones

BCH 553 (PHY 553) Physiological Biochemistry. Prerequisite: BCH 551. 3(3-0) S. Application of biochemical methods to the elucidation of the function of whole organisms. A. Biochemistry of 1) blood, 2) water, electrolyte, acid-base balance, 3) renal function, 4) muscle metabolism, 5) central nervous system, 6) autonomic nervous system, 7) endocrine system. B. Biochemistry of adaptation to environment 1) high and low PO_2, 2) hot and cold, 3) wet and dry, 4) pollution. Longmuir

BCH 554 Radioisotope Techniques in Biology. Prerequisite: BCH 351 or consent of instructor. 2(1-3) F. Theory and application of radioisotope techniques used in biology. The different modes of radioactivity are correlated with methods of measurement. Emphasis on use and limitations of various instruments and techniques and on their application to research problems. Sisler

BCH 557 Introductory Enzyme Kinetics. Prerequisites: BCH 551 and MA 201 or MA 212. 3(3-0) S. Basic principles of chemical kinetics applied to the development of enzyme kinetics. Limitations of the Michaelis equation are considered in light of the general rate equation. Inhibition and activation, pH functions, effects of temperature, and elucidation of mechanisms are also considered. Main

BCH 561 (GN 561, MB 561) Biochemical and Microbial Genetics. Prerequisites: BCH 351 or BCH 551, GN 411 or GN 505, MB 401 or equivalent. 3(3-0) S. A study of the development of the fields of biochemical genetics and microbial genetics, emphasizing both techniques and concepts currently used in research in these areas. Includes lectures and discussions of current research publications. Armstrong

BCH 590 Special Topics in Biochemistry. Prerequisite: BCH 351 or equivalent. Credits Arranged, Maximum 3 F,S Sum. The study of topics of special interest by small groups of students instructed by members of the faculty, usually for the purpose of developing new courses. Graduate Staff

FOR GRADUATES ONLY

BCH 651 Physical Biochemistry. Prerequisites: BCH 551, CH 331 or CH 431, or consent of instructor. 3(3-0) S. Structural and physical properties of biological macromolecules and the application of physical methods to their study. Knopp

BCH 652 Biochemical Research Techniques. Prerequisites: BCH 551; BCH 452 or CH 315 or CH 411. 3-5 S. Laboratory projects involving separation and characterization of biochemical constituents including enzymes. Kahn

BCH 653 (ANS 653) Mineral Metabolism. Prerequisite: BCH 551. 3(3-0) F. Principles of mineral metabolism with emphasis on metabolic functions, reaction mechanisms and interrelationships. Matrone

BCH 655 Intermediary Metabolism I. Prerequisite: BCH 551. 3(3-0) S. Enzyme kinetics, energetics, and the metabolism of carbohydrates and lipids. Tove

BCH 657 Intermediary Metabolism II. Prerequisite: BCH 551. 3(3-0) F. Enzyme mechanisms, metabolism of proteins, nucleic acids, and their constituents, and metabolic controls. Horton

BCH 659 (CH 659) Natural Products. 3(3-0) F. (See chemistry, page 92.)

BCH 691 Seminar in Biochemistry. 1 F,S. Graduate Staff

BCH 695 Special Topics in Biochemistry. Prerequisite: Graduate standing in biochemistry. Credits Arranged. Critical study of special problems and selected topics of current interest in biochemistry and related fields. Graduate Staff

BCH 699 Biochemical Research. Credits Arranged. Graduate Staff

Biological and Agricultural Engineering

GRADUATE FACULTY

Professor F. J. HÄSSLER, *Head*

Professors: H. D. BOWEN, D. H. HOWELLS, B. K. HUANG, W. H. JOHNSON, G. J. KRIZ, C. W. SUGGS; *Professor USDA:* J. W. DICKENS; *Associate Professors:* R. G. HOLMES, F. J. HUMENIK, E. G. HUMPHRIES, W. F. MCCLURE, R. P. ROHRBACH, E. H. WISER, J. H. YOUNG; *Associate Professors USDA:* T. B. WHITAKER, *Assistant Professors:* C. F. ABRAMS JR., G. R. BAUGHMAN, M. R. OVERCASH, R. W. SKAGGS, R. E. SOWELL

ASSOCIATE MEMBERS OF THE DEPARTMENT

Associate Professors: D. D. HAMANN, V. A. JONES

The Department of Biological and Agricultural Engineering offers programs of study for the Master of Science, Doctor of Philosophy and Master of Biological and Agricultural Engineering degrees.

For those interested primarily in a broadened background of engineering science and technology—without the thesis requirement—the Master of Biological and Agricultural Engineering program permits a wide selection from a variety of advanced courses. While this program is primarily for those intending to terminate graduate study at the master's level, a student may, with departmental approval, develop a plan of study under this program which leads to study for the doctorate.

In the Master of Science program emphasis is placed on mathematics and theory as the unifying link between otherwise widely divergent fields of knowledge in the biological and physical sciences, and as prerequisites to effective engineering advances in biological and agricultural areas. As the student acquires competence in the advanced methods of science, he applies knowledge by conducting an original research investigation and by writing and defending a thesis.

Study for the Doctor of Philosophy degree builds on the Master of Science program with additional formal study followed by a period of independent dissertation research.

Current departmental research projects available for graduate student participation include: watershed hydrology; drainage and irrigation; functional development of field machinery; fruit and vegetable mechanization; pesticide application; plant growth dynamics; crop process engineering and materials handling; biophysics of agricultural processing; human and biomedical engineering; operations research; computer simulation analysis of biological and physical systems; biological instrumentation; physical properties of biomaterials; engineering aspects of plant and animal physiology; and waste management.

Graduate students have access to modern well-equipped research laboratories, controlled-environment test chambers, a research shop manned by competent mechanics, and excellent computing facilities.

Information concerning fellowships and assistantships may be obtained from the head of the department.

FOR ADVANCED UNDERGRADUATES

BAE 411 Farm Power and Machinery. Prerequisites: BAE 211, PY 211 or PY 221. 3(2-3) S.

BAE 432 (FS 432) Food Engineering II. Prerequisite: FS 331 (BAE 331). 3(2-3) S.

BAE 433 Crop Preservation and Processing. Prerequisite: BAE 341. 3(2-3) F.

BAE 451, 452 Agricultural Engineering Design I, II. Prerequisite: Senior standing in SBE curriculum. 3(1-6) F,S.

BAE 461 Analysis of Agricultural Production Systems. Prerequisites: MA 201, EC 201, CSC 111. 3(3-0) F.

BAE 462 Functional Design of Field Machines. Prerequisites: BAE 361, MAE 301, SSC 200. 3(2-2) S.

BAE 465 (CHE 465) Introduction to Biomedical Engineering. 3(3-0) S. See chemical engineering, page 86.)

BAE 472 Agricultural Water Management. Prerequisites: BS 100, SSC 200. 4(3-2) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BAE 552 Instrumentation for Agricultural Research and Processing. Prerequisites: EE 331, MA 301. 2(1-3) Alternate F. Theory and application of primary sensing elements and transducers. Generalized performance characteristics and the use of standards. Use of specialized measurement systems for agricultural research and processing including an introduction to correlation and power spectral density measurements. Rohrbach

BAE 570 (CE 570, MB 570) Sanitary Microbiology. Prerequisite: MB 401 or equivalent. 3(2-3) S. Fundamental aspects of microbiology and biochemistry are presented and related to problems of stream pollution, refuse disposal and biological treatment. Laboratory exercises present basic microbiological techniques and illustrate from a chemical viewpoint some of the basic microbial aspects of waste disposal. Humenik

BAE 578 (CE 578) Agricultural Waste Management. Prerequisite: Graduate or advanced undergraduate standing. 3(2-3) F. A study of agricultural and associated processing wastes. Special laboratory techniques required for the characterization of these wastes will be emphasized. Principles and examples considered will be utilized to develop waste management and nondestructive waste utilization systems that are integral to the total operation. Humenik

BAE 585 (FS 585) Biorheology. Prerequisites: PY 205, EM 307. 3(2-2) Alternate S. The concepts of strain, stress and the mechanical viscoelastic properties of biological solids, fluids and slurries. The time-dependent deformation and flow of biomaterials elements of strength of materials, rheological equations and model concepts, creep-relaxation and dynamic behavior, contact problems and the Boltzman superposition principle as a function of time, temperature and moisture content. Hamann

BAE 590 Special Problems. Prerequisite: Senior or graduate standing in agricultural engineering. Credits Arranged. Each student will select a subject on which he will do research and write a technical report on his results. He may choose a subject pertaining to his particular interest in any area of study in biological and agricultural engineering. Graduate Staff

FOR GRADUATES ONLY

BAE 654 Nonequilibrium Thermodynamics in Bioengineering. Prerequisite: MA 511. 3(3-0) Alternate S. Generalized classical thermodynamics is extended by Onsager's relations to provide a theoretical basis for analyzing the energetics of systems that include life processes. Topics illustrate applications to special systems including isothermal diffusion and sedimentation, membrane permeability, transport processes in continuous systems, and systems with temperature gradients. Johnson

BAE 661 Analysis of Function and Design of Biological and Physical Systems. Prerequisite: Consent of instructor. 3(2-3) Alternate F. Mathematical and analytical techniques and principles essential in the analysis and design of machines and systems which encompass both the biological and the physical domains and their

interfaces. Analytical treatment of physical and biological systems and the functional analysis of machine components are studied to bridge the gap between theories and applications. Control systems synthesis and design are treated with emphasis on quantitative dynamic relations between elements and system response using transfer function and computer simulation techniques. Bowen, Huang

BAE 671 (SSC 671) Theory of Drainage—Saturated Flow. Prerequisite: MA 513. 3(3-0) Alternate F. Physical concepts and properties of fluids and porous media are discussed in relation to soil water movement. The fundamental laws and equations governing saturated flow in porous media are derived and discussed. Mathematical solutions of steady-state and transient flow equations are analyzed to determine their applicability to drainage problems. Analogs and models of particular drainage problems are considered. Skaggs

BAE 674 (SSC 674) Theory of Drainage—Unsaturated Flow. Prerequisite: BAE 671 or equivalent. 3(3-0) Alternate S. Forces involved and theories utilized in saturated flow of porous media are discussed in relation to soil moisture movement. Steady-state and transient unsaturated flow equations for horizontal and vertical moisture movement are developed and solved. The solutions are applied to present-day laboratory and field technology. Molecular diffusion and hydrodynamic dispersion are considered in light of current tracing techniques. Skaggs

BAE 690 Special Topics. Prerequisite: Graduate standing. Credits Arranged, 1-4. A study of topics in the special fields of interest of graduate students under the direction of the graduate faculty. Graduate Staff

BAE 695 Seminar. Prerequisite: Graduate standing in biological and agricultural engineering. 1(1-0) F,S. Elaboration of the subject areas, techniques and methods peculiar to professional interest through presentations of personal and published works; opportunity for students to present and critically defend ideas, concepts and inferences. Discussions to point up analytical solutions and analogies between problems in biological and agricultural engineering and other technologies, and to present the relationship of biological and agricultural engineering to the socio-economic enterprise. Rohrbach

BAE 699 Research in Biological and Agricultural Engineering. Prerequisite: Graduate standing in biological and agricultural engineering. Credits Arranged. Performance of a particular investigation of concern to biological and agricultural engineering. The study will begin with the selection of a problem and culminate with the presentation of a thesis. Graduate Staff

Biological Sciences

Professor J. L. Apple, *Assistant Director of Academic Affairs and Research for the Biological Sciences*

Professor C. F. Lytle, *Teaching Coordinator*

There is no graduate major per se in the biological sciences, but a number of interdepartmental instructional activities are coordinated through the School of Agriculture and Life Sciences. There are several courses at the graduate level which are interdepartmental or interdisciplinary in scope and which are applicable to several graduate major and minor programs. These courses are:

BS 590 Special Problems in Biological Instrumentation. Prerequisite: Consent of instructor. This course comprises a series of instructional sections, each of five weeks duration, devoted to the principles and concepts of biological instrumentation. Each five-week instructional section carries one semester credit. Advanced undergraduate and graduate students may register for only one or up to three sections (total of three credits) per semester. The sections currently offered cover the following topics: basic components of spectrophotometers including light sources, dispersing devices, detectors and read-out methods; theoretical and practical aspects of electron microscopy; basics of analog and digital computing methods and applications of computers to biological research; methods of separation and identification of biopolymers; principles of measurement; and the application of electronics in biological measuring and sensing devices. (For specific information on instructional sections offered, scheduling and instructors, contact the Biological Sciences Office.)

BS 690 Seminar in Cell Biology. Prerequisites: Graduate standing, background in biology or chemistry. 1(1-0) S. A topical appraisal of the current literature in selected areas of cell biology through presentations and discussions by students, faculty and visiting scientists.

BS 696 Topics in Biological Ultrastructure. Prerequisite: Graduate standing (background preferably in biology). 1(1-0) F. A survey of the ultrastructure of living organisms from viruses to higher plants and animals by means of illustrated lectures. The changes in fine structure associated with differentiating cells and with cells in various metabolic states are examined.

Biomathematics

(For a listing of graduate faculty and departmental information, see statistics, page 251.)

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BMA 451 Mathematical Methods in Biology. Prerequisite: MA 112; two biology courses. Credit will not be allowed for majors in biomathematics, mathematics or statistics. 3(3-0) S.

BMA 493 Special Topics in Biomathematics. Prerequisite: Consent of instructor. 1-3 F,S.

BMA 501 Theoretical Biochemistry I. Prerequisites: MA 405, CH 433, BCH 551 or consent of instructor. 3(3-0) F. Application of physical theory and mathematics to biochemistry. Examination of basic principles of molecular theory, reaction rate theory, statistical mechanics and nonequilibrium thermodynamics as applied to biochemical systems. (Offered fall 1973 and alternate years.) Gold

BMA 502 Theoretical Biochemistry II. Prerequisite: BMA 501. 3(3-0) S. Continuation of BMA 501. Coupling of diffusion and chemical reactions. Mathematical description of enzyme control, coupled sequences of enzyme reactions, feedback loops and oscillatory reactions. Experimentally oriented topics include theory of chemical relaxation and tracer dynamics. (Offered spring 1974 and alternate years.) Gold

BMA 571 (MA 571, ST 571) Biomathematics I. Prerequisites: Advanced calculus, reasonable background in biology or consent of instructor. 3(3-0) F. The role of theory construction and model building in the development of experimental science. Induction vs. deduction. The historical development of mathematical theories and models for the growth of one-species populations (logistic and offshoots), including consideration of age distributions (matrix theory, Leslie and Lopez; continuous theory, Lotka). Some of the more elementary theories on the growth of organisms (von Bertalanffy, with applications to ecology; allometric theories, cultures grown in a chemostat). Mathematical theories of two and more species systems (predator-prey, competition, symbiosis; according to the Volterra-Lotka schemes, including present-day research), and discussion of some related models for chemical reaction kinetics. Much emphasis is placed on scrutiny of the biological concepts as well as of the mathematical structure of the models in order to uncover both weak and strong points of the models discussed. Mathematical treatment of the differential equations in these models stresses qualitative and geometric aspects. van der Vaart

BMA 572 (MA 572, ST 572) Biomathematics II. Prerequisites: BMA 571, elementary probability theory. 3(3-0) S. Continuation of topics of BMA 571. Some more advanced mathematical techniques concerning nonlinear differential equations of the types encountered in BMA 571: several concepts of stability, asymptotic directions, periodic models. Comparison of deterministic and stochastic models for several biological problems including birth and death processes. Certain aspects of linear system theory (time-invariant and variable models) used for the analysis of biological systems. Discussion of various applications of mathematics to biology, e.g., theories of aging, some recent research. van der Vaart

BMA 591 Special Topics. Prerequisite: Consent of instructor. Maximum 3, 1-3 FS. Directed readings, problem sets, written and oral reports as dictated by need and interest of student; new 500-level courses during the developmental phase.
Graduate Staff

FOR GRADUATES ONLY

BMA 691 Advanced Special Topics. Prerequisite: Permission of instructor. 1-3 F,S. Directed readings, problem sets, written and oral reports as dictated by need and interest of student; new 600-level courses during the developmental phase.
Graduate Staff

BMA 694 Seminar. Prerequisite: Graduate standing. 1(1-0) F,S. Prerequisite: Graduate students in biomathematics are expected to attend throughout the period of their residence.

BMA 699 Research. Credits Arranged. F,S.

Botany

GRADUATE FACULTY

Professor G. R. NOGGLE, *Head*

Professors: A. W. COOPER, (on leave), R. J. DOWNS, J. W. HARDIN, J. R. TROYER; *Professor USFS:* A. KROCHMAL; *Adjunct Professor:* W. W. HECK; *Professors*

Emeriti: D. B. ANDERSON, H. T. SCOFIELD, B. W. WELLS, L. A. WHITFORD; *Associate Professors:* C. E. ANDERSON, R. C. FITES; *Adjunct Associate Professor USDA:* D. W. DEJONG; *Associate Professors USDA:* H. E. PATTEE, H. SELTMANN; *Assistant Professors:* U. BLUM, E. D. SENECA, C. G. VAN DYKE; *Research Associate:* R. L. MOTT

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: B. J. COPELAND, J. S. KAHN, R. J. THOMAS, D. H. TIMOTHY; *Professor USDA:* D. E. MORELAND

The Department of Botany offers programs leading to the Master of Life Sciences (non-thesis), Master of Science and Doctor of Philosophy degrees.

Excellent physical facilities and equipment are available for instruction and research in all phases of the departmental program. The Phytotron (part of a two-unit controlled environment facility operated in collaboration with Duke University) offers opportunities for research in experimental taxonomy, ecology, morphology and plant physiology. An electron microscope laboratory is available. The department supports a strong research program in cell and tissue culture. A herbarium supports studies in systematic botany, and is augmented by herbaria in the Departments of Botany at nearby Duke University and the University of North Carolina at Chapel Hill. Field laboratories are available at the coast, in the Piedmont and in the mountains. The facilities of branch Agricultural Experiment Stations also are available for field research. The department participates in tropical biology programs through membership in the Organization for Tropical Studies.

Air and water pollution research and training programs have been developed in the School of Agriculture and Life Sciences and the School of Engineering at North Carolina State University in collaboration with groups at Duke University, the University of North Carolina at Chapel Hill and the Environmental Protection Agency in the Research Triangle.

FOR ADVANCED UNDERGRADUATES

BO 400 Plant Diversity. Prerequisite: BO 200. 4(3-3) F.

BO 402 (CS 402) Economic Botany. Prerequisite: BO 200. 3(2-3) S.

BO 403 Systematic Botany. Prerequisite: BS 100 or BO 200. 4(2-4) S.

BO 414 (ZO 414) Cell Biology. Prerequisites: CH 223, PY 212, ZO 201. 3(3-0) F.

BO 421 Plant Physiology. Prerequisites: BS 100 or BO 200 and year of college chemistry. 4(3-3) F,S.

BO 480 Air Pollution Biology. Prerequisites: An introductory biological course and chemistry, junior standing. 3(2-3) S.

BO 499 Independent Study in Botany. Prerequisites: At least eight hours of botany, advanced standing, and presentation of plan of work approved by a faculty member. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

BO 510 Plant Anatomy. Prerequisite: BO 200. 4(2-6) F. A study of the cells, tissues and organs of common flowering plants and gynmosperms. Growth and differentiation patterns will be considered with emphasis on current research.
Anderson

BO 522 Advanced Morphology and Phylogeny of Seed Plants. Prerequisite: BO 403. 4(3-3) S. A comprehensive survey of the morphology and evolution of angiosperms and gymnosperms. Special emphasis is given to detailed vegetative and reproductive morphology of fossil and living forms, and to their presumed evolutionary relationships. (Offered 1974-75 and alternate years.) Hardin

BO 524 Grasses, Sedges, and Rushes. Prerequisite: BO 403. 4(2-6) F. A course dealing with three large, economically and ecologically important plant families. A working familiarity with these three groups will be achieved through an introduction to the special terminology used in dealing with these plants, extensive field work emphasizing keying out plants collected and a study of the recently developed modern classification of the grasses. (Offered 1973-74 and alternate years.) Staff

BO 544 Plant Geography. Prerequisites: BO 403, BO 360 (ZO 360), GN 411 or equivalents. 3(3-0) S. A course in descriptive and interpretive plant geography, synthesizing data from the fields of ecology, genetics, geography, paleobotany and taxonomy. Includes a survey of the present distribution of major vegetation types throughout the world, a discussion of the history and development of this present pattern of vegetation and a discussion of the principles and theories of plant geography. (Offered 1974-75 and alternate years.) Cooper

BO 551 Advanced Plant Physiology I. Prerequisites: General botany or biology, and biochemistry. 3(3-0) F. The first half of a two-semester sequence covering the current status of plant physiology. Topics will include plant organization, metabolism, water relations, solute relations, photobiology and respiration.
Troyer, Noggle

BO 552 Advanced Plant Physiology II. Prerequisites: General botany or biology, and biochemistry. 3(3-0) S. The second half of a two-semester sequence covering the current status of plant physiology. Topics will include inorganic nutrition, nitrogen assimilation, plant growth substances, physiology of seeds, vegetative growth, reproductive growth, aging and senescence. Noggle, Troyer

BO 553 Laboratory in Advanced Plant Physiology I. Prerequisite or corequisite: BO 551. 1(0-3) F. Laboratory to accompany BO 551 Advanced Plant Physiology I. Laboratory procedures in plant nutrition, plant structure and composition, water relations, respiration. Staff

BO 554 Laboratory in Advanced Plant Physiology II. Prerequisite or corequisite: BO 552. 1(0-3) S. Laboratory to accompany BO 552 Advanced Plant Physiology II. Laboratory procedures in enzymes, photosynthesis, photobiology, plant growth substances. Staff

BO 560 (ZO 560) Principles of Ecology. Prerequisite: Three semesters of college level biology courses. 4(3-3) F. A consideration of the principles of ecology at the graduate level. Each of the major subject areas of ecology is developed in sufficient depths to provide a factual and philosophical framework for the understanding of ecology. Blum, Shaw

BO 561 Physiology Ecology. Prerequisites: BO 421 and BO 560 (ZO 560) or equivalent. 4(3-3) S. This course will approach the plant community from a physio-

logical standpoint. Emphasis will be placed on the individual in the community and how it responds to its immediate environment on a short- and long-term basis. (Offered 1974-75 and alternate years.) Blum

BO 574 (MB 574) Phycology. Prerequisite: BS 100 or BO 200. 3(1-4) S. An introduction to the structure, reproduction and importance of organisms which may be included in the algae. Considerable time is devoted to the local freshwater and marine floras and the ecology of important species. Witherspoon

BO 575 (MB 575, PP 575) The Fungi. Prerequisite: BO 200 or equivalent. 3(3-0) F. An overview of the fungi within the framework of a survey of the major classes. Lectures while covering the major groups systematically will also include ancillary material on aspects of ultrastructure, experimental adaptations, sexuality, ontogeny, and economic, including historical, importance. Van Dyke

BO 576 (MB 576, PP 576) The Fungi—Lab. Corequisite: BO 575. 1(0-3) F. The course will provide illustrative material of the fungal assemblages discussed in BO 575. Van Dyke

BO 590 Topical Problems. Prerequisite: Consent of instructor. 1-3 F,S. Discussions and readings on problems of current interest in the fields of ecology, anatomy and morphology, taxonomy, and cell biology. May be repeated with a change in topic for a maximum of six credits. Graduate Staff

FOR GRADUATES ONLY

BO 612 Plant Morphogenesis. Prerequisite: Six hours of botany equivalent to BO 400 and BO 421. 4(3-3) S. A review and synthesis of the factors involved in the development of plant form. Levels of control from the molecular to the whole organism will be considered. (Offered 1973-74 and alternate years.) Anderson

BO 620 Advanced Taxonomy. Prerequisite: BO 403. 3(2-2) S. A course in the principles of plant taxonomy including the history of taxonomy, systems of classification, rules of nomenclature, taxonomic literature, taxonomic and biosystematic methods, and monographic techniques. (Offered 1973-74 and alternate years.) Hardin

BO 625 (PP 625) Advanced Mycology. 4(2-6) F. (See plant pathology, page 224.)

BO 631 Water Relations of Plants. Prerequisite: BO 551 or equivalent. 3(3-0) S. A discussion of the physiological water relations of plants with emphasis on theoretical principles and quantitative description. (Offered 1973-74 and alternate years.) Troyer

BO 633 Plant Growth and Development. Prerequisites: BO 414 (ZO 414) or BO 421, organic chemistry. 3(3-0) S. An advanced course in plant physiology covering plant growth, development, differentiation, senescence and biological control mechanisms. Fites

BO 634 Introduction to the Thermodynamics of Biological Systems. Prerequisite: BO 551 or consent of instructor. 3(3-0) S. An introductory development of the thermodynamic theory relevant to biological systems together with consideration of examples of biological problems to which thermodynamic theory has been applied. (Offered 1974-75 and alternate years.) Troyer

BO 636 Discussions in Plant Physiology. Prerequisites: BO 414 (ZO 414) or BO

421, organic chemistry. 1(1-0) F,S. Group discussions at an advanced level of selected topics of current interest in plant physiology. Graduate Staff

BO 660 (ZO 660) Advanced Topics in Ecology I. Prerequisite: BO 560 (ZO 560). 4(3-3) S. A consideration in depth of the major fields of ecology. Subject matter will be developed through seminars and lectures based on classical and current literature, and principles will be illustrated by laboratory exercises and field trips. Topics covered include microenvironment, community ecology, ecosystems and nutrient cycling. (Offered 1973-74 and alternate years.)

BO 661 (ZO 661) Advanced Topics in Ecology II. 4(3-3) S. (See zoology, page 279.)

BO 691 Botany Seminar. 1(1-0) F,S. Scientific articles, progress reports in research and special problems of interest to botanists are reviewed and discussed. Graduate student credit is allowed if one paper per semester is presented at the seminar. Graduate Staff

BO 693 Special Problems in Botany. Credits Arranged. Directed research in some specialized phase of botany other than a thesis problem, but designed to provide experience and training in research. Graduate Staff

BO 699 Research. Credits Arranged. Original research preliminary to writing a master's thesis or a doctoral dissertation. Graduate Staff

Cell Biology

Many biologists seek a basic understanding of biological phenomena at the cellular and subcellular levels. They recognize that principles and concepts developed in one cellular system may apply to a variety of organisms and may help to explain the activities of more highly organized systems such as organs and tissues.

Biologists interested in this approach need a broader background than that generally provided by the customary major and minor. Such a background can be obtained through the Interdisciplinary Minor at North Carolina State University by selection of appropriate courses from the wide array available in the biological science departments at this institution, the University of North Carolina at Chapel Hill and Duke University at Durham.

Chemical Engineering

GRADUATE FACULTY

Professor J. K. FERRELL, *Head*

Professors: K. O. BEATTY JR., R. P. GARDNER, D. C. MARTIN, E. M. SCHOENBORN, J. F. SEELY, H. B. SMITH, V. T. STANNETT; *Professor Emeritus:* W. L. MCCABE; *Associate Professors:* R. M. FELDER, H. B. HOPFENBERG, D. B. MARSLAND, E. P. STAHEL; *Assistant Professors:* M. R. OVERCASH, R. W. ROUSSEAU

The Department of Chemical Engineering offers programs of advanced study

leading to the Master of Science, Master of Chemical Engineering and Doctor of Philosophy degrees. Students entering graduate study in the department normally have a bachelor's degree in chemical engineering or its equivalent, but programs can be worked out to accommodate students with bachelor's degrees in applied mathematics, chemistry, physics and other branches of engineering. Entering students should have a background in undergraduate mathematics, physics and chemistry, including physical chemistry; and a background equivalent to undergraduate work in heat transfer, fluid mechanics, and mass transfer and diffusional operations. Deficiencies in any of these areas can normally be made up in one semester.

The most extensive area of research in the department is in the field of polymer science and engineering. Graduate and post-doctoral efforts in this field include studies of ionic and free-radical polymerization, grafting reactions, membrane technology and design of polymerization reactors. Other active research areas include chemical reaction engineering, heat and mass transfer, process optimization and control, particulate processes, pollution abatement and control, thermodynamics and biomedical engineering.

The proximity of UNC-Chapel Hill and Duke University, as well as the Research Triangle Park which houses a number of government and industrial research facilities, lends considerable support to many of the research programs at North Carolina State University. The Environmental Protection Agency, for example, has a facility in the Research Triangle Park which provides a natural contact between government and university scientists studying air pollution problems.

The Department of Chemical Engineering occupies 40,000 square feet in the east wing of Riddick Engineering Laboratories. Within the building there are several excellent general-purpose laboratory facilities for graduate research. The department also has several other special facilities including laboratories for process control and dynamics, thermodynamics, powder science and technology, desalination and polymer research. In addition, three pilot plant systems have been built to study heat transfer, reaction kinetics and complex mixing phenomena in polymerization systems. A well-equipped instrumental analysis laboratory is maintained within the department; other specialized instruments such as electron beam and scanning microscopes are available on campus should a research project require their use. The School of Engineering computer facilities are conveniently housed within the chemical engineering wing of Riddick Hall. A new terminal link to an IBM 370/165 computer located in the Research Triangle Park provides rapid service on almost all digital jobs. Additional digital capabilities are provided by an IBM 1130 computer which is interfaced to an EAI TR 48 analog computer providing a hybrid facility. Finally, a machine shop assures the student that almost any special equipment needed for research can be constructed within the department.

A number of research projects within the department are supported by industry as well as state and federal agencies. Research assistantships for work on these specific projects are available and may be nine- or twelve-month appointments. The department also offers teaching assistantships which carry a nine-month stipend of $3,000. These are half-time appointments and usually involve assisting in the teaching of courses, supervising undergraduate laboratories or other labora-

tory work. In addition, the department has several industrially sponsored fellowships which require no specific duties.

FOR ADVANCED UNDERGRADUATES

CHE 412 Transport Processes II. Prerequisite: CHE 327. 3(3-0) S.

CHE 425 Process Measurement and Control I. Prerequisites: CHE 225, CHE 327. 3(2-2) F.

CHE 426 Process Measurement and Control II. Prerequisite: CHE 425 or EE 435 or MAE 435. 3(2-2) S.

CHE 428 Separation Processes II. Prerequisite: CHE 327. 3(3-0) S.

CHE 431 Chemical Engineering Laboratory I. Prerequisite: CHE 311. 3(1-5) S.

CHE 432 Chemical Engineering Laboratory II. Prerequisite: CHE 431. 3(1-5) F.

CHE 446 Chemical Process Kinetics. Prerequisite: CHE 315. 3(3-0) F.

CHE 451 Chemical Engineering Design. Prerequisites: CHE 315, CHE 327, CHE 432. 3(2-2) F,S.

CHE 465 (BAE 465) Introduction to Biomedical Engineering. Prerequisites: MA 202 or MA 212, PY 212 or PY 221. 3(3-0) S.

CHE 495 Seminar in Chemical Engineering. Prerequisite: One semester required of seniors in chemical engineering. 1(1-0) F,S.

CHE 497 Chemical Engineering Projects. Elective for seniors in chemical engineering. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CHE 511 Problem Analysis for Chemical Engineers. Prerequisites: CHE 428, MA 301. 3(3-0) S. The application of the methods of mathematical analysis to the formulation and solution of problems in transport phenomena, transient phenomena in unit operations, process dynamics and thermodynamics. Study and use of analog computer solutions of these problems. Martin

CHE 513 Thermodynamics I. Prerequisite: CHE 315. 3(3-0) F. An intermediate course in thermodynamic principles and their application to chemical and phase equilibria. The course is largely from a macroscopic viewpoint but consideration will be given to some aspects of the statistical viewpoint. Beatty

CHE 515 Transport Phenomena. Prerequisite: CHE 327. 3(3-0) F. A theoretical study of transport of momentum, energy and matter with emphasis on the latter two. The diffusional operations, including coupled heat and mass transfer, are introduced in the light of the theory. Marsland

CHE 517 Kinetics and Catalysis. Prerequisite: CHE 446. 3(3-0) F. An intensive study of homogeneous and heterogeneous kinetic reactions, rates and rate laws, experimental methods and mathematical techniques in engineering analysis of chemical reaction systems. Felder

CHE 521 Mass Transfer Operations. Prerequisite: CHE 327 or equivalent. 3(3-0) S. Multicomponent mass transfer operations will be discussed in light of recent developments and innovations in both the operations themselves and in calculational techniques used in analyzing the operations. The equilibrium stage concept will be developed and as time permits, a discussion of the continuous rate processes will be undertaken. Problems unique to given operations, such as are encountered in extractive and azeotropic distillation will be discussed during the course. Rousseau

CHE 523 Fluid Dynamics and Heat Transfer. Prerequisite: CHE 311. 3(3-0) F. Convective heat transfers in chemical process equipment, such as heat exchangers, chemical reactors, distillation and extraction reboilers, etc., and fluid dynamics and heat transfer of multiphase, multicomponent and chemically reactive systems. Ferrell

CHE 525 Process Dynamics. Prerequisite: CHE 425. 3(3-0) F. A detailed study of the dynamic response of typical chemical process equipment including instrumentation and process control devices. Fundamental concepts of automatic control of process variables such as temperature, pressure, flow and liquid level. Martin

CHE 527 (OR 527) Optimization of Engineering Processes. Prerequisites: MA 511, CSC 111 or equivalent. 3(3-0) F. A survey of mathematical methods for the optimization of engineering processes. Emphasis on applications of the techniques discussed rather than rigorous development of the theory. Felder

CHE 535 Engineering Economy in Air Pollution Control Systems. Prerequisites: MAE 409, CE 576, or equivalent first course. 3(3-2) S. Principles and practice in designing equipment for the abatement of air pollution; estimation of capital cost and operating expense; economic optimization under various kinds of tax laws. Marsland

CHE 541 Cellulose Industries. Prerequisite: Organic chemistry. 3(3-0) F. Methods of manufacture and application of cellulose chemical conversion products. Emphasis placed on recent developments in the field of synthetic fibers, film, lacquers and other cellulose compounds. Seely

CHE 543 Technology of Plastics. Prerequisite: Organic chemistry. 3(3-0) S. The properties, methods of manufacture and applications of synthetic resins. Recent developments in the field are stressed. Schoenborn

CHE 561 Biomedical Engineering I: Fluid Flow and Heat Transfer. Prerequisites: CHE (BAE) 465, or equivalent background. 3(3-0) F. The extension of fluid flow and heat transfer concepts to biomedical engineering is presented along with the grounding in physiology requisite to proper modeling of mammalian flow and thermal processes. Cardio-vascular blood flow, pulmonary air flow and heat flow in temperature regulation are subjected to critical engineering analysis. Flows in the urinary, alimentary and lymphatic systems and in extracorporeal assist devices including the heart-lung machine and artificial kidney are also studied. Beatty

CHE 596 (TC 569) Polymers, Surfactants and Colloidal Materials. Prerequisites: CHE 315, CH 431, CH 223. 3(3-0) F. A survey of the relationship between molecular structure and bulk properties of nonmetallic materials as applied in chemical engineering processes. Special attention will be directed to the application of surface and colloid chemistry as well as polymer science. Hopfenberg

CHE 597 Chemical Engineering Projects. Prerequisite: Graduate standing. 1-3 F,S. A laboratory study of some phase of chemical engineering or allied field. Graduate Staff

CHE 598 Special Topics in Chemical Engineering. Prerequisite: Graduate standing. 1-3 F,S. Study and investigation of special topics in chemical engineering. The course may consist of directed reading of the literature of chemical engineering, introduction to research methodology, special topics of current interest, seminar discussions dealing with special topics, etc. Graduate Staff

FOR GRADUATES ONLY

CHE 611 Chemical Process Design and Simulation. Prerequisite: CHE 511. 3(3-0) S. Application of process analysis, simulation and optimization techniques to case studies of complex chemical processes. Marsland

CHE 613 Thermodynamics II. Prerequisite: CHE 513. 3(3-0) F. A consideration of various thermodynamic topics of special interest to chemical engineers. The effects of high pressures and high temperatures on equilibria, relationship of thermodynamics to rate process, thermodynamics of the steady state including coupled transfer process and experimental methods in thermodynamics would be typical. Beatty

CHE 617 Chemical Reaction Engineering. Prerequisite: CHE 517. 3(3-0) S. An advanced study of ideal and real reactor systems. The approach employed is twofold: characterization of actual systems by empirical rate expressions coupled with fundamental analysis; simulation of coupled physical and chemical processes in a reactor by solution of various types of physical models. Stahel

CHE 621 Advanced Mass Transfer. Prerequisite: CHE 515. 3(3-0) F. Application of transport theory and empirical devices to the analysis, synthesis and design of mass-transfer equipment. The operations of absorption, extraction, distillation, humidification and drying will be considered. Rousseau

CHE 623 Advanced Fluid Dynamics. Prerequisites: CHE 515, CHE 523. 3(3-0) S. The principles of fluid dynamics and their application to laminar and turbulent flow, flow in closed channels, flow in packed beds and porous media, particle technology, industrial rheology and two-phase flow. Ferrell

CHE 624 Advanced Heat Transfer. Prerequisite: CHE 515. 3(3-0) F. An advanced course dealing primarily with heat transfer between liquids and solids, optimum operating conditions and design of equipment, conduction, heating and cooling of solids, radiant heat transmission. Beatty

CHE 669 (TC 669) Diffusion in Polymers. Prerequisite: CHE 569 or consent of instructor. 2(2-0) S. An up-to-date treatment of the theory and practice of small molecule transport in polymers as applied to the chemical, polymer, textile, coatings and natural fiber industries. Hopfenberg

CHE 671 (TC 671) Special Topics in Polymer Science. Prerequisite: Consent of instructor. 1-3 F. An intensive treatment of selected topics in fiber and polymer science. Stannett

CHE 693 Advanced Topics in Chemical Engineering. 1-3 F,S. A study of recent developments in chemical engineering theory and practice, such as ion exchange, crystallization, mixing, molecular distillation, hydrogenation, fluorination. The topic will vary from term to term.

CHE 695 Seminar. 1(1-0) F,S. Literature investigations and reports of special topics in chemical engineering and allied fields. Graduate Staff

CHE 699 Research. Credits Arranged F,S. Independent investigation of an advanced chemical engineering problem. A report of such an investigation is required as a graduate thesis. Graduate Staff

Chemistry

GRADUATE FACULTY

Professor C. L. BUMGARDNER, *Acting Head*

Professors: H. A. BENT, L. H. BOWEN, L. D. FREEDMAN, F. W. GETZEN, F. C. HENTZ JR., Z ZIMMERMAN HUGUS JR., G. LEVINE, R. H. LOEPPERT—*Assistant to Head,* G. G. LONG, W. J. PETERSON, P. P. SUTTON, W. P. TUCKER—*Director of Graduate Studies,* R. C. WHITE; *Adjunct Professor:* M. E. WALL; *Professors Emeriti:* G. O. DOAK, W. A. REID; *Associate Professors:* J. BORDNER, H. H. CARMICHAEL, A. F. COOTS, M. K. DEARMOND, C. E. GLEIT, L. A. JONES, M. L. MILES, C. G. MORELAND, A. F. SCHREINER, G. H. WAHL JR.; *Assistant Professors:* T. C. CAVES, K. W. HANCK, T. M. WARD, D. W. WERTZ

The Department of Chemistry offers programs leading to the Master of Science and Doctor of Philosophy degrees. Major fields of specialization are analytical, inorganic, organic, nuclear and physical chemistry. A wide variety of advanced courses and a broad spectrum of research topics provide preparation for almost every type of position open to a chemist with an advanced degree.

A student entering graduate work in chemistry should have a bachelor's degree in chemistry or its equivalent. This includes the equivalent of one-year courses in general, organic, physical and analytical chemistry, and a semester of inorganic chemistry. At least one year of college physics and two years of mathematics, including differential equations, are necessary. Students who fail to meet these requirements may in some cases be admitted on a provisional basis.

With a large graduate faculty and favorable graduate student to faculty ratio, the chemistry department emphasizes individual attention, small classes and personal collaboration on research with faculty members. Among the variety of active research projects available for thesis work are organic and inorganic synthesis, structure and properties of organometallic compounds and transition metal complexes, stereochemistry of natural and synthetic products, kinetics and mechanisms of reactions, radiochemistry, microanalysis, electrochemistry, quantum chemistry, and infrared, Raman, Mossbauer, nuclear magnetic resonance, nuclear quadrupole resonance and electron spin resonance spectroscopy.

The department is equipped with standard instruments and apparatus for teaching and research. Many items of specialized equipment are available, including recording spectrophotometers covering the range from far infrared to ultraviolet, three nuclear magnetic resonance spectrometers, gas chromatographs, mass spectrometer, electron spin resonance spectrometer, circular dichroism recorder and spectropolarimeter, nuclear quadrupole resonance spectrometer, Mossbauer spectrometer and X-ray diffractometer. A complete glassblowing

facility manned by a glassblower is available for constructing special apparatus. All research activities of the department are concentrated in a new nine-story laboratory building equipped with modern, spacious facilities and completely air-conditioned.

The department has available for qualified applicants teaching and research assistantships, as well as a number of fellowships.

FOR ADVANCED UNDERGRADUATES

CH 401 Systematic Inorganic Chemistry. Corequisite: CH 433. 3(3-0) S.

CH 411 Analytical Chemistry I. Prerequisite: CH 434. 4(2-6) F.

CH 413 Analytical Chemistry II. Prerequisite: CH 411. 4(2-6) S.

CH 428 Qualitative Organic Analysis. Prerequisite: CH 223. 3(1-6) F,S.

CH 431 Physical Chemistry I. Prerequisites: CH 107, MA 202, PY 203 or PY 208; Corequisite: MA 301. 3(3-0) F,S.

CH 432 Physical Chemistry I Laboratory. Corequisite: CH 431. 1(0-3) F.

CH 433 Physical Chemistry II. Prerequisites: CH 431, MA 301. 3(3-0) F,S.

CH 434 Physical Chemistry II Laboratory. Corequisite: CH 433. 2(0-6) S.

CH 435 Physical Chemistry III. Prerequisites: CH 431, MA 301. 3(3-0) F.

CH 441 Colloid Chemistry. Prerequisites: CH 220, CH 315. 3(2-3) S.

CH 461 (TC 461) Chemistry of Fibers. 3(3-0) F. (See textile chemistry page 262.)

CH 490 Chemical Preparations. Prerequisite: Three years of chemistry. 3(1-6) F,S.

CH 491 Reading in Honors Chemistry. Prerequisite: Three years of chemistry. 2-6 F,S.

CH 493 Chemical Literature. Prerequisite: Three years of chemistry. 1(1-0) F.

CH 495 Special Topics in Chemistry. Prerequisite: Permission of instructor. 1-3.

CH 499 Senior Research in Chemistry. Prerequisite: Three years of chemistry. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CH 501 Inorganic Chemistry I. Prerequisite: CH 433. 3(3-0) F. The study of modern inorganic chemistry from the point of view of the chemical bond, molecular structure, and spectroscopy. The course is built upon several topics chosen from group theory, molecular symmetry, molecular orbital and crystal field theories, electronegativity, solid state, magnetic properties, electronic absorption, ORD, CD, and MCD, Mössbauer, nmr, nqu, ESCA, photoelectron, and vibrational spectroscopies. Computer facilities are also used.

CH 503 Inorganic Chemistry II. Prerequisite: CH 501. 3(3-0) S. This course is a continuation of CH 501 and rests heavily upon the latter. Knowledge of physical methods of investigation is employed in order to understand the basis and systematize the chemistry of representative elements, transition metals (3d, 4d, 5d), lanthanides, and actinides. Methods of synthesis are discussed and reasons for their success given, and for these reasons areas of discussion are chosen from nonaqueous solvents, acids and bases, inorganic reaction mechanisms of importance or contemporary interest, solid state reactions, coordination chemistry including chelates and organometallic compounds, crystal field stabilization energy, Jahn-Teller and trans effects stabilization of valence states, and some bio-inorganic chemistry.

CH 511 Chemical Spectroscopy. Prerequisite: CH 433. 3(3-0) F. Theory, analytical applications and interpretation of spectra as applied to chemical problems. Major emphasis will be placed upon ultraviolet, visible and infrared spectra.

CH 515 Chemical Instrumentation. Prerequisite: CH 431; Corequisite: CH 411. 3(3-0) S. Basic electronic components and circuits, the response of laboratory instruments, design and modification of typical electronic control and measurement systems. Emphasis will be placed on the transducers and control elements utilized in chemical research.

CH 517 Physical Methods of Elemental Trace Analysis. Prerequisite: CH 315 or CH 331 or consent of instructor. 3(3-0) F. The principles and applications of currently used methods of trace analysis are presented. Designed for students with little or no experience in trace analysis but with a strong interest in or need for analytical data at the trace level. Topics include pulse polarography, potentiometry, UV-Vis spectrophotometry, atomic absorption, emission spectrometry, fluorescence, neutron activation analysis, and spark source mass spectrometry.

CH 518 Trace Analysis Laboratory. Corequisite: CH 517 or consent of instructor. 2(0-6) F. The trace element content of samples is determined by a variety of instrumental techniques including UV-Vis spectrophotometry, fluorescence, emission spectrometry, atomic absorption, pulse polarography, and neutron activation analysis.

CH 521 Advanced Organic Chemistry I. Prerequisites: CH 223, CH 433 or CH 435. 3(3-0) F. Structure, stereochemistry and reactions of the various classes of hydrocarbons. The molecular orbital treatment of bonding and reactivity of alkenes, the conformational interpretation of cycloalkane and cycloalkene reactivity, and the application of optical isomerism to the study of reaction mechanisms will be emphasized.

CH 523 Advanced Organic Chemistry II. Prerequisite: CH 521. 3(3-0) S. An introduction to acid-base theory and mechanistic organic chemistry as applied to synthetically useful organic reactions.

CH 525 Physical Methods in Organic Chemistry. Prerequisites: CH 223 and CH 433 or CH 435. 3(3-0) S. Application of physical methods to the solution of structural problems in organic chemistry. Emphasis will be on spectral methods including infrared, ultraviolet, nuclear magnetic resonance, mass spectrometry, electron paramagnetic resonance, X-ray and electron diffraction, and optical rotatory dispersion.

CH 531 Chemical Thermodynamics. Prerequisites: CH 433, MA 301. 3(3-0) F. An extension of elementary principles to the treatment of ideal and real gases, ideal solutions, electrolytic solutions, galvanic cells, surface systems and irreversible

processes. An introduction to statistical thermodynamics and the estimation of thermodynamic functions from spectroscopic data.

CH 533 Chemical Kinetics. Prerequisites: CH 433, MA 301. 3(3-0) S. An intensive survey of the basic principles of chemical kinetics with emphasis on experimental and mathematical techniques, elements of the kinetic theory, and theory of the transition state. Applications to gas reactions, reactions in solution and mechanism studies.

CH 535 Surface Phenomena. Prerequisites: CH 433, MA 301. 3(3-0) S. An intensive survey of the topics of current interest in surface phenomena. Formulations of basic theories are presented together with illustrations of their current applications. (Offered spring 1974 and alternate years.)

CH 537 Quantum Chemistry. Prerequisites: MA 301, CH 435, or PY 407. 3(3-0) S. The elements of wave mechanics applied to stationary energy states and time dependent phenomena. Applications of quantum theory to chemistry, particularly chemical bonds.

CH 545 Radiochemistry. Prerequisite: PY 410 or CH 431. 3(2-3) S. The applications of radioactivity to chemistry and the applications of chemistry to the radioactive elements, particularly the transuranium elements and fission products.

CH 562 (TC 562) Physical Chemistry of High Polymers-Bulk Properties. 3(3-0) F. (See textile chemistry, page 262.)

FOR GRADUATES ONLY

CH 623 Valence and the Structure of Organic Molecules. Prerequisites: CH 523, CH 433. 3(3-0) F. Applications of molecular orbital theory, thermodynamics and free energy relations to organic problems.

CH 625 Organic Reaction Mechanisms. Prerequisites: CH 523, CH 433. 3(3-0) S. A study of the effects of structure and substituents on the direction and rates of organic reactions.

CH 627 Chemistry of Metal-Organic Compounds. Prerequisite: CH 521. 3(3-0) F. Preparation, properties and reactions of compounds containing the carbon-metal bond, with a brief description of their uses.

CH 631 Chemical Thermodynamics II. Prerequisite: CH 531. 3(3-0) S. Statistical interpretation of thermodynamics; use of partition functions; introduction to quantum statistics; application of statistical mechanics to chemical problems, including calculation of thermodynamic properties, equilibria and rate processes.

CH 659 (BCH 659) Natural Products. Prerequisites: CH 523, CH 525 or consent of instructor. 3(3-0) F. Illustrative studies of structure determination, synthesis and biosynthesis of natural substances. Modern physical methods and fundamental chemical concepts are stressed. Examples are chosen from such classes as alkaloids, terpenes, steroids and antibiotics.

CH 691 Seminar. Prerequisite: Graduate standing in chemistry. 1(1-0) F,S. Scientific articles, progress reports on research, and special problems of interest to chemists are reviewed and discussed.

CH 693 Advanced Topics in Physical Chemistry. Prerequisite: Two of the following: CH 531, 533, 535, 537. 3(3-0) F,S. An intensive treatment of selected topics of importance in current physiochemical research.

CH 695 Special Topics in Chemistry. Prerequisite: Consent of department head. Maximum 3. F,S. Critical study of special problems in one of the branches of chemistry.

CH 699 Chemical Research. Prerequisite: Graduate standing in chemistry. Credits Arranged. F,S. Special problems that will furnish material for a thesis. A maximum of six semester credits is allowed toward a master's degree; there is no limitation on credits in the doctoral program.

Civil Engineering

GRADUATE FACULTY

Professor D. L. DEAN, *Head*

Professor P. Z. ZIA, *Associate Head*

Professors: M. AMEIN, W. F. BABCOCK, C. R. BRAMER, P. D. CRIBBINS, J. F. ELY, R. E. FADUM-*Dean, School of Engineering,* C. L. HEIMBACH, J. W. HORN, A.-A. I. KASHEF, L. J. LANGFELDER, W. G. MULLEN, C. SMALLWOOD JR., M. E. UYANIK, H. E. WAHLS—*Graduate Administrator; Adjunct Professor;* C. L. MANN JR.; *Associate Professors:* W. S. GALLER, K. S. HAVNER, J. F. MIRZA, C. C. TUNG; *Adjunct Associate Professors:* C. P. FISHER JR., S. D. SHEARER JR.; *Assistant Professors:* N. V. COLSTON JR., W. J. HEAD, J. L. MACHEMEHL, J. C. SMITH

The Department of Civil Engineering offers programs of study leading to Master of Civil Engineering, Master of Science and Doctor of Philosophy degrees. The Master of Civil Engineering degree requires additional course work in lieu of a thesis and the student must pass comprehensive written and oral examinations. Students may major in soil mechanics and foundation engineering, structural engineering and mechanics, transportation engineering or sanitary and water resources engineering.

The faculty is actively engaged in a broad area of research including deterministic and probabilistic structural theories and mechanics, fundamental behavior of soils and structures, highway safety, land use and urban planning, hydraulics and hydrology, materials, waste disposal and pollution control. Many of the investigations, conducted in well-equipped laboratories, are sponsored by industries and federal and state agencies including the continuing North Carolina Cooperative Highway Research Program. Graduate students are assigned adequate office and laboratory spaces for study and research.

The department cooperates with other divisions of the University in a number of joint programs. Qualified students may schedule their courses in this department and in the Department of City and Regional Planning at the University of North Carolina at Chapel Hill to receive a dual degree, a Master of Science with a major in transportation engineering and a Master of Regional Planning. Multidisciplinary study and research programs are also available through the North Carolina Highway Safety Research Institute, Water Resources Research Institute and the Center for Marine and Coastal Studies.

Students in other disciplines find opportunities for developing minor areas of study within the framework of course offerings of the department. In particular, courses of instruction in stream sanitation and industrial waste disposal provide the types of training in pollution often in great demand by industry.

A brochure and supplementary information, describing in greater detail the opportunities for graduate study and research as well as assistantships and fellowships in the Department of Civil Engineering, are available upon request from the head of the department.

FOR ADVANCED UNDERGRADUATES

CE 406 Transportation Engineering II. Prerequisite: CE 305. 3(2-2) F.

CE 415, 416 (ARC 415, 416) Architectural Structures I,II. Prerequisites: (415): ARC (EM) 316; (416): ARC (EM) 415. Not open to civil engineering students. 3(2-3) F,S.

CE 425 Intermediate Structural Analysis. Prerequisite: CE 325. 3(3-0) S.

CE 427 Structural Engineering II. Prerequisite: CE 326. 3(2-3) F.

CE 443 Soil Engineering II. Prerequisite: CE 342. 3(3-0) F.

CE 450 Civil Engineering Design. Prerequisite: One from CE 406, CE 427, CE 443, or CE 484. 3(1-6) S.

CE 460 Construction Engineering Project. Prerequisites: CE 463, CE 466. 3(2-3) S.

CE 463 Cost Analysis and Control. Prerequisite: CE 365. 3(2-3) F.

CE 464 Legal Aspects of Contracting. Prerequisite: Senior standing. 3(3-0) S.

CE 466 Construction Engineering II. Prerequisites: CE 326, CE 365. 3(2-3) F.

CE 472 Elements of Air Quality Management. Prerequisite: College-level physics and senior standing. 3(2-3) S.

CE 484 Water Resources Engineering II. Prerequisite: CE 383. 3(3-0) F.

CE 486 Sanitary Engineering Measurements of Water Quality. Prerequisite: Freshman chemistry and senior standing in the School of Engineering or the School of Agriculture and Life Sciences.

CE 487 (OY 487, MAS 487) Physical Oceanography. (See physical oceanography, page 214.) 3(3-0) S.

CE 498 Special Problems in Civil Engineering. Prerequisite: Senior standing in in CE or CEC. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CE 507 Airphoto Analysis I. Prerequisite: Senior standing. 3(2-3) F,S.

Principles and concepts for engineering evaluation of aerial photographs, including analysis of soils and surface drainage characteristics. Wahls

CE 508 Airphoto Analysis II. Prerequisite: CE 507. 3(2-3) S. Continuation of CE 507 with applications to highway and airport projects. Wahls

CE 509 Photogrammetry. Prerequisite: CE 201 or CE 301. 3(2-3) F. Elements of aerial photogrammetry as applied to civil engineering, surveying and mapping, geometry of aerial photographs, flight planning for aerial photography and stereoscopic plotter instruments, especially the Kelsh Plotter. Staff

CE 514 Municipal Engineering Projects. Prerequisite: Senior standing in CE or CEC. 3(2-3) S. Special problems relating to public works, public utilities, urban planning and city engineering. Babcock, Horn

CE 515 Transportation Operations. Prerequisite: CE 305. 3(3-0) F. The analysis of traffic and transportation engineering operations. Heimbach, Horn

CE 516 Transportation Design. Prerequisite: CE 305. 3(2-3) S. The geometric elements of traffic and transportation engineering design. Cribbins, Horn

CE 517 Water Transportation. Prerequisite: CE 305. 3(3-0) F. The planning, design, construction and operation of waterways, ports, harbors and related facilities. Development of analytical techniques for evaluating the feasibility of piers, ports and multipurpose river basin projects. The design of marine structures and civil works that are significant in civil engineering, including locks, dams, harbors, ports, and contractive and protective works. Cribbins

CE 524 Analysis and Design of Masonry Structures. Corequisite: CE 427. 3(3-0) F. Theory and design of masonry arches, culverts, dams, foundations and masonry walls subjected to lateral loads. Bramer, Mirza

CE 525, 526 Matrix Structural Analysis I, II. Prerequisite: (525): CE 425; (526): CE 326. 3(3-0) F,S. Matrix methods of structural analysis for digital computer solutions for general plane frames, trusses, and grids as well as general three dimensional trusses and frames. Inclusion of effects due to prestrain, temperature, elastic stability functions, joint deformations, and support settlements. Introduction to finite-element analysis of plane elasticity problems. Dean, Smith

CE 531 Structural Models. Prerequisite: CE 427. 3(2-3) F. Dimensional analysis and structural similitude, indirect and direct models, model materials and experimental techniques, individual project in structural model analysis.
Bramer, Mirza, Zia

CE 534 Plastic Analysis and Design. Prerequisite: CE 427. 3(3-0) S. Theory of plastic behavior of steel structures; concept of design for ultimate load and the use of load factors. Analysis and design of components of steel frames including bracings and connections. Bramer

CE 536 Theory and Design of Prestressed Concrete. Corequisite: CE 427. 3(3-0) F. The principles and concepts of design in prestressed concrete including elastic and ultimate strength analyses for flexure, shear, bond and deflection. Principles of concordancy and linear transformation for indeterminate prestressed structures. Application of prestressing to tanks and shells. Mirza, Zia

CE 541 (MAS 541, OY 541) Gravity Wave Theory I. 3(3-0) S. (See physical oceanography, page 214.)

CE 544 Foundation Engineering. Prerequisite: CE 342. 3(3-0) S. Subsoil investigations; excavations; design of sheeting and bracing systems; control of water; footing, grillage and pile foundations; caisson and cofferdam methods of construction. Kashef, Langfelder

CE 547 Fundamentals of Soil Mechanics. Prerequisite: EM 301. 3(3-0) F,S. Physical and mechanical properties of soils governing their use for engineering purposes; stress relations and applications to a variety of fundamental problems. Wahls

CE 548 Engineering Properties of Soils I. Prerequisite: CE 342. 3(2-3) F. The study of soil properties that are significant in earthwork engineering, including properties of soil solids, basic physiochemical concepts, classification, identification, plasticity, permeability, capillarity and stabilization. Laboratory work includes classification, permeability and compaction tests. Kashef, Langfelder

CE 549 Engineering Properties of Soils II. Prerequisite: CE 548. 3(2-3) S. Continuation of CE 548, including the study of compressibility, stress-strain relations and shear strength theories for soil. Laboratory work includes consolidation and shear strength tests. Langfelder

CE 551 Theory of Concrete Mixtures. Prerequisite: CE 332. 3(3-0) F. A study in depth of the theory of portland cement concrete mixtures including types and properties of portland special cements; chemical reactions; brief examination of history of mixture design; detailed study of current design methods; properties of fresh and hardened concretes; strength-age-curing relationships; durability; admixtures; special concretes; production and quality control. Mullen

CE 553 Asphalt and Bituminous Materials. Prerequisite: CE 332. 3(2-3) F. A study in depth of properties of asphalts and tars for use in waterproofing and bituminous materials, and theories of design of bituminous mixtures for construction and paving uses including types and properties of asphalt cements, cutbacks, emulsions, blown asphalts and tars; brief examination of historical developments; detailed study of properties and design of bituminous mixtures; and current research. Laboratory work includes standard tests on asphalts, tars, and road oils; design, manufacture and testing of trial batches; and current research tenchiques. Head, Mullen

CE 555 Highway and Airport Pavement Design. Prerequisite: CE 406 or CE 443. 3(2-3) S. Theoretical analysis and design of highway and airport pavements with critical evaluation of current design practices. Head

CE 570 (BAE 570, MB 570) Sanitary Microbiology. Prerequisite: MB 401 or equivalent. 3(2-3) S. Fundamental aspects of microbiology and biochemistry are presented and related to problems of stream pollution, refuse disposal and biological treatment. Laboratory exercises present basic microbiological techniques and illustrate from a chemical viewpoint some of the basic microbial aspects of waste disposal. Humenik

CE 571 Theory of Water and Waste Treatment. Prerequisite: Graduate standing. 3(3-0) F. Study of the physical, chemical and biological principles underlying water and waste treatment processes, including diffusion of gases, solubility, equilibrium and ionization, aerobic and anaerobic stabilization processes, sludge conditioning and disposal. Galler

CE 572 Unit Operations and Processes in Wastes Engineering. Prerequisite: CE 571. 3(1-6) S. Processes and operations in wastes engineering, including sedi-

mentation, coagulation, filtration, adsorption, biological treatments, softening and new developments. Colston

CE 573 Analysis of Water and Wastes. Corequisite: CE 571. 3(1-6) F. Chemical and physical analysis of water and wastes and interpretation of results. Colston

CE 574 (NE 574) Environmental Consequences of Nuclear Power. Prerequisite: Consent of instructor. 3(3-0) S. An examination of the environmental consequences resulting from the siting, construction and operation of nuclear power plants as well as the environmental consequences of alternatives to nuclear power. Fuel sources; fuel reprocessing; sources and treatment of solid, liquid, gaseous wastes; the costs of minimizing wastes and the effects of rejected heat; beneficial uses of rejected heat; pertinent federal and state regulations are examined. Smallwood

CE 575 Civil Engineering Systems. Prerequisite: MA 405. 3(3-0) S. An examination of civil engineering systems and their design optimization. The systems to be studied include water resources engineering, structural engineering, transportation engineering and construction. Galler

CE 576 Atmospheric Pollution. Prerequisite: Graduate or advanced undergraduate standing. 3(3-0) S. A survey of the problem of atmospheric pollution. Topics to be discussed include: pollutant sources; effects on man and other animals, vegetation, materials and visibility; meteorological factors, air sampling; control devices; air quality and emission standards; and legal economic and administrative aspects. Graduate Staff

CE 578 (BAE 578) Agricultural Waste Management. 3(2-3) F. (See biological and agricultural engineering, page 77.)

CE 580 Flow in Open Channels. Prerequisite: CE 382. 3(3-0) F,S. The theory and applications of flow in open channels, including dimensional analysis, momentum-energy principle, gradually varied flow, high-velocity flow, energy dissipators, spillways, waves, channel transitions and model studies. Amein

CE 581 (MAS 581) Introduction to Oceanographic Engineering. Prerequisite: CE 382. 3(3-0) F. A rigorous treatment of the engineering aspects of physical oceanography. The theory for the propagation of waves, methods of wave forecasting and the analysis of wave spectra are presented. The applications of physical oceanography to the design of marine and coastal installations are shown. Amein, Machemehl

CE 591, 592 Civil Engineering Seminar. 1(1-0) F,S. Discussions and reports of subjects in civil engineering and allied fields. Graduate Staff

CE 598 Civil Engineering Projects. 1-6 F,S. Special projects in some phase of civil engineering. Graduate Staff

FOR GRADUATES ONLY

CE 601 Transportation Planning. Prerequisite: CE 515. 3(3-0) S. The planning, administration, economics and financing of various transportation engineering facilities. Cribbins

CE 602 Advanced Transportation Design. Prerequisite: CE 516. 3(2-3) F. Design of major traffic and transportation engineering projects. Horn

CE 603 Airport Planning and Design. Corequisite: CE 515. 3(2-3) F. The analysis, planning and design of air transportation facilities. Cribbins, Horn

CE 604 Urban Transportation Planning. Prerequisite: CE 515. 3(3-0) S. Planning and design of urban transportation systems as related to comprehensive urban planning; principles of land use planning, urban thoroughfare planning and regional planning. Heimbach, Horn

CE 605 Traffic Flow Theory. Prerequisites: CE 515, ST 515. 3(3-0) F. The theoretical techniques used to describe vehicular traffic movement on a street or highway network, including the use of differential-difference equations, hydro-dynamic models, probabilistic models, and computer simulation. Heimbach

CE 624 Analysis and Design of Structural Shells and Folded Plates. Prerequisites: CE 525, EM 511. 3(3-0) S. Treatment of roof structures in the form of folded and curved surfaces. Membrane and bending stress analysis of folded plates, shells of revolution, cylindrical and conical shells and free-form systems. Numerical and closed form solutions. Design criteria for concrete and metallic structures. Dean, Havner, Uyanik

CE 625, 626 Advanced Structural Design I, II. Prerequisite: (625): CE 427, CE 525; Corequisites: (626): CE 525, CE 526. (625): 3(3-0), (626): 3(2-3) F,S. Complete structural design of a variety of projects including comparative study of alternative structural systems, synthesis and optimization. Uyanik

CE 627 Analysis and Design of Structures for Dynamic Loads. Prerequisites: CE 526, EM 555. 3(3-0) S. Response of structural systems to dynamic loads; review of principles of dynamic analysis; computation of structural response by numerical methods, nonlinear elastic and inelastic response of structures. Vibration of bridges under moving traffic loads. Dynamic effects of blast, earthquake and wind loads on structures. Tung

CE 631 Field Analysis of Structural Systems. Prerequisite: CE 525. 3(3-0) F. Primarily an exposition of the techniques of discrete field mechanics for the analysis of structures. Emphasis is on the closed-form analysis of regular structural lattices or nets and ribbed or reinforced continuous systems. Additional topics include: a cursory study of special continuous field solutions; and openform solutions for irregular systems. Dean

CE 635 Advanced Theory of Concrete Structures. Prerequisite: CE 536. 3(3-0) S. Inelastic theory of structural concrete members under flexure, axial load, combined flexure and axial compression, shear and torsion. Yield line theory of slabs. Limit analysis of beams and frames of reinforced and prestressed concrete. Zia

CE 641, 642 Advanced Soil Mechanics. Prerequisite: Graduate standing. 3(3-0) F,S. Theories of soil mechanics; failure conditions; mechanical interaction between solids and water, and problems in elasticity and plasticity pertaining to earthwork engineering. Wahls

CE 643 Hydraulics of Ground Water. Prerequisite: Graduate standing. 3(3-0) F,S. Principles of ground water hydraulics; theory of flow through idealized porous media; the flow net solution; seepage and well problems. Kashef

CE 644 Ground Water Engineering. Prerequisite: CE 643 or equivalent. 3(3-0) F. Ground water problems as related to engineering works, ground water circulation and inventories, subsidence of the ground and its evaluation due to pumping, method of images applied to water circulation of wastes and salt water encroach-

ment in coastal aquifers, transient flow systems in wells and earth dams and embankments. Leakage problems, practical ground water problems and their analysis by computers and electrical models. The legal aspects of ground water conservation and the implied technical and engineering phases. Kashef

CE 646 Dynamics of Soils and Foundations. Prerequisite: CE 641. 3(3-0) F. The application of vibration and wave propagation theories to soil media; the review of existing experimental data and empirical procedures for analysis of foundation vibrations , the prediction of soil responses to impulse loads, dynamic properties of soils and methods for their determination, design procedures for foundation subjected to dynamic forces. Wahls

CE 651 Theory of Limit Analysis. Prerequisite: CE 526 or EM 551. 3(3-0) F. General theorems of limit analysis and shakedown in elastic-plastic structures. Applications to frames (cyclic loading), grids, arches, plates and shells. Introduction to plastic instability and impact loading. Havner

CE 652 Inelastic Solids and Structures. Prerequisites: EM 503 or EM 501 and MA 405 or equivalent. 3(3-0) S. Mechanisms of slip in metals, Schmid's law; general theories of a polycrystalline aggregate. Phenomenological yield and hardening laws; comparisons with experiment. Extremum principles and formulation of boundary value problems; numerical methods of plastic strain analysis in two and three dimensions. Introduction to finite deformation theory. Havner

CE 661 Numerical Methods in Structural Mechanics. Prerequisites: CE 525 and EM 551 or EM 503. 3(3-0) F. Finite difference and finite element methods in two and three dimensional elastic structures, including plates, plane stress and plane strain problems, axisymmetric solids. Analytical basis of approximations: series expansions; energy theorems; virtual work. Matrix decompositions and iteration techniques for digital computer solution. Introduction to nonlinear analysis. Havner

CE 662 Probabilistic Methods of Structural Engineering. Prerequisites: CE 525 and MA 421. 3(3-0) F. Application of probability theory and stochastic processes to the study of safety of structures. Fundamentals of probability theory and stochastic processes; probabilistic modelings of structural loadings, material properties and risk. Reliability analysis of structures; reliability-based design criteria. Random vibration of simple structures; safety analysis of structures under dynamic loads. Tung

CE 671 Advanced Water Supply and Waste Water Disposal. Prerequisite: CE 484. 4(3-3) F. Problems relating to water supply and waste collection. Galler

CE 672 Advanced Water and Wastes Treatment. Prerequisite: CE 484. 4(3-3) S. Problems relating to the treatment of water and wastes. Galler

CE 673 Industrial Water Supply and Waste Disposal. Corequisite: CE 571.- 3(3-0) F,S. Water requirements of industry and the disposal of industries wastes. Smallwood

CE 674 Stream Sanitation. Corequisite: CE 571. 3(3-0) F,S. Biological, chemical and hydrological factors that affect stream sanitation and stream use. Smallwood

CE 698 Special Topics in Civil Engineering. Prerequisite: Graduate standing. 1-3 F,S. The study of special advanced topics of particular interest in various areas of civil engineering. Graduate Staff

CE 699 Civil Engineering Research. Credits Arranged F,S. Independent investigation of an advanced civil engineering problem; a report of such an investigation is required as a graduate thesis. Graduate Staff

Computer Science

GRADUATE FACULTY

Assistant Professor N. F. WILLIAMSON, *Acting Head*

Professors: P. E. LEWIS, D. A. LINK, L. B. MARTIN, *Director of the Computing Center and Assistant Provost for University Computing; Associate Professors:* D. R. DEUEL, Y. N. PATT; *Assistant Professors:* S. D. DANIELOPOULOS, R. J. FORNARO, J. W. HANSON, T. L. HONEYCUTT, W. E. ROBBINS, A. L. THARP

The Department of Computer Science offers a minor program for graduate students majoring in any other field. A student wishing to minor in computer science should have a knowledge of a programming language as a prerequisite and should anticipate a research project involving computers as an integral part. For a student who is candidate for a master's degree, three courses at the 400 level or above are required, and the student is encouraged that at least one be at the 500 level or above. The student's advisory committee, which should include at least one member from the Computer Science Department, will assist in selecting a meaningful sequence of courses. For a student who is a candidate for a Ph.D., no specific courses are required, but the student is expected to achieve a high level of proficiency in at least one of these five areas of computer science:

Artificial Intelligence
Computer Organization
Numerical Analysis
Programming Languages (including compiler design)
Operating Systems

The Computer Science Department has established cooperative programs—one with the Chemical Engineering Department and one with the Operations Research Committee—leading to a master's degree in either chemical engineering or operations research with a major emphasis in computer science. The requirements for these Master of Science degrees, which include a thesis, are satisfied in such a way that a strong emphasis is placed on computer science in both course and research work.

Students admitted to these cooperative programs are expected to satisfy all requirements for admission to the Graduate School. In addition, they should have a strong background in mathematics, statistics or the physical sciences, and a working knowledge of a versatile, higher-level programming language, such as ALGOL or PL/1. Those students who do not have the necessary background will be required to take courses eliminating the deficiencies in addition to a normal program of study. A few research and teaching assistantships are available to qualified applicants from the cooperative programs each year.

Additional information regarding the cooperative programs may be obtained by

writing: Computer Science Department, P. O. Box 5972, Raleigh, North Carolina 27607.

FOR ADVANCED UNDERGRADUATES

CSC 411 Introduction to Simulation. Prerequisite: MA 312 and ST 371 or equivalent. 3(3-0) F.

CSC 412 Introduction to Computability, Language and Automata. Prerequisite: CSC 322. 3(3-0) F.

CSC 421 Computer Systems for Management. Prerequisite: CSC 311. 3(3-0) S.

CSC 431 Information Retrieval. Prerequisite: CSC 311. 3(3-0) S.

CSC 432 Introduction to Digital Signal Processing. Prerequisite: CSC 302, ST 371 and MA 231 or MA 405. 3(2-2) S.

CSC 462 Computing for the Social Sciences. Prerequisite: ST 311 or equivalent. CSC majors may not receive credit for CSC 462. 3(3-0) S.

CSC 495 Special Topics in Computer Science. Prerequisite: Permission of instructor. 1-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CSC 501 Design of Systems Programs. Prerequisite: CSC 311, CSC 312 (CSC 301 recommended). 3(3-0) F. Review of batch process systems programs, their components, operating characteristics, user services and their limitations. Implementation techniques for parallel processing of input-output and interrupt handling. Overall structure of multiprogramming systems on multi-processor hardware configurations. Details on addressing techniques, core management, file system design and management, system accounting, and other user-related services. Traffic control, interprocess communication, design of system modules, and interfaces. System updating, documentation and operation.

CSC 502 Computational Linguistics. Prerequisite: Consent of instructor. 3(3-0) F. Use of a symbol manipulation language (SNOBOL 4) in solving nonnumeric problems. Study of generative grammars, including finite-state, context-free, context-sensitive, and transformational grammars. Syntactic analysis by computers: algorithms and existing analysis systems for English. Computational semantics. Information retrieval and question-answering systems. This course is open to computer science students and those in other fields.

CSC 504 Application of Linguistic Techniques to Computer Problems. Prerequisite: CSC 502. 3(3-0) S. Semiotics and programming languages. Comparison of semantic theories. Representation, classification and interpretation of scenes and other multi-dimensional illustrations. Design of a formal language for describing two-dimensional geometric figures, such as flowcharts, chemical structures and logic diagrams. Characterization of programming languages according to the theory of transformational grammar.

CSC 511 Artificial Intelligence. Prerequisite: CSC 311. 3(3-0) F. Definition of heuristic verus algorithmic methods, rationale of heuristic approach, description of

cognitive processes. Objectives of work in artificial intelligence, simulation of cognitive behavior. Heuristic programming techniques. Survey of examples from representative application areas. The mind-brain problem and the nature of intelligence. Individual projects to illustrate basic concepts.

CSC 512 **Metaprograms.** Prerequisite: CSC 311 (CSC 412 recommended). 3(3-0) F. This course is intended to provide a detailed understanding of the techniques used in the design and implementation of compilers. Introduction to formal grammars and relations concerning a grammar. Detailed study of algorithms for lexical scanners, top-down recognizers, bottom-up recognizers for simple precedence grammars, operator precedence grammars, higher order precedence grammars, and bounded-context grammars. Runtime storage organization for a compiler including symbol tables, internal forms for source programs, semantic routines, error recovery and diagnostics, code generation and optimization, and interpreters.

CSC 522 **Formal Languages and Syntactic Analysis.** Prerequisite: CSC 412 (CSC 512 recommended). 3(3-0) S. Detailed study of formal languages and their relation to automata: languages and their representation, grammars, finite automata and regular grammars, context-free grammars and pushdown automata, type 0 grammars and Turning machines, the Halting Problem, context-sensitive grammars and linear bounded automata, and operations on languages.

CSC 527 (MA 527) **Numerical Analysis I.** Prerequisite: CSC 101 or CSC 111, MA 301 or MA 312, MA 231 or MA 405. 3(3-0) F,S. Theory of interpolation, numerical integration, iterative solution of non-linear equations, numerical integration of ordinary differential equations, matrix inversion and solution of simultaneous linear equations.

CSC 528 (MA 528) **Numerical Analysis II.** Prerequisite: CSC 527 (MA 527). 3(3-0) F,S. Least squares data approximation, expansions in terms of orthogonal functions, Gaussin quadrature, economization of series, minimax approximations, Pade's approximations, eigenvalues of matrices.

CSC 532 **Artificial Intelligence II.** Prerequisite: CSC 511, course in mathematical logic. 3(3-0) S. A rigorous approach to artificial intelligence emphasizing pattern recognition, theorem proving, game playing, learning and heuristic programming. Students will be assigned computer projects illustrating theoretical concepts introduced in lecture.

CSC 585 (OR 585) **Graph Theory.** Prerequisite: MA 231 or MA 405. 3(3-0) F. Basic concepts of graph theory. Trees and forests. Vector spaces associated with a graph. Representation of graphs by binary matrices and list structures. Traversability. Connectivity. Matching and assignment problems. Planar graphs. Colorability. Directed graphs. Applications of graph theory with emphasis on organizing problems in a form suitable for computer solution.

CSC 595 **Special Topics.** Prerequisite: Consent of instructor. 1-6 F,S. Topics of current interest in computer science not covered in existing courses.

FOR GRADUATES ONLY

CSC 603 **Computational Semantics.** Prerequisite: CSC 502, course in mathematical logic. 3(3-0) F. Theoretical prerequisites and computational techniques for the mechanical interpretation of artificial and natural language sentences. Semantics of formal languages. Structural representations of meaning. Semantics of natural languages.

Crop Science

GRADUATE FACULTY

Professor P. H. HARVEY, *Head*

Professors: D. S. CHAMBLEE, W. K. COLLINS, D. A. EMERY—*Coordinator, Graduate Programs,* D. U. GERSTEL, W. C. GREGORY, H. D. GROSS, G. L. JONES, K. R. KELLER, W. M. LEWIS, T. J. MANN, P. A. MILLER, R. P. MOORE, L. L. PHILLIPS, T. J. SHEETS, D. H. TIMOTHY, J. B. WEBER, E. A. WERNSMAN, J. A. WEYBREW, A. D. WORSHAM; *Extension Professor:* C. T. BLAKE; *Professors USDA:* C. A. BRIM, J. F. CHAPLIN, W. A. COPE, J. A. LEE, D. E. MORELAND, D. L. THOMPSON; *Professor Emeritus:* G. K. MIDDLETON; *Associate Professors:* F. T. CORBIN, W. T. FIKE, W. B. GILBERT, R. C. LONG, C. F. MURPHY, R. P. PATTERSON, E. C. SISLER; *Extension Associate Professor:* J. G. CLAPP JR.; *Associate Professors USDA:* J. C. BURNS, T. H. BUSBICE, G. R. GWYNN; *Assistant Professor:* J. W. SCHRADER, W. W. WEEKS; *Extension Assistant Professor:* H. D. COBLE; *Assistant Professor USDA:* C. F. TESTER

The Department of Crop Science offers instruction leading to the Master of Science and Doctor of Philosophy degrees in the fields of plant breeding, crop production and physiology, forage crops ecology, weed control and plant chemistry. For students who wish general training, the Master of Agriculture degree is offered.

Excellent facilities for graduate training are available. Each student is assigned office and laboratory space. Many special facilities such as preparation rooms for plant and soil samples, cold storage facilities for plant material, air-conditioned rooms for studying the physical properties of cotton fiber and tobacco leaf, and growth control chambers are provided for projects which require these facilities. Greenhouse space, growth control chambers and access to the plant environment laboratories (Phytotron) are provided for projects which require these facilities. Sixteen farms are owned and operated by the state for research investigations. Research farms are located throughout North Carolina, and include a variety of soil and climatic conditions needed for experiments in plant breeding, crop management, forage ecology and weed control.

Strong supporting departments increase opportunities for broad and thorough training. Included among those departments in which graduate students in crop science work cooperatively or obtain instruction are: botany, chemistry, entomology, horticultural science, genetics, mathematics, plant pathology, soil science and statistics.

In North Carolina, a state which derives 80 percent of its agricultural income from farm crops, the opportunities for the well-trained agronomist are great. Recipients of advanced degrees in crop science at North Carolina State University are found in positions of leadership in research and education throughout the nation and the world.

FOR ADVANCED UNDERGRADUATES

CS 402 (BO 402) Economic Botany. Prerequisite: BO 200. 3(2-3) S.

CS 411 Environmental Aspects of Crop Production. Prerequisite: BO 421. 2(2-0) F.

CS 413 Plant Breeding. Prerequisite: GN 411. 2(2-0) S.

CS 414 Weed Science. Prerequisite: CH 220 or equivalent. 3(2-2) F.

CS 490 Senior Seminar in Crop Science. Prerequisite: Senior standing. 1(0-1) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

CS 511 Tobacco Technology. Prerequisite: BO 421 or equivalent. 2(2-0) S. A study of special problems concerned with the tobacco crop. The latest research problems and findings dealing with this important cash crop will be discussed. Collins

CS 513 Physiological Aspects of Crop Production. Prerequisite: BO 421. 3(3-0) S. Discussion will emphasize pertinent physiological processes associated with crops and crop management such as plant growth, maturation, respiration and photoperiodism. Relationship of the environment to maximum crop yields will be discussed. (Offered in spring of 1974 and alternate years.) Fike

CS 514 (HS 514) Principles and Methods in Weed Science. Prerequisite: CS 414 or equivalent. 3(2-2) S. Studies on the losses caused by the ecology of weeds, biological control, basic concepts of weed management, herbicide-crop relationships and herbicide development. Introduction to greenhouse and bioassay techniques and field research techniques. Monaco, Schrader

CS 541 (GN 541, HS 541) Plant Breeding Methods. Prerequisites: GN 506, ST 511. 3(3-0) F. An advanced study of methods of plant breeding as related to principles and concepts of inheritance. Henderson, Wernsman

CS 542 (GN 542, HS 542) Plant Breeding Field Procedures. Prerequisite: CS 541 (GN 541, HS 541). 2(0-4) Sum. Laboratory and field study of the application of the various plant breeding techniques and methods used in the improvement of economic plants. (Offered in summer of 1974 and alternate years.) Harvey

CS 545 (GN 545) Origin and Evolution of Cultivated Plants. Prerequisite: CS 541 (GN 541, HS 541) or GN 540 (ZO 540). 2(2-0) S. Discussion topics include: mankind as a potential cultivator; man's anatomy, physiology and alimentary needs; origins of cultivation; spread of agriculture in terms of various theories; interactions of crops and environments with reference to crop evolution; special attributes of cultigens; modern aspects of evolution (breeding). (Offered in spring of 1974 and alternate years.) Lee

CS 591 Special Problems. Prerequisite: Consent of instructor. Credits Arranged. Special problems in various phases of crop science. Problems may be selected or will be assigned. Emphasis will be placed on review of recent and current research. Graduate Staff

FOR GRADUATES ONLY*

CS 613 (GN 613, HS 613) Plant Breeding Theory. Prerequisites: CS 541 (GN

* Students are expected to consult with the instructor before registration.

541, HS 541), GN 506, ST 512. 3(3-0) S. A study of theoretical bases for plant breeding procedures with special emphasis on the relationship between type and source of genetic variability, mode of reproduction and effectiveness of different selection procedures. The latest experimental approaches to plant breeding will be discussed as well as standard procedures. (Offered in spring of 1974 and alternate years.) Miller

CS 614 (HS 614, SSC 614) **Herbicide Behavior in Plants and Soils.** Prerequisites: BO 551 and CH 223 or consent of instructor. 3(3-0) F. The chemical and physiological processes involved in the behavior of herbicides in plants and soils will be examined. Topics to be discussed include absorption, translocation, metabolism and mechanisms of action of herbicides on plants; reactions, movement and degradation of herbicides in the soil; and interactions among herbicides and other pesticides. (Offered in fall of 1973 and alternate years.) Monaco, Weber

CS 690 **Seminar.** Prerequisite: Graduate standing. 1(1-0) F,S. A maximum of two credits is allowed toward the master's degree; however, additional credits toward the doctorate are allowed. Scientific articles, progress reports in research and special problems of interest to agronomists are reviewed and discussed. Graduate Staff

CS 699 **Research.** Prerequisite: Graduate standing. Credits Arranged. A maximum of six credits is allowed toward the master's degree, but no restrictions toward the doctorate. Graduate Staff

Design

(For a listing of graduate faculty and departmental information, see architecture, page 70.)

FOR ADVANCED UNDERGRADUATES

DN 411, 412 **Advanced Visual Laboratory III, IV.** Prerequisites: DN 311, DN 312. 2-4 F,S.

DN 422 **History of Design III.** Prerequisite: DN 122. 3(3-0) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

DN 505 **Introduction to Design as Task.** Prerequisite: Graduate standing in design or consent of school dean. 3(0-6) F,S,Sum. A studio course which approaches design primarily as task. A program of exercises will be undertaken to acquaint the student with the defining of tasks and their interpretation within a designer's power of action. Task as purpose or intention takes precedence over technique, which is considered as emergent from a defined task.

DN 506 **Introduction to Design as Technique.** Prerequisite: Graduate standing in design or consent of school dean. 3(0-6) F,S,Sum. A studio course which approaches design primarily as technique. A program of exercises will be undertaken to acquaint the student with the techniques available to him and their relationship to existing and potential tasks. Technique as capability takes precedence over task, which is considered as emergent from a designated technique.

DN 507 Introduction to Design as Practice. Prerequisite: Graduate standing in design or permission of school dean. 3(3-0) F,S,Sum. A seminar course intended to provide a comprehensive overview of current design concepts and activities. Presentations and discussions by School of Design faculty and design practitioners will explore the design fields in terms of issues, attitudes, methods, and operations.

DN 511, 512 Advanced Visual Laboratory V, VI. Prerequisite: Graduate standing. 2-4 F,S. Advanced experimental studies in visual phenomena related to design.

DN 541 Seminar on Ideas in Design. Prerequisite: Graduate standing. 2(2-0) F,S. An examination of aesthetics and the relationships of philosophic thought to design.

FOR GRADUATES ONLY

DN 611, 612 Advanced Visual Laboratory VII, VIII. Prerequisite: Graduate standing. 2(0-6) F,S. Advanced experimental studies in visual phenomena related to design.

Ecology

GRADUATE FACULTY

Professors: F. S. Barkalow, K. R. Barker, S. W. Buol, D. S. Chamblee, B. J. Copeland, D. E. Davis, J. W. Duffield, J. W. Hardin, D. W. Hayne, J. E. Hobbie, H. L. Lucas, B. S. Martof, T. O. Perry, T. L. Quay, R. L. Rabb, R. van der Vaart; *Associate Professors:* L. F. Grand, A. G. Wollum; *Assistant Professors:* U. Blum, E. D. Seneca, G. G. Shaw

Ecology is the science concerned with the interactions of organisms with each other and with their environment. It is an integrative science through which one gains an understanding of biological and physical interrelationships and predicts the consequences of altering one or several components of an ecosystem.

Students in a number of basic and applied curricula may elect to minor in ecology at either the master's or doctor's level. The minor provides an opportunity for a coherent picture of the field of ecology, but does not usurp the normal prerogatives of graduate advisory committees in structuring graduate programs.

The ecology minor is an interdepartmental program drawing faculty from the Departments of Botany, Crop Science, Entomology, Forestry, Plant Pathology, Soil Science, Statistics and Zoology. The program is administered by an Ecology Advisory Committee. Additional information about the program may be obtained by writing to one of the faculty members listed above or to Chairman, Ecology faculty, P. O. Box 5577, North Carolina State University, Raleigh, North Carolina 27607.

The following courses are recognized as ecological and have been grouped into certain related areas (for course descriptions see respective departmental listings).

Population Ecology: ZO 517 Population Ecology; ENT 531 Insect Ecology; GN 550 (ZO 550) Experimental Evolution.

Limnology and Marine Science: ZO 519 Limnology; ZO 529 (MAS 529) Biological Oceanography; ZO 619 Advanced Limnology.

Behavior: ZO 501 Ornithology; ZO 510 Adaptive Behavior of Animals; ZO 610 Current Aspects of Animal Behavior.

Microbial Ecology: MB 521 Microbial Ecology; PP 611 Advanced Plant Nematology; SSC 632 (MB 632) Ecology and Functions of Soil Microorganisms; PP 625 (BO 625) Advanced Mycology.

Terrestrial Ecology: BO 544 Plant Geography; SSC 551 Soil Morphology, Genesis and Classification; MY 555 Meteorology of the Biosphere.

Physiological Ecology: ZO 513 (PHY 513) Comparative Physiology; ZO 515 Growth and Reproduction of Fishes; BO 561 Physiological Ecology.

Mathematical Biology and Ecology: ZO 553 Principles of Wildlife Science; BMA 571, 572, (MA 571, 572; ST 571, 572) Biomathematics I, II.

The requirements for a minor in ecology are:

Ph.D. Degree: Four ecological courses, including BO-ZO 560 (or its equivalent) and either BO-ZO 660 or BO-ZO 661. The other two courses may include BO-ZO 660 or BO-ZO 661 (if both are taken) and courses from those listed above. If two courses from this list are taken, they must be from different designated areas and generally should not be from the same department as the major.

Master of Science Degree: Three ecological courses, including BO-ZO 560 (or its equivalent) and either BO-ZO 660 or BO-ZO 661. The third course course generally should not be in the same department as the major.

Incoming students may apply equivalent courses toward these requirements at the discretion of their graduate committee. Students minoring in ecology, particularly at the Ph.D. level, are encouraged to take courses in mathematics and statistics, at least ST 511 and ST 512.

Economics

GRADUATE FACULTY

Professor W. D. Toussaint, *Head*

Professors: A. J. Coutu, D. M. Hoover, L. A. Ihnen, P. R. Johnson, R. A. King, G. A. Mathia, B. M. Olsen, E. C. Pasour Jr., J. A. Seagraves, R. L. Simmons, C. B. Turner, T. D. Wallace, W. H. Wallace, J. C. Williamson Jr.; *Extension Professors:* R. C. Brooks, G. L. Capel, T. E. Nichols Jr., C. R. Pugh, F. D. Sobering; *USDA Professors:* G. D. Irwin, J. G. Sutherland; *Professors Emeriti:* J. G. Maddox, E. W.

SWANSON; *Associate Professors:* D. S. BALL, J. S. CHAPPELL, W. D. COOPER, M. M. EL-KAMMASH, E. W. ERICKSON, R. M. FEARN, B. L. GARDNER, C. W. HARRELL JR., D. N. HYMAN, E. W. JONES, F. A. MANGUM JR., R. J. PEELER JR.—*Coordinator of Graduate Programs,* R. K. PERRIN, R. A. SCHRIMPER, R. E. SYLLA; *Extension Associate Professors:* R. D. DAHLE, L. H. HAMMOND, J. E. IKERD, R. C. WELLS; *Assistant Professors:* J. B. BULLOCK, G. A. CARLSON, A. R. GALLANT, D. L. HOLLEY, C. P. JONES, J. C. POINDEXTER JR., C. R. SHUMWAY; *Adjunct Assistant Professor:* I. P. NIJHAWAN

The Department of Economics offers programs of study leading to the Master of Economics, the Master of Arts in economics, the Master of Science in agricultural economics and the Ph.D. degree in economics. Emphasis is placed on economic theory and quantitative economic analysis and their application to economic problems. Special seminars and workshops are available to students as a means of pursuing topics of special interest.

Master's programs require a minimum of 30 semester hours. A semester each of intermediate undergraduate micro and macro theory in addition to basic calculus are minimum prerequisites. Within the 30 hours, a nine-hour minor is required in some disciplines outside the department. No foreign language is required. The Master of Arts and Master of Science degrees require a thesis which receives up to six hours of credit toward the degree. The Master of Economics has no thesis requirement.

The Ph.D. program has no specific hour requirements; however, at least six semesters of work beyond the bachelor's degree are required, of which at least two consecutive semesters must be in residence. Candidates take course work and written examinations in economic theory and a minor of their choice. In addition, each student chooses a field of study within the department (e.g., agricultural economics, economic development, econometrics, international trade, labor economics and human resources, or managerial economics). A minimum of two semesters of statistics and differential and integral calculus is required of all Ph.D. candidates. There is no foreign language requirement for the Ph.D. Specific programs are designed to meet the interest of the individual student and his professional objectives.

A well-equipped departmental library, the D. H. Hill Library and library facilities of two nearby major universities are readily available for graduate student use. Graduate students on financial support are provided office space. Computational facilities are available for students whose research involves extensive analysis of data and to students interested in learning to use computer facilities. The department has a well-trained clerical staff and has access to the IBM System/370 Model 165 operated by the Triangle Universities Computational Center. Access is also available to other medium speed terminals and an IBM System/360 Model 40 located on the University campus.

FOR ADVANCED UNDERGRADUATES

EC 401 Economic Analysis for Nonmajors. Prerequisite: EC 201 or EC 212. 3(3-0) F,S.

EC 410 Public Finance. Prerequisite: EC 301. 3(3-0) F.

EC 413 Competition, Monopoly and Public Policy. Prerequisite: EC 301. 3(3-0) F,S.

EC 415 Farm Appraisal and Finance. Prerequisite: EC 303 or EC 310. 3(2-2) F.

EC 420 Corporation Finance. Prerequisites: EC 201 or EC 212, and EC 260. 3(3-0) F,S.

EC 422 Investments and Portfolio Management. Prerequisites: EC 201 and EC 317 or ST 311. 3(3-0) F,S.

EC 430 Agricultural Price Analysis. Prerequisite: EC 301. 3(3-0) F.

EC 431 Labor Economics. Prerequisite: EC 301. 3(3-0) F,S.

EC 435 Urban Economics. Prerequisite: EC 301. 3(3-0) S.

EC 436 Environmental Economics. Prerequisite: EC 301. 3(3-0) F.

EC 440 Economic Development. Prerequisite: EC 201 or EC 212. 3(3-0) S.

EC 442 Evolution of Economic Ideas. Prerequisite: EC 202 or EC 212. 3(3-0) S.

EC 448 International Economics. Prerequisite: EC 301. 3(3-0) F.

EC 451 Introduction to Econometrics. Prerequisites: EC 301, EC 302 and EC 317 or ST 311. 3(3-0) F,S.

EC 460 Specialized Financial Reporting Theory and Practice. Prerequisite: EC 361. 3(3-0) F.

EC 464 Income Taxation. Prerequisite: EC 260. 3(3-0) F,S.

EC 466 Examination of Financial Statements. Prerequisite: EC 361. 3(3-0) S.

EC 468 Professional Accountancy Résumé. Prerequisites: EC 362 and EC 460. 3(3-0) S.

EC 475 Comparative Economic Systems. Prerequisite: EC 201 or EC 212. 3(3-0) F.

EC 482 (TX 482) Sales Management for Textiles. 3(3-0) S. (See textile technology, page 264.)

EC 490, 491 Senior Seminars in Economics. Prerequisites: EC 301 and 302 and 317 or ST 311 (plus two courses from list of restricted economics electives). 3(3-0) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

EC 501 Price Theory. Prerequisites: MA 112 and EC 301. 3(3-0) F,S. An intensive analysis of the determination of prices and of market behavior, including demand, cost and production, pricing under competitive conditions and pricing under monopoly and other imperfectly competitive conditions. Graduate Staff

EC 502 Income and Employment Theory. Prerequisites: MA 112 and EC 301 and EC 302. 3(3-0) F,S. A study of the methods and concepts of national income analysis with particular reference to the role of fiscal and monetary policy in maintaining full employment without inflation. Graduate Staff

EC 515 Water Resources Economics. Prerequisite: EC 401 recommended. 3(3-0) S. The application of economic principles in the allocation of water resources. Attention is given especially to the basic issues of how to effect maximum economic efficiency in the use of a resource that is no longer a free good, under the consideration of the goals of the public and private sectors of the enterprise economy. Both economic and political consequences of decision-making are studied.
Graduate Staff

EC 521 Markets and Trade. Prerequisite: EC 301 or EC 401. 3(3-0) F. This course emphasizes the space, form and time dimensions of market price and the location and product combination decisions of firms. Consideration is given to the ways in which non-price factors and public policy choices influence firm behavior and the efficiency of marketing systems. Application of these models to agricultural, industrial and public service questions is emphasized, including the relationships between resource availability and the spatial arrangement of economic activity. King

EC 523 Planning Farm and Area Adjustments. Prerequisite: EC 301, EC 303 or EC 401. 3(2-2) S. The application of economic principles in the solution of production problems on typical farms in the state; methods and techniques of economic analysis of the farm business; application of research findings to production decisions; development of area agricultural programs. Liner

EC 525 Management Policy and Decision Making. Prerequisite: EC 301 or EC 401. 3(3-0) F,S. A review and consideration of modern management processes used in making top-level policies and decisions. An evaluation of economic, social and institutional pressures, and of the economic and noneconomic motivations, which impinge upon the individual and the organization. The problem of coordinating the objectives and the mechanics of management is examined.
Graduate Staff

EC 533 Agricultural Policy. Prerequisite: EC 301 or EC 401. 3(3-0) S. A review of the agricultural policy and action programs of the federal government as regards both input supply and commodities, analysis of objectives, principal means and observable results as regards resource use and income distribution within agriculture, and between agriculture and the rest of the economy; appraisal of the effects alternative policy proposals would have on domestic and foreign consumption. Mangum

EC 535 Social Science Concepts in Managerial Processes. Prerequisite: Six hours in economics. 3(3-0) S. Interrelationships between concepts from economics and from other social sciences in managerial processes of clarifying goals, discovering alternatives and choosing courses of action. Cases are used to provide opportunities to compare contributions of theoretical concepts from economics, political science, social psychology, sociology and management science to managerial processes. Theoretical concepts are drawn from readings in the various disciplines. Graduate Staff

EC 550 Mathematical Models in Economics. Prerequisites: EC 301, EC 302, MA 212 and MA 405 recommended but not required. 3(3-0) F. An introductory study of economic models emphasizing their formal properties. The theory of individual economic units is presented as a special case in the theory of inductive

behavior. Mathematical discussions of the theory of the consumer, the theory of the firm and welfare economics will show the relevance of such topics as constrained maxima and minima, set theory, partially and simply ordered systems, probability theory and game theory to economics. El-Kammash

EC 551 Agricultural Production Economics. Prerequisites: MA 112 and EC 301 or EC 401. 3(3-0) F. An economic analysis of agricultural production including: production functions, cost functions, programming and decision-making principles; and the applications of these principles to farm and regional resources allocation, and to the distribution of income to and within agriculture. Perrin

EC 555 Linear Programming. Prerequisites: MA 231 or MA 405 and EC 301 or EC 401. 3(3-0) F,S. Recent developments in the theory of production, allocation and organization. Optimal combination of integrated productive processes within the firm. Applications in the economics of industry and of agriculture. Harrell

EC 561 (ST 561) Intermediate Econometrics. Prerequisites: EC 501 and ST 513. 3(3-0) S. The formalization of economic hypotheses into testable relationships and the application of appropriate statistical techniques will be emphasized. Major attention will be given to procedures applicable for single equation stochastic models expressing microeconomic and macroeconomic relationships. Statistical considerations that are relevant in working with time series and cross sectional data in economic investigations will be covered. The use of simultaneous equation models and the available estimation techniques will be surveyed. Johnson

EC 570 Analysis of American Economic History. Prerequisite: EC 371 (HI 371) or graduate standing. 3(3-0) S. Stresses the application of economic analysis to the formulation and testing of hypotheses concerning economic growth and development in the historical context. Problems selected for analysis will be drawn primarily from American economic history. Sylla

EC 574 (SOC 574) The Economics of Population. Prerequisite: EC 301 or EC 401. 3(3-0) S. A review of pre-Malthusian thought up to contemporary population theories. The student is introduced to data sources, statistical tools and methodology for economic analysis in demography. There follows an intensive treatment of microeconomic models of fertility. On the macroeconomic side, economic demographic models are examined. Implications of these economic models for public policy are developed. Underpopulation, overpopulation, optimum growth rate and incentive schemes are discussed. El-Kammash

EC 585 (TX 585) Market Research in Textiles. 3(3-0) S. (See textile technology, page 264.)

EC 590 Special Economics Topics. Prerequisite: Consent of instructor. Maximum 6. An examination of current problems in economics organized on a lecture-discussion basis. The content of the course will vary as changing conditions require the use of new approaches to deal with emerging problems. Graduate Staff

EC 598 Topical Problems in Economics. Prerequisite: Consent of instructor. 1-6. An investigation of topics of particular interest to advanced students under the direction of faculty members on a tutorial basis. Credits and content will vary with the needs of the students. Graduate Staff

FOR GRADUATES ONLY

EC 600 Advanced Price Theory. Prerequisites: EC 501, MA 212. 3(3-0) F. Alternative economic organizations and the role of prices; equilibrium and price

determination in a market economy; theory of consumer behavior; derivation of individual demand curves and aggregation to market supply curves; demand for factors of production. Pasour

EC 601 Prices, Value and Welfare. Prerequisite: EC 600. 3(3-0) S. The supply of factors of production; alternative nonmonetary theories of capital and interest; productivity; income distribution; determinants of firm size; the nature of market organization; welfare economics topics, including externalities, compensation, social welfare function and consumer surplus. Gardner

EC 602 Advanced Income and Employment Theory. Prerequisite: EC 502. 3(3-0) F. The course consists of an analysis of the forces determining the level of income and employment; a review of some of the theories of economic fluctuations; and a critical examination of a selected macroeconomic system. McElroy

EC 603 History of Economic Thought. Prerequisites: EC 501 and EC 502 or equivalent. 3(3-0) F. A systematic analysis of the development and cumulation of economic thought, designed in part to provide a sharper focus and more adequate perspective for the understanding of contemporary economics. Turner

EC 604 Monetary Economics. Prerequisite: EC 502 or equivalent. 3(3-0) S. Consideration of the money market and portfolio management, the cost of capital, effects of monetary phenomena on investment and accumulation of wealth with emphasis throughout on problems arising from uncertainty; general equilibrium theory of money, interest, prices and output. Lapp

EC 606 Industrial Organization and Control. Prerequisite: EC 501. 3(3-0) F. Microeconomic theory is applied to the empirical analysis of public policies that affect the efficiency of resource allocation in the U. S. economy. Special attention is given to the interrelationships between industrial structure, conduct and performance. Erickson

EC 610 Theory of Public Finance. Prerequisite: EC 501. 3(3-0) S. An application of microeconomic theory and welfare economics to the public sector. Areas covered include externalities and public policy, the theory of public goods, collective choice, program budgeting and cost-benefit analysis, the theory of taxation and its application to tax policy, public debt, and fiscal federalism. Hyman

EC 625 Long Range Planning in Business and Industry. Prerequisite: EC 501. 3(3-0) S. Theory and practice of long range planning in business and industry. Case discussions and intensive readings dealing with techniques for identifying opportunities and risks in the environment of the firm, determining corporate strengths and weaknesses, specifying long range strategy. Special attention is given to the roles of management and the internal processes of large organizations as the organizations respond to changes in external conditions. Dahle

EC 630 Labor Economics and Manpower Problems. Prerequisites: EC 501, EC 502. 3(3-0) S. A course devoted to analysis of labor force problems and labor market behavior. Labor force measurement and behavior, the measurement and analysis of unemployment, the determinants or relative wages, wage structures, and hours of work and national manpower policy. Emphasis on empirical studies. Fearn

EC 631 Human Capital. Prerequisites: EC 501, EC 502. 3(3-0) F. An examination of human resource development from an economic view. Emphasis is placed on recent research and theoretical developments related to the economics of education, on-the-job training, discrimination and migration. Ihnen

EC 632 Economic Welfare and Public Policy. Prerequisite: EC 601. 3(3-0) S. Description of the conditions defining optimal resource allocation; application of the conditions for maximum welfare in appraisal of economic policies and programs affecting resource allocation and income distribution. Hoover

EC 640 Analysis of Economic Development. Prerequisite: EC 502. 3(3-0) S. Theoretical and empirical studies of the processes of economic development are compared and analyzed. Contemporary developments in the theories of economic growth are related to the problems of underdeveloped countries. Policies and programs needed for effecting economic development are studied and evaluated for consistency. Olsen

EC 641 Agricultural Production and Supply. Prerequisites: EC 501 and ST 513. 3(3-0) S. An advanced study in the logic of, and empirical inquiry into, producer behavior and choice among combinations of factors and kinds and quantities of output; aggregative consequences of individuals' and firms' decisions in terms of product supply and factor demand; factor markets and income distribution; general interdependency among economic variables. Hoover

EC 642 Consumption, Demand and Market Interdependency. Prerequisites: EC 501 and ST 513. 3(3-0) F. An analysis of the behavior of individual households and of consumers in the aggregate with respect to consumption of agricultural products; the impact of these decisions on demand for agricultural resources, the competition among agricultural regions and for markets; and the interdependence between agriculture and other sectors of the economy. King

EC 645 Planning Programs for Economic Development. Prerequisites: EC 550, EC 640. 3(3-0) F,S. Consideration is given to the necessary quantitative measures for basing plans of national economic development. Models for program development and the techniques for their construction are studied. King

EC 648 Theory of International Trade. Prerequisites: EC 501, EC 502. 3(3-0) S. A consideration of the specialized body of economic theory dealing with the international movement of goods, services, capital and payments. Also, a theoretically oriented consideration of policy. Johnson

EC 649 Monetary Aspects of International Trade. Prerequisite: EC 502. 3(3-0) S. Study of the macroeconomic problems of an open economy including the balance of payments adjustment mechanism, alternative exchange rate systems, external effects of monetary and fiscal policy, optimum currency areas and international monetary reform. Grennes

EC 650 Economic Decision Theory. Prerequisite: EC 501. 3(3-0) F,S. Study of general theories of choice. Structure of decision problems, the role of information; formulation of objectives. Current research problems. Carlson

EC 651 (ST 651) Econometrics. Prerequisites: EC 600, ST 421, ST 502. 3(3-0) F. The role and uses of statistical inference in economic research; the problem of spanning the gap from an economic model to its statistical counterpart; measurement problems and their solutions arising from the statistical model and the nature of the data; limitations and interpretation of results of economic measurement from statistical techniques. Schrimper

EC 652 (ST 652) Topics in Econometrics. Prerequisite: EC 651 (ST 651). 3(3-0) S. Survey of current literature on estimation and inference in simultaneous stochastic equations systems. Techniques for combining cross section and time series data including covariance, error correlated and error component models.

Lag models and inference in dynamic systems. Production functions, productivity measurement and hypotheses about economic growth. Complete and incomplete prior information in regression analysis. Nonlinear estimation in economic models. Wallace

EC 665 Economic Behavior of the Organization. Prerequisite: EC 501. 3(3-0) F,S. This seminar will apply methods and findings derived from the behavioral sciences to the economic behavior of the organization, particularly the business firm. Among the approaches which may be utilized are organization theory, information theory, reference group theory and decision theory. Graduate Staff

EC 699 Research in Economics. Prerequisite: Graduate standing. Credits Arranged. Individual research in economics under staff supervision and direction. Graduate Staff

EDUCATION

GRADUATE FACULTY

Professor C. J. DOLCE, *Dean*

Professor J. B. KIRKLAND, *Dean Emeritus*

Associate Professor W. MAXWELL JR., *Assistant Dean*

Professor: J. K. COSTER; *Adjunct Professor:* THELMA L. ROUNDTREE; *Associate Professors:* L. J. BETTS JR., S. D. IVIE, P. J. RUST, T. N. WALTERS; *Adjunct Associate Professors:* W. J. BROWN, J. R. CLARY, C. H. ROGERS, H. G. ROYALL JR.; *Assistant Professors:* W. L. COX JR., C. W. HARPER JR., D. R. KNIEFEL, BARBARA M. PARRAMORE; *Instructor:* KATHLEEN A. MCCUTCHEN; *Research Associates:* R. L. MORGAN, MOLLIE W. SHOOK

The following master's degree programs are offered by the School of Education:

Adult and Community College Education
Agricultural Education
Curriculum and Instruction
Educational Administration and Supervision
Guidance and Personnel Services
Industrial Arts Education
Mathematics Education
Occupational Education
Psychology
Science Education
Special Education
Vocational Industrial Education

Students may enroll in programs leading to the Master of Science degree or the Master of Education degree. The Master of Science degree is a research degree and is preparation for further graduate study. The Master of Education

degree is a professional degree which allows for a wider latitude in the choice of course work than is allowed by the Master of Science degree programs.

The following doctoral programs are offered by the School of Education:

Adult and Community College Education	Ed.D.
Curriculum and Instruction	Ed.D.
Educational Administration and Supervision	Ed.D.
Guidance and Personnel Services	Ed.D.
Industrial Arts Education	Ed.D.
Mathematics Education	Ph.D.
Occupational Education	Ed.D.
Psychology	Ph.D.
Science Education	Ph.D.

Graduate programs are planned in terms of the educational objectives, experience, and preparation of students.

The School of Education is housed in Poe Hall, a modern building with up-to-date research facilities such as a variety of computer terminals.

Prior to consideration of applications for admission, the following must have been received: a completed application form, an official copy of current Graduate Record Examination scores, official transcripts for all undergraduate and prior graduate courses taken and at least three completed recommendation forms. In most programs, an interview is required. In order to maintain personalized, quality graduate programs, each program can enroll only a limited number of students irrespective of the qualifications of the applicants.

A limited number of teaching and research assistantships are available for qualified graduate students.

Adult and Community College Education

(Adult and Community College Education is a component of both the School of Education and the School of Agriculture and Life Sciences. For a listing of graduate faculty and departmental information, see Adult and Community College Education, page 65.)

Agricultural Education

GRADUATE FACULTY

Professor Emeritus: C. C. SCARBOROUGH; *Associate Professors:* T. R. MILLER—*Graduate Administrator*, C. D. BRYANT

The Department of Agricultural Education offers programs of study leading to the Master of Science and the Master of Education degrees. Graduate programs

are designed to meet the needs of individual students for further study and research as well as to prepare them for educational leadership roles in teaching, administration, supervision and research.

For complete course descriptions, see page 122.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 554 Planning Programs in Agricultural Education. 3(3-0) F,S.

ED 565 Agricultural Occupations. 3(3-0) F,S.

ED 566 Occupational Experience in Agriculture. 3(3-0) F,S.

ED 568 Adult Education in Agriculture. 3(3-0) F,S.

ED 593 Special Problems in Agricultural Education. Credits Arranged. F,S,Sum.

FOR GRADUATES ONLY

ED 664 Supervision in Agricultural Education. 3(3-0) F,S,Sum.

ED 693 Advanced Problems in Agricultural Education. Credits Arranged. F,S, Sum.

ED 694 Seminar in Agricultural Education. Maximum 2, 1(1-0) F,S,Sum.

Curriculum and Instruction

The master's degree program in Curriculum and Instruction is designed for those individuals who wish to develop instructional skills in innovative techniques in program areas ranging from pre-school through post-secondary education and who wish to qualify as instructional specialists and consultants in school systems. The program is a two-year program for those students who have not had prior experience in teaching, and who do not have a degree in professional education. The program for students who have had prior experience includes a minimum of 36 semester hours of study with emphasis upon the student's teaching field as well as upon professional education. Students who complete this program may qualify for a Graduate Teaching Certificate.

The doctoral program requires prior university preparation in professional education as well as actual teaching experience. The doctoral program is aimed at preparing as curriculum specialists, university instructors in professional education and instructional evaluation specialists. This Ed.D. program includes a large amount of work in developing competencies in research.

Programs are individually developed from the courses described beginning on page 122.

Educational Administration and Supervision

The master's degree program in Educational Administration and Supervision is designed to prepare individuals for entry level administrative and supervisory positions in the schools. The program is also designed to enable graduates to meet certification requirements for such positions.

The doctoral degree (Ed.D) program is designed for those individuals who have had prior professional education or experience in school administration and supervision. There is a multidisciplinary emphasis which includes courses in economics, politics, psychology, and sociology, as well as in professional education. The program includes a large component of clinical practice. Students may select a special emphasis in educational planning and evaluation.

For education courses see course listing beginning on page 122.

Guidance and Personnel Services

GRADUATE FACULTY

Professor W. E. HOPKE, *Head*

Professor: C. G. MOREHEAD; *Associate Professor:* B. C. TALLEY; *Assistant Professors:* L. K. JONES, JULIE GEGNER MCVAY

The department offers work leading to the Master of Science, Master of Education and Doctor of Education degrees with a major in the field of guidance and personnel services (or counselor education). Each of these degrees is designed to prepare individuals for guidance and personnel positions at various levels in elementary and secondary schools, junior and community colleges, trade and technical schools and institutes, institutions of higher education, agencies (such as employment and rehabilitation offices), as well as guidance and personnel work in business, industry and government. The student may specialize in one of several areas depending upon individual career goals.

It is desirable for an applicant to have had undergraduate or graduate course work in economics, education, psychology, sociology or social work. Students accepted into the department are those who anticipate devoting full- or part-time to guidance and personnel work.

Admission requirements for the department are: a minimum of a B average in the undergraduate major; satisfactory scores on the aptitude section of the Graduate Record Examination; three satisfactory letters of recommendation in regard to previous educational and employment experiences, personal charteristics and emotional maturity.

For descriptions of the guidance and personnel courses listed below, see page 122.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 520 Personnel and Guidance Services. 3(3-0) F,S,Sum.

ED 521 Internship in Guidance and Personnel Services. Credits Arranged. F,S.

ED 524 Occupational Information. 3(3-0) F,S,Sum.

ED 530 Group Guidance. 3(3-0) F,S,Sum.

ED 533 Organization and Administration of Guidance Services. 3(3-0) S,Sum.

ED 534 Guidance in the Elementary School. 3(3-0) S,Sum.

ED 535 Student Personnel Work in Higher Education. 3(3-0) F,Sum.

ED 540 Individual and Group Appraisal I. 3(3-0) F.

ED 590 Individual Problems in Guidance. Maximum 6 F,S.

FOR GRADUATES ONLY

ED 631 Vocational Development Theory. 3(3-0) F.

ED 633 Techniques of Counseling. 3(3-0) F,S,Sum.

ED 636 Observation and Supervised Field Work. Maximum 3 F,S.

ED 640 Individual and Group Appraisal II. 3(3-0) S.

ED 641 Laboratory and Practicum Experiences in Counseling. 2-6 F,S,Sum.

ED 666 Supervision of Counseling. 3(1-8) F,S,Sum.

Industrial and Technical Education

GRADUATE FACULTY

Professor D. M. HANSON, *Head*

Professor: J. T. NERDEN; *Assistant Professors:* T. C. SHORE, F. S. SMITH; *Adjunct Assistant Professor:* W. A. MCINTOSH

The Department of Industrial and Technical Education offers graduate work leading to the degrees of Master of Science and Master of Education. The rapid development of industrial and technical education in North Carolina and throughout the nation provides opportunities for teachers, supervisors and administrators who have earned advanced degrees.

The facilities at the University afford an excellent program of supporting courses at the graduate level in the related fields of computer science, economics, engineering, guidance and personnel services, mathematics, psychology, science, sociology and statistics. The prerequisite for graduate work in the Department of Industrial and Technical Education is a proficiency in the undergraduate courses required for the bachelor's degree in industrial or technical education, or a substantial equivalent.

A limited number of teaching and research assistantships and fellowships are available for qualified graduate students.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 516 Community Occupational Surveys. 2(2-0) S.

ED 517 Implications for Data Processing in Education. 3(3-0) F,S.

ED 525 Trade Analysis and Course Construction. 3(3-0) F.

ED 527 Philosophy of Occupational Education. 3(3-0) F,S,Sum.

ED 528 Cooperative Occupational Education. 3(3-0) F,S.

ED 529 Curriculum Materials Development. 3(3-0) F,S.

ED 591 Special Problems in Industrial Education. Maximum 6.

FOR GRADUATES ONLY

ED 608 Supervision of Vocational and Industrial Arts Education. 3(3-0) F.

ED 609 Planning and Organizing Technical Educational Programs. 3(3-0) F,S.

ED 610 Administration of Vocational and Industrial Arts Education. 3(3-0) S.

ED 611 Laws, Regulations and Policies Affecting Vocational Education. 3(3-0) F,S.

ED 612 Finance, Accounting and Management of Vocational Education Programs. 3(3-0) F,S.

ED 691 Seminar in Industrial Education. 1(1-0) F,S.

Industrial Arts Education

GRADUATE FACULTY

Professor D. W. Olson—*Coordinator of Graduate Studies for Industrial Arts; Associate Professor:* T. B. Young

The Industrial Arts section offers graduate work leading to the degrees of Master of Science, Master of Education and Doctor of Education. Graduate programs are designed for teachers who wish to develop their instructional competencies and for those who wish to be supervisors and administrators of Industrial Arts programs.

FOR GRADUATE AND ADVANCED UNDERGRADUATES

IA 510 Design for Industrial Arts Teachers. Prerequisites: Six hours of drawing, IA 205 or equivalent. 3(2-2) Sum. A study of new developments in the field of design with emphasis on the relationship of material and form in the selection and designing of industrial arts projects. Graduate Staff

IA 560 (ED 560) New Developments in Industrial Arts Education. Prerequisites: Twelve hours of education and teaching experience. 3(3-0) F,S,Sum. This course is a study of the new developments in industrial arts education. It is designed to assist teachers and administrators in developing new concepts and new content based on the changes in technology. Olson, Graduate Staff

IA 590 Laboratory Problems in Industrial Arts. Prerequisites: Senior standing, consent of instructor. Maximum 6. Courses based on individual problems and designed to give advanced majors in industrial arts education the opportunity to broaden or intensify their knowledge and abilities through investigation and research in the various fields of industrial arts, such as metals, plastics, ceramics or electricity-electronics. Graduate Staff

IA 592 Special Problems in Industrial Arts. Prerequisite: One term of student teaching or equivalent. Maximum 6. The purpose of this course is to broaden the subject matter experience in the areas of industrial arts. Problems involving curriculum, investigation or research in one or more industrial arts areas will be required. Graduate Staff

IA 595 (ED 595) Industrial Arts Workshop. Prerequisite: One or more years of teaching experience. 3(3-0) Sum. A course for experienced teachers, administrators and supervisors of industrial arts. The primary purpose will be to develop sound principles and practices for initiating, conducting and evaluating programs in this field. Enrollees will pool their knowledge and practical experiences and will do intensive research work on individual and group problems. Graduate Staff

FOR GRADUATES ONLY

IA 645 Technology and Industrial Arts. Prerequisites: IA 560, ED 630. 3(3-0) F,S. Technology: its nature, origins, advance. Impact of technological advance on man and culture. Technology as the material culture. Changing concepts of work, skill, occupations, discretionary time. Technology and its relation to industrial arts education. Olson

IA 660 (ED 660) Industrial Arts Curriculum. Prerequisite: IA 645. 3(3-0) F,S, Sum. Industrial arts curriculum origins, analysis, organization, evaluation, revision. Subject matter derivation and classification applicable to all levels of instruction. Relationships among curriculum, philosophy and methodology. Olson

Mathematics and Science Education

GRADUATE FACULTY

Professor H. E. SPEECE, *Head*

Professor: N. D. ANDERSON; *Associate Professors:* J. R. KOLB, H. A. SHANNON; *Assistant Professors:* W. M. WATERS JR., L. W. WATSON

The Department of Mathematics and Science Education offers graduate work leading to the degrees of Master of Science, Master of Education, and Doctor of Philosophy with majors in mathematics education or science education. Each student's program is individually planned by a graduate committee and will reflect

the individual's undergraduate and graduate preparation, teaching experience and future professional plans. Areas of specialization include mathematics, biological science, earth science, chemistry, and physics for a Master's degree. In the master's programs, a minimum of 36 semester hours is required, of which 60 percent must be in the area of subject matter specialization and 20 per cent in professional education. Candidates for the Master of Education degree are required to submit a scholarly research paper or otherwise demonstrate competency in educational research. Candidates for the Master of Science degree must conduct an investigation culminating in a thesis. Doctoral programs are individually planned by the student's graduate committee; and as in the Master's programs, students take courses in both professional education and the area of their teaching specialty.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 511 Implications of Mathematical Content, Structure and Processes for the Teaching of Mathematics in the Elementary School. 3(3-0) F,S,Sum.

ED 512 Active Learning Approaches to Teaching Mathematics in the Elementary School. 3(3-0) F,S,Sum.

ED 592 Special Problems in Mathematics Teaching. 3(3-0) F,S,Sum.

ED 594 Special Problems in Science Teaching. 3(3-0) F,S,Sum.

FOR GRADUATES ONLY

ED 603 Teaching Mathematics and Science in Higher Education. 3(3-0) F.

ED 604 Curriculum Development and Evaluation in Science and Mathematics. 3(3-0) F,S.

ED 605 Education and Supervision of Teachers of Mathematics and Science. 3(3-0) S.

ED 690 Seminar in Mathematics Education. Maximum 2 F,S.

ED 695 Seminar in Science Education. Maximum 2 F,S.

Occupational Education

The master's degree program in Occupational Education has two options. One option is aimed at developing competencies for entry level administrative and supervisory positions in occupational education. The second option is aimed at developing specialized competencies in teaching courses such as introduction to vocations and middle grades exploratory occupational classes.

The doctoral program has as a primary purpose the development of leadership in research, administration and supervision, teacher education, and curriculum and instruction in occupational education. The doctoral program is a comprehensive

one which seeks to develop a broad perspective of the entire field of occupational education. Students should have a prior specialization in one vocational education area.

Psychology

(See page 234.)

Special Education

The education of teachers of students who require specialized instructional skills and techniques, e.g., mentally retarded and sensory impaired students such as visually handicapped, is the primary focus of the master's degree program in Special Education. The program of studies in Special Education places emphasis upon the fields of psychology and education.

Education Courses

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ED 500 The Community College System. Prerequisite: Graduate or advanced undergraduate standing. 3(3-0) F,S,Sum. Comprehensive community colleges and technical institutes and the state systems of which they are a part: underlying concepts, educational needs they are designed to serve, role in meeting these needs, historical development, issues in the establishment and operation of state systems and individual institutions, unresolved issues and emerging trends. Segner

ED 501 (SOC 501) Leadership. Prerequisite: SOC 202 or equivalent. 3(3-0) F,S. A study of leadership in various fields of American life; analysis of the various factors associated with leadership; techniques of leadership. Particular attention is given to recreational, scientific and executive leadership procedures.

ED 502 (PS 502) Public Administration. Prerequisite: PS 200 or consent of instructor. 3(3-0) F,S,Sum. A study of the factors which contribute to goal displacement in public agencies and the institutions, concepts and techniques which may be used in such agencies to reduce the effects of these factors.

ED 503 The Programming Process in Adult and Community College Education. Prerequisites: ED 501, consent of instructor. 3(3-0) F,S,Sum. The principles and processes involved in programming, including basic theories and concepts supporting the programming process. Attention will be given to the general framework in which programming is done, the organization needed and the program roles of both professional and lay leaders. Boone

ED 504 Principles and Practices of Introduction to Vocations. Prerequisites: Twelve hours in education. 3(3-0) F,S. This course is designed for teachers in the public schools of North Carolina who teach Introduction to Vocations. The course emphasizes the place of the Introduction to Vocations Program in the overall school curriculum, special methods of instruction, use of teaching aids and use of student evaluation instruments. An overview is also presented in the areas of community organization, job markets, group procedures, occupational and educational information, and the changing occupational structure in our society. Graduate Staff

ED 505 Public Area Schools. Prerequisite: Graduate standing. 3(3-0) F,Sum. Junior and community colleges, technical institutes, vocational schools and branches of universities: their development, status and prospects policy and policy making, clientele, purposes, evaluation programs, personnel, organization administration, financing, facilities, research and development functions. Graduate Staff

ED 506 Education of Exceptional Children. Prerequisites: Six hours education or psychology. 3(3-0) S,Sum. Discussion of principles and techniques of teaching the exceptional child with major interest on the mentally handicapped and slow learner. Practice will be given in curriculum instruction for groups of children, and individual techniques for dealing with retarded children in the average classroom. Opportunity for individual work with an exceptional child will be provided.

ED 507 Analysis of Reading Abilities. Prerequisites: Six hours of education or psychology. 3(3-0) F,Sum. A study of tests and techniques in determining specific abilities; a study of reading retardation and factors underlying reading difficulties.
Rust

ED 508 Improvement of Reading Abilities. Prerequisites: Six hours education or psychology. 3(3-0) S,Sum. A study of methods used in developing specific reading skills or in overcoming certain reading difficulties; a study of methods used in developing pupil vocabularies and word analysis skills; a study of how to control vocabulary burden of reading material.

ED 509 Methods and Materials—Teaching Retarded Children. Prerequisite: ED 506. 3(3-0) F,S,Sum. Emphasis on understanding and correlating developmental levels of mentally retarded children and appropriate educational methods and materials. Use of individual child's diagnostic data; consideration of long and short range educational goals; curriculum planning in terms of realistic usefulness; scheduling; teacher guidance of children toward social and emotional maturity.
McCutchen

ED 510 Adult Education: History, Philosophy, Contemporary Nature. Prerequisite: Graduate standing. 3(3-0) F,S,Sum. A study of the historical and philosophical foundations of adult education from ancient times to the present, giving attention to key figures, issues, institutions, movements and programs, including consideration of the relationship between adult education's historical development and prevailing intellectual, social, economic and political conditions. Consideration of adult education's contemporary nature, present-day schools of thought on its objectives and trends.
Trent

ED 511 Implications of Mathematical Content, Structure, and Processes for the Teaching of Mathematics in the Elementary School. Prerequisites: Bachelor's degree in elementary education, or permission of instructor. 3(3-0) F,S,Sum. A course designed for teachers and supervisors of mathematics in the elementary school. Special emphasis is given to the implications of mathematical content, structure, and processes in teaching arithmetic and geometry in the elementary school. Attention is given to the use of logic and fundamental rules of inference, deductive and inductive reasoning, the field properties in the sets of integers and rational numbers, elementary number theory, metric and non-metric geometry.
Watson

ED 512 Active Learning Approaches to Teaching Mathematics in the Elementary School. Prerequisites: Bachelor's degree in elementary education or permission of the instructor. 3(3-0) F,S,Sum. A course that will stress active learning approaches to the teaching of mathematics in the elementary school. Special emphasis will be given to the laboratory approach to teaching mathematics and the use of manipulative materials and activities of the Nuffield Project, the Madison Project, Dienes, Cuisenaire, and Gattegno.
Watson

ED 513 (SOC 513) Community Organization. Prerequisite: SOC 202 or equivalent. 3(3-0) F. Community organization is viewed as a process of bringing about desirable changes in community life. Community needs and resources available to meet these needs are studied. Democratic processes in community action and

principles of community organization are stressed, along with techniques and procedures. The roles of leaders, both lay and professional, in community development are analyzed.

ED 516 Community Occupational Surveys. Prerequisites: Six hours education, consent of instructor. 2(2-0) S. Methods in organizing and conducting local surveys and evaluation of findings in planning a program of vocational education.
Shore, Hanson

ED 517 Implications for Data Processing in Education. Prerequisites: CSC 111; ED 529 or consent of instructor. 3(3-0) F,S. An intensive study of current attempts to apply new technologies to education. Attention will be given to research findings related to Computer Assisted Instruction, gamed instructional simulation, approaches to guidance and prescription learning as well as administrative problems pertaining to student scheduling, pupil transportation and data reporting systems.
Graduate Staff

ED 518 Principles of School Law. Prerequisites: Six hours graduate credit. 3(3-0) F,S. This course will be an intensive study of the legal right, duties, privileges and responsibilities entailed in the educational enterprise. It will cover the essentials of school law in such a way that the student will be able to obtain both a general understanding of the processes of law as they affect American education and also important specific legal aspects which affect vocational education. Included are the secondary, post-secondary and adult vocational education laws and their implications.
Graduate Staff

ED 519 Early Childhood Education. Prerequisite: PSY 475 or PSY 576. 3(1-4) S,Sum. This course is concerned with the planning, selection and utilization of human resources, activities, materials and facilities relating to the education of young children. Emphasis on student observation, participation and evaluation of educational experiences appropriate for the developmental level of individual children including flexible grouping, curricula planning and instructional techniques for an optimum learning environment. A synthesis of the student's knowledge of human development, learning theory and research findings as related to classroom application.
McCutchen

ED 520 Personnel and Guidance Services. Prerequisite: Six hours in education or psychology. 3(3-0) F,S,Sum. An introduction to the philosophies, theories, principles and practices of personnel and guidance services; the relationship of personnel services with the purpose and objectives of the school and the curriculum.

ED 521 Internship in Guidance and Personnel Services. Prerequisite: Eighteen hours in department and permission of instructor. Credits Arranged F,S. A continuous full-time internship of at least one-half semester. Framework of school and community. Work with students, teachers, administrators, guidance and pupil personnel workers, parents, and resource personnel in the community. Supervision of intern by guidance personnel in a school as well as by course instructors.

ED 522 Career Exploration. Prerequisites: ED 344 and graduate status or permission of instructor. 3(3-0) F,S,Sum. This course is designed for teachers in the public schools of North Carolina who teach in Career Exploration programs. The course exphasizes the philosophy of Career Exploration, theories supporting Career Exploration, the place of exploration programs in the overall school curriculum, correlation of Occupational Information in academic subjects, sources of Occupational Information and its use, and approaches to teaching in a Career Exploration program.

ED 523 Orientation and Mobility of the Visually Impaired. 3(3-0) Sum. The sensory processes and sensory cues on which independent mobility depends for the visually impaired person will be discussed. Various techniques and modes of travel will be considered. Particular emphasis will be given to instruction and background which will enable persons not teaching orientation mobility as a skill to reinforce the learning that takes place in other situations.

ED 524 Occupational Information. Prerequisites: Six hours education or psychology, ED 520 or equivalent. 3(3-0) F,S,Sum. This course is intended to give teachers, counselors, placement workers and personnel workers in business and industry an understanding of how to collect, classify, evaluate and use occupational and educational information. This will include a study of the world of work, sources of occupational information, establishing an educational-occupational information library, using educational, occupational and social information and sociological and psychological factors, influencing career planning.

ED 525 Trade Analysis and Course Construction. Prerequisites: ED 344, PSY 304. 3(3-0) F. Principles and practices in analyzing occupations for the purpose of determining teaching content. Practice in the principles underlying industrial course organization based on occupational analysis covering instruction skills and technology and including course outlines, job sequences, the development of industrial materials and instructional schedules.

ED 526 Teaching in College. 3(3-0) F,S,Sum. Designed primarily for graduate students in the departments outside the School of Education, this course focuses on the development of competencies to perform the day-to-day tasks of a college teacher as well as consideration of more long-range tasks such as course development and the university responsibilities of a professor. In addition to attending lectures and other types of presentations, students will make video tapes of their teaching, develop tests, design an introductory course in teaching field, and engage in other similar types of activities. Anderson

ED 527 Philosophy of Occupational Education. Prerequisites: Graduate standing. 3(3-0) F. An historical and philosophical investigation into the social and economic aspects of occupational education; an overview of the broad field of vocational education for youth and adults with emphasis upon the trends and problems connected with the conduct of occupational education under federal and state guidance; an overview study of federal and state legislation pertaining to vocational education.

ED 528 Cooperative Occupational Education. Prerequisites: Consent of instructor. 3(3-0) F,S. This course is designed to guide and assist in the growth patterns of individuals who are preparing to be directors, administrators or supervisors of vocational education programs at the local, state and/or national levels, with special emphasis upon the organization and operation of cooperative occupational education on secondary, post-secondary and adult levels. It will refer to the accepted programs. The course will cover the entire field of cooperative occupational education on secondary, post-secondary and adult levels. It will refer to the accepted essentials of cooperative education in order that the application of the philosophy to the details of planning, organization, establishment, and operation of cooperative occupational programs will be practical and meaningful. Included will be student visitations to existing quality programs in cooperative occupational education, for the purpose of studying on-site conditions related to this specialized area of study. Smith

ED 529 Curriculum Materials Development. Prerequisite: ED 525. 3(3-0) F,S. Selection and organization of curricula used in vocational-industrial and technical education; development of curricula and instructional materials.

ED 530 Group Guidance. Prerequisites: Six hours education or psychology, ED 520 or equivalent. 3(3-0) F,S,Sum. This course is designed to help teachers, counselors, administrators and others who work with groups, or who are responsible for group guidance activities, to understand the theory and principles of effective group work, to develop skill in using specific guidance techniques, and to plan and organize group activities in the secondary school and other institutions.

ED 531 (PSY 531) Mental Deficiency. Prerequisites: Nine hours psychology and special education. 3(3-0) S,Sum. This will be a course in description, causation, psychological factors and sociological aspects of mental retardation. Educational methods for the mentally retarded will be examined. The course is designed primarily for school psychologists and special-class teachers of retarded children, both educable and trainable. McCutchen

ED 533 Organization and Administration of Guidance Services. Prerequisites: Graduate standing, ED 520 or equivalent. 3(3-0) S,Sum. This course is designed for school guidance counselors, prospective counselors, personnel and guidance directors, and school administrators. The philosophy and scope of guidance and personnel services; the functions and responsibilities of personnel involved; basic principles and current practices in planning, developing, operating and supervising guidance and personnel services will be considered.

ED 534 Guidance in the Elementary School. Prerequisite: Nine hours psychology or consent of instructor. 3(3-0) S,Sum. Designed for acquainting elementary school teachers, counselors and administrators with theory, practice and organization of elementary school guidance.

ED 535 Student Personnel Work in Higher Education. Prerequisite: Nine hours psychology or consent of instructor. 3(3-0) F,Sum. Examines practices in various areas of student personnel work. Studies both structure and function of personnel programs in higher education.

ED 536 Structure and Function of the Eye and Use of Low Vision. Prerequisite: Consent of instructor. 3(5-0) Sum. This is a special institute in which participants will spend a minimum of 45 hours in class and class related activities. Medical and educational consultants will discuss the structure and function of the eye, eye anomalies likely to affect children with low vision, and methods of teaching children to use minimal vision effectively; for teachers and administrators either presently employed in educational programs for low vision persons or planning to participate in such programs next year. Graduate Staff

ED 537 The Extension and Public Service Function in Higher Education. Prerequisite: ED 510. 3(3-0) S,Sum. An examination of the background, history, philosophy and contemporary nature of the extension and public service function of institutions of higher education in the United States. Emphasis is placed on the adult education role of public and private universities and colleges. Specific focus is on: General Extension, Industrial Extension, Engineering Extension, Cooperative Extension and Continuing Education. Trent

ED 538 Instructional Strategies in Adult and Community College Education. Prerequisite: ED 559, graduate standing. 3(3-0) F,Sum. This course examines forms of instruction appropriate for the teaching of adults. Special emphasis will be placed upon methods which maximally involve the adult learner. The study of concepts, theories, and principles relevant to the selection, utilization, and evaluation of instructional strategies will focus on the integration of theory into practice. Through participation in classroom exercises, the student will develop proficiency in using teaching techniques which are applicable in adult and community college education. Glass

ED 540 Individual and Group Appraisal I. Prerequisites: ED 520, PSY 535, or equivalent. 3(3-0) F. Use of group tests of intelligence, interest and achievement in educational and career planning and in placement. Theories of intelligence and interest will be followed by laboratory in evaluating, administering and interpreting widely used group test of intelligence, interest and achievement. Emphasis is on the use of group test in group guidance.

ED 542 Contemporary Approaches in the Teaching of Social Studies. Prerequisites: Advanced undergraduate or graduate; must have completed student teaching. 3(3-0) S,Sum. An analysis of the principles, strategies and application of new teaching approaches. Team-teaching, programmed instruction, inductive and reflective oriented teaching, role-playing, simulation and gaming, independent study and block-time organization will be explored. Harper, Parramore

ED 550 Principles of Educational Administration. Prerequisites: Graduate standing, consent of instructor. 3(3-0) F,S,Sum. This course is designed as an introductory course in educational administration. Emphasizing basic principles of administration, the course will draw upon administrative theory, business, and public administration models as well as theoretical constructs from various disciplines.
Graduate Staff

ED 552 Industrial Arts in the Elementary School. Prerequisites: Twelve hours education, consent of instructor. 3(3-0) Sum. This course is organized to help elementary teachers and principals understand how tools, materials and industrial processes may be used to vitalize and supplement the elementary school child's experiences. Practical children's projects along with the building of classroom equipment. Graduate Staff

ED 554 Planning Programs in Agricultural Education. Prerequisite: ED 411 or equivalent. 3(3-0) F,S. Consideration of the need for planning programs in education; objectives and evaluation of community programs; use of advisory group; organization and use of facilities.

ED 555 Comparative Crafts and Industries. Prerequisites: Advanced undergraduate or graduate standing, consent of instructor. 6 Sum. A travel seminar as a cultural appreciations course involving study of indigenous crafts and industries, their materials, processes, products and design in foreign countries.

ED 559 Learning Concepts and Theories Applied to Adult and Community College Education. Prerequisite: Six hours in education. 3(3-0) S,Sum. Principles involved in adult education programs including theories and concepts undergirding and requisite to these programs. Emphasis will be given to the interrelationship of the nature of adult learning, the nature of the subject matter and the setting in which learning occurs. The applicability of relevant principles and pertinent research findings to adult learning will be thoroughly treated. Parsons

ED 560 (IA 560) New Developments in Industrial Arts Education. 3(3-0) F,S, Sum. (See industrial arts education, page 120.)

ED 563 Effective Teaching. Prerequisites: Twelve hours education including student teaching. 3(3-0) F,S,Sum. Analysis of the teaching-learning process; assumptions that underlie course approaches; identifying problems of importance; problem solution for effective learning; evaluation of teaching and learning; making specific plans for effective teaching. Graduate Staff

ED 565 Agricultural Occupations. Prerequisite: ED 411. 3(3-0) F,S. The theory of education and work is related to the expanding field of agricultural occupations. Career development in agricultural occupations is associated with curriculum de-

velopment needs. Occupational experience in agriculture is seen in relation to the curriculum and the placement in agricultural occupations.

ED 566 Occupational Experience in Agriculture. Prerequisite: ED 411. 3(3-0) F,S. A major and critical element in all programs of vocational education is the provision for appropriate student learning experiences in a real and simulated employment environment. Due to recent developments in education and agriculture, new and expanded concepts of occupational experience have been devised. Current research substantiates the need and desire of teachers of agriculture for assistance in implementing the new concepts. The course is designed not only to provide this aid but to develop a depth of understanding of the theoretical foundations underlying the new developments in occupational experiences to stimulate individual growth and creativity in implementing further developments.

ED 568 Adult Education in Agriculture. Prerequisite: ED 411 or equivalent. 3(3-0) F,S. Designed to meet the needs of leaders in adult education. Opportunity to study some of the basic problems and values in working with adult groups. Attention will be given to the problem of fitting the educational program for adults into the public school program and other educational programs as well as to the methods of teaching adults.

ED 590 Individual Problems in Guidance. Prerequisite: Six hours graduate work in department or equivalent and permission of instructor. Maximum 6 F,S. Intended for individual or group studies of one or more of the major problems in guidance and personnel work. Problems will be selected to meet the interests of individuals. The workshop procedure will be used whereby special projects, reports, and research will be developed by individuals and by groups.

ED 591 Special Problems in Industrial Education. Prerequisites: Six hours graduate credit, permission of department head. Maximum 6. Directed study to provide individualized study and analysis in specialized areas of trade, industrial or technical subjects.

ED 592 Special Problems in Mathematics Teaching. Prerequisite: ED 471 or equivalent. 3(3-0) F,S,Sum. An investigation of current problems in mathematics teaching, with emphasis on the areas of curriculum, methodology, facilities, supervision and research. Specific problems will be studied in depth. Opportunities will be provided to initiate research studies.

ED 593 Special Problems in Agricultural Education. Prerequisite: ED 411 or equivalent. Credits Arranged F,S,Sum. Opportunities for students to study current problems under the guidance of the staff.

ED 594 Special Problems in Science Teaching. Prerequisite: ED 476 or equivalent. 3(3-0) F,S,Sum. An investigation of current problems in science teaching with emphasis on areas of curriculum, methodology, facilities, supervision and research. Specific problems will be studied in depth. Opportunities will be provided to initiate research studies.

ED 595 (IA 595) Industrial Arts Workshop. Prerequisite: One or more years of teaching experience. 3(3-0) Sum. A course for experienced teachers, administrators and supervisors of industrial arts. The primary purpose will be to develop sound principles and practices for initiating, conducting and evaluating programs in this field. Enrollees will pool their knowledge and practical experiences and will do intensive research work on individual and group programs.

ED 596 Topical Problems in Adult and Community College Education. Prerequisite: Graduate standing. Credits Arranged. Study and scientific analysis of problems in adult education, and preparation of a scholarly research type of paper.

ED 597 Special Problems in Education. Prerequisites: Graduate standing and consent of instructor. 1-3 F,S. This course is designed to provide graduate students in education the opportunity to study problem areas in professional education under the direction of a member of the graduate faculty. Graduate Staff

ED 598 Concepts and Strategies of Understanding, Motivating and Teaching Disadvantaged Adults. Prerequisite: Graduate standing. 3(3-0) S,Sum. Designed to help adult educators acquire a comprehensive understanding of the educational, psychological, social, cultural, and economic problems of the culturally deprived segments of society. In-depth explorations of the theoretical basis for understanding, motivating and teaching disadvantaged adults will be interwoven with practical application of these bases to specific educational opportunities with the disadvantaged adult learner. White

FOR GRADUATES ONLY

ED 600 Organizational Concepts and Theories Applied to Adult and Community College Education. Prerequisites: ED 503, PS 502, SOC 541. 3(3-0) F,Sum. This course is designed for present and potential administrators interested in increasing their understanding of organization as a basis for administering effective Adult and Community College Education programs. Shearon

ED 601 Administrative Concepts and Theories Applied to Adult and Community College Education. Prerequisite: ED 600 or a comparable course(s) on organizational theory. 3(3-0) S,Sum. Education 601 is designed for persons interested in building a more consistent philosophy of educational administration, extending and strengthening their understanding of administrative concepts and processes, improving their comprehension of the theoretical and research foundations upon which administrative processes are predicated, and increasing their ability to apply administrative concepts, theories and principles to the management of the complex educational system. George, Gragg

ED 602 Curriculum. Prerequisite: PSY 535, PSY 510, ED 503 and/or a comparable course in occupational education. 3(3-0) F,S. This course is designed to equip the student with the conceptual tools and intellectual skills needed to develop and critically assess curricula in all educational fields. The elements of the curriculum development process that are studied in the course include: Identification and formulation of educational objectives, selection of learning experiences, developing and implementing plans for evaluating learning experiences and assessing educational outcomes, and staff-leader involvement in the curriculum development process. Parramore

ED 603 Teaching Mathematics and Science in Higher Education. Prerequisites: ED 592 or ED 594, graduate standing, consent of instructor. 3(3-0) F. This course is designed to provide an opportunity for graduate students and faculty to investigate the changing forces and values which are shaping the objectives of science and mathematics teaching. Attention will be given to the role of the college teacher in adapting to change and to developing college courses and curricula.

ED 604 Curriculum Development and Evaluation in Science and Mathematics. Prerequisites: 500-level statistics, ED 615 or PSY 535; consent of instructor. 3(3-0)

F,S. This course is designed to look critically at the elements in schools and society which shape the curricula of our schools, the mechanisms for curriculum change, and the role of formative and summative evaluation in determining the magnitude and direction of curriculum change in mathematics and science.

ED 605 Education and Supervision of Teachers of Mathematics and Science. Prerequisites: ED 470 or ED 475 or equivalent, ED 592 or ED 594. 3(3-0) S. The classroom teacher needs help and leadership in curriculum implementation, teaching strategies, and professional philosophy. The supervisor must not only be sensitive to the needs and strengths of individuals with whom he works, but must also assume a leadership role in the administrative unit for which he is responsible. This course is designed to develop the competencies described, as well as to offer supervisory strategies through readings, role playing, and school experience. It is planned to take advantage of our proximity to the State Department of Public Instruction in providing further experiences.

ED 608 Supervision of Vocational and Industrial Arts Education. Prerequisites: ED 527, ED 554, ED 609, ED 630 or equivalents. 3(3-0) F. An intensive study of the principles of supervision and the applications of these principles to the vocational and industrial arts education programs being conducted in secondary, post-secondary and adult facilities. Emphasis is placed upon the competencies needed in supervisors in order to effectively discharge their responsibilities in such areas as teacher selection, teacher transfer and promotion, assistance in teacher professional growth, the conduct of workshops and in-service programs for professional and non-professional staff, self-evaluative processes in education, curriculum generation and modification, guidance and counseling provisions, and action research.

Hanson, Nerden, Graduate Staff

ED 609 Planning and Organizing Technical Education Programs. Prerequisites: ED 344, ED 420, ED 440, ED 516, PSY 304. 3(3-0) F,S. In this course a study will be made of the influences which impinge upon the development of programs of technical education. Adequate opportunity will also be provided to examine in detail steps that may be taken to analyze needs for technical education, to organize for its provision, to study its offerings and to evaluate its results.

ED 610 Administration of Vocational and Industrial Arts Education. Prerequisites: ED 527, ED 554, ED 609, ED 630 or equivalent. 3(3-0) S. An intensive study of the major elements of administrative practice applied to vocational and industrial arts education, as it is being conducted in comprehensive high schools, comprehensive community colleges, technical institutes and area vocational centers. Emphasis is placed upon leadership, personnel management, instructional program management and evaluation, public relations and financial management, in connection with preparatory, part-time, supplementary, extension and adult education programs of vocation and industrial arts education.

Hanson, Nerden, Graduate Staff

ED 611 Laws, Regulations and Policies Affecting Vocational Education. Prerequisites: ED 527, ED 610 or equivalent. 3(3-0) F,S. A detailed study of legislation, (national and state) which applies directly to occupational education. Basic social issues and economic conditions which precipitated the legislation will be studied in depth. A review will also be made of the organizational structure and policies under which national legislation is converted into programs of occupational education.

ED 612 Finance, Accounting and Management of Vocational Education Programs. Prerequisites: ED 527, ED 610 or equivalent. 3(3-0) F,S. A study of the steps which must be taken in financing a new vocational enterprise, following the

determination of curriculum by area study. Costs of operation, equipment purchase procedures, costs for construction, etc. will be investigated in detail.

ED 614 Modern Principles and Practices in Secondary Education. Prerequisite: Twelve hours of education. 2(2-0) F,S. Foundations of modern programs of secondary education purposes, curriculum, organization, administration, and the place and importance of the high school in the community in relation to contemporary social force.

ED 615 Introduction to Educational Research. Prerequisite: PSY 535 or equivalent. 3(3-0) F,S,Sum. An introductory course for students preparing for an advanced degree. The purposes are: to assist the student in understanding the meaning and purpose of educational research and the research approach to problems; to develop the student's ability to identify educational problems; to plan and carry out research to solve these problems; to aid in the preparation of the research report. Special attention is given to tools and methods of research. Consideration is also given to the educator as a consumer of research. Kniefel

ED 620 Cases in Educational Administration. Prerequisites: Graduate standing and permission of instructor. 3(3-0) S,Sum. This course utilizes the case study and case simulation approach to the study of school administration. Administrative concepts will be developed and applied to simulated situations and to actual case histories. The administrative process is viewed as a decision-making process. The student will be expected to make decisions after considering alternative courses of action and after projecting probable consequences. Graduate Staff

ED 621 Internship in Education. Prerequisites: Nine credit hours in graduate level courses and consent of instructor. 3-9 F,S,Sum. Utilizing the participant-observer role, this course requires participation in selected educational situations with emphasis upon development of observational skills, ability to record relevant observations by means of written journals, skills in analyzing experiences identifying critical incidents, and prediction of events and consequences. The student is required to develop possible alternative courses of action in various situations, select one of the alternatives and evaluate the consequences of the course of action selected. Graduate Staff

ED 630 Philosophy of Industrial Arts. Prerequisite: Twelve hours in education. 2(2-0) F,S. Origins, development of industrial arts education. Philosophical foundations, derivation of objectives and criteria for evaluation. Contributions of the heritage to contemporary concepts of industrial arts education.

ED 631 Vocational Development Theory. Prerequisite: Six hours in education or psychology. 3(3-0) F. A study of the major theories and constructs of vocational development with implications for counseling and career planning.

ED 633 Techniques of Counseling. Prerequisite: Nine hours from following fields: economics, education, psychology or sociology. 3(3-0) F,S,Sum. ED 633 is a first course in counseling which combines the study of theory and philosophy in counseling with techniques and practices in this field. Attention will also be paid to the concerns and characteristics of counselees and counselors as well as the education of counselors. The course is designed for majors and minors in the Department of Guidance and Personnel Services and those wishing to elect a beginning course in counseling.

ED 635 Administration and Supervision of Industrial Arts. Prerequisite: Twelve hours in education. 2(2-0) F,S. Study of the problems and techniques of administration and supervision of industrial arts in school and university. Selection of

teachers, teacher improvement methods. Public relations, facilities planning and specification.

ED 636 Observation and Supervised Field Work. Prerequisite: Permission of instructor. Maximum 3 F,S. Provides opportunity for observation and practice of guidance and personnel services in schools, institutions of higher education, agencies, business and industry.

ED 640 Individual and Group Appraisal II. Prerequisites: ED 540, ED 520, PSY 535, or equivalent. 3(3-0) S. Theory and evaluation of intelligence, aptitude and personality; laboratory in evaluating, administering, scoring, and interpreting tests of intelligence, aptitude, and personality; emphasis on use of test results in individual counseling and guidance.

ED 641 Laboratory and Practicum Experiences in Counseling. Prerequisites: Advanced graduate standing, consent of instructor. 2-6 F,S,Sum. A practicum course in which the student participates in actual counseling experience under supervision in a school, college, social service agency, employment office and business or industrial establishment. The student may observe and participate in some personnel and guidance services and may study the organization and administration of the program.

ED 660 (IA 660) Industrial Arts Curriculum. 3(3-0) F,S,Sum. (See industrial arts education, page 120.)

ED 664 Supervision in Agricultural Education. Prerequisite: ED 563 or equivalent. 3(3-0) F,S,Sum. Organization, administration, evaluation and possible improvement of supervisory practice; theory, principles and techniques of effective supervision in agricultural education at different levels.

ED 665 Supervising Student Teaching. Prerequisite: Twelve hours of education. 3(3-0) F,S,Sum. A study of the program of student teaching in teacher education. Special consideration will be given the role of the supervising teacher including the following areas: planning for effective student teaching, observation and orientation, school community study, analysis of situation, evaluating student teachers and coordination with North Carolina State University. Graduate Staff

ED 666 Supervision of Counseling. Prerequisite: Permission of instructor. 3(1-8) F,S,Sum. A supervised practicum for doctoral students in assisting with the supervision of first year students in laboratory and practicum experiences in counseling.

ED 688 Research Application in Occupational Education. Prerequisite: ED 615. 3(3-0) F,S,Sum. This course will be concerned with methodology, application, analysis and synthesis of research in occupational education. A review of current occupational education studies, clustered by areas, will be made with attention to statistical techniques, data collecting, data handling, and the audience and impact of particular projects and research organizations. The class activities in research application are designed to bridge the gap between the theories of research methodology and the student's independent research projects. Graduate Staff

ED 689 Evaluation in Occupational Education. Prerequisites: ED 615, ST 513. 3(3-0) F,S,Sum. This course will be concerned with the conceptual and methodological aspects of occupational education evaluation, with attention to techniques for determining empirically the extent to which educational goals are being achieved, to locate the barriers to the advancement of these goals and to discover the consequences of educational programs. Graduate Staff

ED 690 Seminar in Mathematics Education. Prerequisite: Departmental major or permission of instructor. Maximum 2 F,S. An in-depth examination and analysis of the literature and research in a particular topic(s) in mathematics education. Students will be expected to make presentations to the faculty and class on the topic under consideration.

ED 691 Seminar in Industrial Education. Prerequisite: Graduate standing or consent of instructor. 1(1-0) F,S. Reviews and reports of topics of special interest to graduate students in industrial and technical education. The course will be offered in accordance with the availability of distinguished professors, and in response to indicated needs of the graduate students.

ED 692 Seminar in Industrial Arts Education. Prerequisite: Graduate standing. 1(1-0) F,S. Reviews and reports on special topics of interest to students in industrial arts education.

ED 693 Advanced Problems in Agricultural Education. Prerequisite: ED 554 or equivalent. Credits Arranged F,S,Sum. Study of current and advanced problems in the teaching and administration of educational programs, evaluation of procedures and consideration for improving.

ED 694 Seminar in Agricultural Education. Maximum 2 1(1-0) F,S,Sum. A critical review of current problems, articles and books of interest to students of agricultural education.

ED 695 Seminar in Science Education. Prerequisite: Departmental major or consent of instructor. Maximum 2 F,S. An in-depth examination and analysis of the literature and research in a particular topic(s) in science education. Students will be expected to make presentations to the faculty and class on the topic under consideration.

ED 696 Seminar in Adult and Community College Education. Prerequisite: Graduate standing. 1-3 F,S. Identification and scientific analysis of major issues and problems relevant to adult education. Credit for this course will involve the active participation of the student in a formal seminar and the scientific appraisal and solution of a selected problem. The course is designed to help the student acquire a broad perspective of issues confronting adult educators and to acquire experiences in the scientific analysis and solution of specific issues.

ED 697 (PSY 697) Advanced Seminar in Research Design. Prerequisites: Nine hours of statistical methods and research or approval of instructor, advanced graduate status. 3(3-0) S. This course will be designed as a seminar-type course, with topics selected each semester in accordance with the interests and needs of the students. Attention will be given to the research strategies that underlie educational and psychological research, to the development of theoretical constructs, to a critical review of research related to problems in which the students are interested, and to a systematic analysis and critique of research problems in which the students are engaged. Kniefel

ED 698 Seminar in Occupational Education. Prerequisites: Nine hours of occupational education or approval of instructor; advanced graduate status. 3(3-0) F,S, Sum. This course will be designed as a seminar-type course, with topics selected each semester. Attention will be given to the broad concepts of occupational education as manifested in the Vocational Education Amendments of 1968, and to the problems and issues underlying the development of and implementation of programs of occupational education at elementary junior high, senior high, and postsecondary

levels, with emphasis on articulation between career choice and preparation for gainful employment. Coster

ED 699 Research. Prerequisites: Fifteen hours, consent of adviser. Credits Arranged. Individual research on a specific problem of concern to the student.

Electrical Engineering

GRADUATE FACULTY

Professor G. B. HOADLEY, *Head*

Professor W. D. STEVENSON JR.-*Associate Head and Graduate Administrator*

Professors: W. J. BARCLAY, A. R. ECKELS, W. A. FLOOD, J. R. HAUSER, N. F. J. MATTHEWS, I. K. MONTEITH, J. B. O'NEAL, D. R. RHODES, J. STAUDHAMMER, F. J. TISCHER; *Adjunct Professors:* G. K. MEGLA, J. J. WORTMAN; *Associate Professors:* N. R. BELL, A. J. GOETZE, M. A. LITTLEJOHN, E. G. MANNING, W. C. PETERSON; *Adjunct Associate Professors:* E. CHRISTIAN, J. D. SPRAGINS, M. G. ZAALOUK; *Assistant Professors:* J. W. GAULT, T. H. GLISSON JR., J. F. KAUFFMAN, R. W. STROH

The Department of Electrical Engineering offers the degrees of Master of Electrical Engineering, Master of Science and Doctor of Philosophy.

Four core courses (EE 512, EE 520, EE 530, EE 540) are required for the Master of Electrical Engineering degree, and the student must pass an oral comprehensive examination. No thesis is required for this degree.

The Master of Science degree has no specified course requirements but the student must pass an oral comprehensive examination. The thesis may account for as many as six semester hours.

In the more advanced study for the doctorate, a comprehensive understanding of several fields of electrical engineering is required, and specialization appears in part of the course program and in the research problem undertaken.

Advanced courses of a general and fundamental nature are required for those who plan to carry their advanced studies to the level of the doctorate. Minor sequences of study in advanced mathematics, physics or other appropriate discipline are planned to fit the needs of individual students.

The laboratories in the department are well equipped for research in communications, computers, electromagnetics, solid-state materials and devices, and automatic control. Active research is in progress in these and other areas.

FOR ADVANCED UNDERGRADUATES

EE 401 Advanced Electric Circuits. Prerequisites: EE 202, MA 301. 3(3-0) F,S.

EE 403 Electric Network Design. Prerequisite: EE 401. 3(3-0) S.

EE 406 Dynamical Systems Analysis. Prerequisite: EE 202 or 331, EM 305, MA 301. 3(3-0) F.

EE 431 Electronics Engineering. Prerequisite: EE 314. 3(2-3) F.

EE 432 Communication Engineering. Prerequisite: EE 431. 3(2-3) S.

EE 433 Electric Power Engineering. Prerequisite: EE 305 or EE 332. 3(2-3) S.

EE 434 Power System Analysis. Prerequisite: EE 305. 3(3-0) F.

EE 435 Elements of Control. Prerequisites: EE 314, EE 305. 3(2-3) F.

EE 438 Electronic Instrumentation. Prerequisites: EE 314 or EE 332, MA 301. 3(3-0) S.

EE 440 Fundamentals of Digital Systems. Prerequisite: EE 314. 3(3-0) F,S.

EE 441 Introduction to Electron Devices. Prerequisites: MA 301, PY 207, or PY 208. 3(3-0) F.

EE 442 Introduction to Solid-State Devices. Prerequisites: EE 441 or PY 407, MA 301. 3(3-0) S.

EE 445 Introduction to Antennas. Prerequisites: EE 304, EE 314. 3(2-3) F.

EE 448 Introduction to Microwaves. Prerequisites: EE 304, EE 314. 3(2-3) S.

EE 492 Special Topics in Electrical Engineering. Prerequisite: Junior standing. 3(3-0 to 0-9) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

EE 503 Computer-Aided Circuit Analysis. Prerequisites: EE 314, EE 401, B average in electrical engineering and mathematics. 3(3-0) F. Analysis of electrical circuits with emphasis on computer methods. Steady-state and transient analysis of linear and nonlinear networks; tolerance analysis; programming considerations. Staudhammer

EE 504 Introduction to Network Synthesis. Prerequisites: EE 401, B average in electrical engineering and mathematics. 3(3-0) S. A study of the properties of network functions and the development of the methods of network synthesis of one-port and two-port passive structures. Hoadley

EE 511 Electronic Circuits. Prerequisites: EE 314, B average in electrical engineering and mathematics. 3(3-0) F. Electronic amplifiers, oscillators, modulators, switches, converters, and systems design with integrated circuits. Communications, power and industrial applications. Barclay

EE 512 Communication Theory. Prerequisites: EE 314, B average in electrical engineering and mathematics. 3(3-0) F. Communication signals in the frequency and time domains. Probability and associated functions, random signal theory, modulation and frequency translation, noise, sampling theory and correlation functions. Principles of information theory. Fundamentals of encoding. Accent on methods and problems unique to the field of digital communication. (Offered fall every year, spring 1974 and summer 1976.) Barclay, O'Neal, Stroh

EE 516 Feedback Control Systems. Prerequisites: EE 435 or EE 401, B average in electrical engineering and mathematics. 3(3-0) S. Study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Theory of regulating systems and servo-mechanisms. Steady-state and transient responses. Evaluation of stability. Transfer function loci and root locus plots. Analysis using differential equation and operational methods. System compensation and introduction to design. Peterson

EE 517 Control Laboratory. Corequisite: EE 516. 3(0-3) S. Laboratory study of feedback systems for automatic control of physical quantities such as voltage, speed and mechanical position. Characteristics of regulating systems and servomechanisms. The laboratory work is intended to contribute to an understanding of the theory developed in EE 516. Peterson

EE 520 Fundamentals of Logic Systems. Prerequisites: EE 314, B average in electrical engineering and mathematics. 3(3-0) F. A study of elementary machine language theory, logic algebras, computer organization, and logic design. Introductory combination and sequential logic, including circuits, basic building blocks and realizations. (Offered fall every year, summer 1974 and spring 1976.) Bell, Gault, Staudhammer

EE 521 Digital Computer Technology and Design. Prerequisite: EE 520. 3(3-0) S. A study of the internal organization and structure of digital systems including gates, toggle circuits, pulse circuitry and advanced machine language theory. Analysis and synthesis of the major components of computers, including the logic section, storage devices, registers, input-output and control. Bell, Staudhammer

EE 530 Physical Electronics. Prerequisites: EE 304, B average in electrical engineering and mathematics. 3(3-0) F. A study of behavior of charged particles under the influence of fields and in solid materials. Quantum mechanics, particle statistics, semi-conductor properties, fundamental particle transport properties and lasers. (Offered fall every year, spring 1975 and summer 1977.) Hauser

EE 533 Integrated Circuits. Prerequisites: EE 314, B average in electrical engineering and mathematics. 3(3-0) S. A study of the implementation of solid state circuits in integrated form. Includes thin film, bipolar and MOS technologies and their application to digital and linear systems. Manning

EE 535 (MAE 535) Gas Lasers. 3(3-0) F,S. (See mechanical and aerospace engineering, page 195.)

EE 540 Electromagnetic Fields and Waves. Prerequisites: EE 304, B average in electrical engineering and mathematics. 3(3-0) F. Basic laws and concepts of static and dynamic electromagnetic fields. Fundamental equations and their applications. Fundamentals, forms and applications of Maxwell's equations. Vector and scalar potentials, relativistic aspects of fields, energy and power. Waves in unbounded and bounded regions, radiation, waveguides and resonators. Geometrical and physical optics. (Offered fall every year and summer 1975.) Tischer

EE 545 Introduction to Radio Wave Propagation. Prerequisites: EE 304, B average in electrical engineering and mathematics. 3(3-0) S. Characteristics of plane electromagnetic waves in homogeneous and nonhomogeneous media with application to tropospheric and ionospheric propagation. Relationships between electron density, collision frequency and complex refractive index, theory of the formation and dynamics of ionospheric layers and theorems for the prediction of ionospheric propagation. Flood

EE 591, 592 Special Topics in Electrical Engineering. Prerequisite: B average in technical subjects. 3(3-0) F,S. A two-semester sequence to develop new courses and to allow qualified students to explore areas of special interest. Graduate Staff

EE 593 Individual Topics in Electrical Engineering. Prerequisite: B average in technical subjects. 1-3 F,S. A course providing an opportunity for individual students to explore topics of special interest under the direction of a member of the faculty.

EE 610 Non-Linear Analysis. Prerequisites: EE 516, MA 405. 3(3-0) F. Methods of analysis of non-linear systems. Linear stability criteria applied to certain non-linear systems. Liapunov stability for dynamic systems in general. Optimal control systems with quadratic index of performance. (Offered 1975-76 and alternate years.) Goetze

EE 611 Digital Filtering. Prerequisite: EE 504. 3(3-0) S. Theory of digital signal processing: the sampling theorem, A/D and D/A conversion, and Z-transforms. Digital filter design techniques including impulse invariance, the bilinear Z-transform and high speed convolution via the Fast Fourier Transform. Finite word length effects: quantization noise, stability, limit cycles. Hardware organization and speed considerations. Glisson, Stroh

EE 613, 614 Advanced Feedback Control. Prerequisite: EE 516. 3(3-0) F,S. An advanced study of feedback systems for the control of physical variables. Follower systems and regulators. Mathematical description of systems by use of state variables. Stability theory and performance criteria. Sensitivity analysis. Introduction to non-linear systems and optimization theory. Continuous and sampled data systems. Peterson

EE 616 Microwave Electronics. Prerequisite: EE 540. 3(3-0) S. Limitations imposed by frequency on electronic devices and circuits. Microwave power generation, amplification and control by use of vacuum, gas and solid-state devices including klystrons, masers, traveling-wave tubes, tunnel and Gunn effect diodes. Measurement problems and techniques in the microwave region. (Offered 1975-76 and alternate years.) Barclay

EE 617 Pulse and Digital Circuits. Prerequisite: EE 533. 3(3-0) S. Integrated and discrete circuit techniques for the production, shaping and control of nonsinusoidal wave forms. Fundamental circuits and systems needed in digital information systems, instrumentation and computers. Barclay

EE 618 Antennas and Radiation. Prerequisite: EE 540. 3(3-0) S. A research course in radiating electromagnetic systems. Physical principles of analysis and synthesis of antennas as derived from the Maxwell theory of electromagnetism. Investigation of radiative and reactive properties. Conditions for physical realizability. Construction of realizable aperture distributions and space factors. (Offered 1974-75 and alternate years.) Rhodes

EE 619 Applied Electromagnetic Fields and Waves. Prerequisite: EE 540. 3(3-0) S. A study of networks at frequencies above 100 MHz. General waveguides and resonators as elements of transmission systems, circuitry, and components. Fundamentals of guided waves and their applications. Network elements, resonators, and filters with distributed parameters. Optical waveguides (fiber optics). Integration with active devices in mixers, multipliers, oscillators, and parametric devices. Tischer

EE 622 Electronic Properties of Solid-State Materials I. Prerequisite: EE 530. 3(3-0) S. A study of the electronic properties of solids; details of crystal structure,

lattice properties and electronic energy states. Emphasis on properties of special importance in solid-state devices. Littlejohn

EE 623 Electronic Properties of Solid-State Materials II. Prerequisite: EE 622. 3(3-0) F. Detailed treatment of thermal and electrical transport phenomena, equilibrium and non-equilibrium semiconductor statistics. Also optical properties and hot electron effects in solid-state materials. Littlejohn

EE 624 Electronic Properties of Solid-State Devices. Prerequisite: EE 530. 3(3-0) S. Physical properties of devices, I-V characteristics, power and frequency limitations, and small signal equivalent circuits of diodes, bipolar transistors, junction FET's, Schottky barrier FET's, MOS transistors, and charge coupled devices. (Offered 1974-75 and alternate years.) Hauser

EE 625 Advanced Solid-State Device Theory. Prerequisite: EE 624. 3(3-0) F. A study of the latest development in solid-state devices. The properties of metal-insulator-semiconductor devices, high-field devices and optical devices. Emphasis on the basic fundamental physical principles of operation as opposed to circuit applications. (Offered 1975-76 and alternate years.) Hauser

EE 640 Advanced Logic Circuits. Prerequisite: EE 520. 3(3-0) S. A study of state-of-the art concepts in the area of logic circuits. Threshold logic, multi-valued logic, universal logic modules, and cellular arrays. Current developments in the theory of logic systems. Bell, Gault

EE 641 Sequential Machines. Prerequisite: EE 520. 3(3-0) F. The study of finite automata, both synchronous and asynchronous. Machine equivalence and minimization, state identification and the state assignment problem. Flip-flop activation from the state diagram and other realization techniques. Gault, Staudhammer

EE 642 Automata and Adaptive Systems. Prerequisite: EE 520. 3(3-0) S. The study of neural nets in natural systems, artificial nerve nets, artificial intelligence, goal-directed behavior, the logic of automata and adaptive Boolean logic. Computability, Turing machines and recursive function theory. Bell, Gault

EE 651 Statistical Communication Theory. Prerequisites: EE 401, EE 512 or MA 541 (ST 541). 3(3-0) S. Generalized waveform analysis including Fourier transforms, correlation functions and other statistical descriptions of stationary random processes; manipulation of signal descriptions as affected by linear time-invariant networks; derivation of the optimum impulse response and transfer function of the general linear operator; optimum filter synthesis by the use of orthonormal functions; problems to illustrate the applications of the theory. Glisson, O'Neal, Stroh

EE 652 Information Theory. Prerequisite: EE 512. 3(3-0) F. Definition of a measure of information and a study of its properties, information sources and their efficient representation, communication channels and their capacity, encoding and decoding of data for transmission over noisy channels, source encoding systems, error correcting codes, rate distortion bounds. (Offered 1975-76 and alternate years.) O'Neal, Stroh

EE 654 Communication Systems Analysis. Prerequisite: EE 512. 3(3-0) S. Tools for the analysis of RF and optical communication systems—information symbols, communication path, information content, and entropy and redundancy of an information source. Properties of the communication channel including propagation media and losses, antennas, signal processing and signal quality. The analysis of terrestrial, extra terrestrial and hydrospace systems. Megla, Flood

EE 655 Wave Phenomena in Plasma. Prerequisite: EE 540. 3(3-0) S. Discussion, demonstration, and analysis of wave phenomena and oscillations in plasma. Electron and ion orbits, plasma characteristics and their derivation. Statistical particle dynamics and wave interaction. Plasma diagnostics. Laboratory demonstrations of field interactions, oscillations and waves. Applications in energy conversion and generation. (Offered 1975-76 and alternate years.) Tischer

EE 659 Pattern Recognition. Prerequisite: EE 512. 3(3-0) F. A study of pattern recognition techniques, including discriminant functions, parametric and nonparametric training methods, multilayered networks and feature extraction, classification schemes; principal component analysis, discriminant analysis, clustering techniques. Applications to topics of current interest. Goetze

EE 691, 692 Special Studies in Electrical Engineering. 3(3-0) F,S. An opportunity for small groups of advanced graduate students to study topics in their special fields of interest under the direction of members of the graduate faculty.

EE 695 Electrical Engineering Seminar. Prerequisite: Graduate standing in electrical engineering. 1(1-0) F,S. A series of papers and conferences participated in by the instructional staff, invited guests and students who are candidates for advanced degrees. Graduate Staff

EE 699 Electrical Engineering Research. Prerequisites: Graduate standing in electrical engineering, consent of adviser. Credits Arranged. Graduate Staff

Engineering Mechanics

GRADUATE FACULTY

Professor P. H. McDonald, *Head*

Professor R. A. Douglas, *Associate Head*

Professors: T. S. Chang, J. A. Edwards, J. F. Ely; *Professor Emeritus:* A. Mitchell; *Associate Professors:* W. L. Bingham, M. H. Clayton, E. D. Gurley, Y. Horie, C. J. Maday, F. Y. Sorrell; *Assistant Professors:* H. M. Eckerlin, T. E. Smith; *Adjunct Assistant Professor:* D. I. McRee

The Department of Engineering Mechanics offers graduate programs leading to the Master of Science, Master of Engineering Mechanics and Doctor of Philosophy degrees.

Graduate studies in Engineering Mechanics embrace several broad areas including continuum theory, dynamics and systems, fluid mechanics and solid mechanics. Mechanics of materials, structural mechanics and space mechanics are also areas of importance. Professional interests of the faculty are represented by courses devoted to elastic and plastic behavior of solids, viscous and compressible fluid flow, the generalized continuum behavior of matter and the theory of vibrations.

Graduate research in any of the areas outlined may follow either analytical or experimental lines of investigation, and the department seeks to further both in good balance and mutual support. Particularly encouraged is the development of new research methods and techniques, and the laboratories complex of the depart-

ment is aptly suited to contemporary research. A well-equipped and staffed instrument and model shop is especially helpful in furthering graduate research.

The faculty offer a range of courses both for Engineering Mechanics majors and for inclusion in the programs of students in allied areas of engineering and physical and mathematical sciences. EM 501, 502, Continuum Mechanics I, II, for master's degree students, and EM 601, 602, Unifying Concepts in Mechanics I, II, for Ph.D. candidates, are especially recommended. Interdisciplinary programs in mechanics, electrotechnics and materials are encouraged. Serving as a teaching or research assistant is considered to be highly valuable experience during the program of studies.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

EM 501, 502 Continuum Mechanics I, II. Prerequisites: EM 301, EM 303, MAE 301, MA 405. 3(3-0) F,S. The concepts of stress and strain are presented in generalized tensor form. Emphasis is placed on the discussion and relative comparisons of the analytical models for elastic, plastic, fluid, viscoelastic, granular and porous media. The underlying thermodynamic principles are presented, the associated boundary value problems are formulated and selected examples are used to illustrate the theory. T. S. Chang

EM 503 Theory of Elasticity I. Prerequisite: EM 301; Corequisite: MA 511 or MA 401. 3(3-0) F. The fundamental equations governing the behavior of an elastic solid are developed in various curvilinear coordinate systems. Plane problems, as well as the St. Venant Problem of Bending, Torsion and Extension of bars are covered. Displacement fields, stress fields, Airy and complex stress functions are among the methods used to obtain solutions. Douglas, T. E. Smith

EM 504 Mechanics of Ideal Fluids. Prerequisite: EM 304; Corequisite: MA 513. 3(3-0) F. Basic equations of ideal fluid flow; potential and stream functions; vortex dynamics; body forces due to flow fields, methods of singularities in two-dimensional flows; analytical determination of potential functions; conformal transformations; free-streamline flows. Edwards, Sorrell

EM 505 Mechanics of Viscous Fluids I. Prerequisite: EM 304; Corequisite: MA 532. 3(3-0) S. Equations of motion of a viscous fluid (Navier-Stokes Equations); general properties of the Navier-Stokes equations; some exact solutions of the Navier-Stokes equations; boundary layer equations; some approximate methods of solution of the boundary layer equations; laminar boundary layers in axisymmetric and three-dimensional flows; unsteady laminar boundary layers. Edwards, Sorrell

EM 506 Mechanics of Compressible Fluids I. Prerequisites: EM 304, MAE 302; Corequisite: MA 532. 3(3-0) S. Introduction to the flow of a compressible fluid: thermodynamics and one-dimensional energy equation for a compressible gas. Acoustics, normal shock waves and expansion waves, shock tube theory, general one-dimensional flow and flow in ducts and channels. Sorrell

EM 507 Systems Analysis. Prerequisites: EM 305, MA 405. 3(3-0) F. A study of the analysis of dynamical systems. With the employment of state variable techniques, the qualitative features and fundamental concepts of the engineering system are examined. Eckerlin, McDonald

EM 508 Systems Synthesis. Prerequisite: EM 507. 3(3-0) S. A study of the synthesis of dynamical systems. The modern approach to systems synthesis is employed

through the application of variational principles and optimization techniques. Eckerlin, McDonald

EM 509 Space Mechanics I. Prerequisites: EM 302, EM 304; Corequisite: MA 511. 3(3-0) F. The application of mechanics to the analysis and design of orbits and trajectories. Trajectory computation and optimization; space maneuvers; re-entry trajectories; interplanetary guidance. Clayton, Maday

EM 510 Space Mechanics II. Prerequisites: EM 509, MA 511. 3(3-0) F. Continuation EM 509. The analysis and design of guidance systems. Basic sensing devices; the characteristics of an inertial space; the theory of stabilized platforms; terrestrial inertial guidance. Clayton, Maday

EM 511 Theory of Plates and Shells. Prerequisites: EM 301, MA 511. 3(3-0) F. Bending theory of thin plates; geometry of surfaces and stresses in shells. Various methods of analysis are discussed and illustrated by problems of practical interest. Bingham, Clayton, Gurley

EM 521, 522 Properties of Solids I, II. Prerequisites: EM 307, MAT 301, PY 413. 3(3-0) F. Atomic and molecular principles are applied toward an introductory understanding of macroscopic material properties. The concept of the grand canonical ensemble average of atomic behavior is employed to unify the characterization and interrelationships of material properties. Finally, phenomenological behaviors and coupled effects are described within the continuum concept. Horie

EM 551 Advanced Strength of Materials. Prerequisite: EM 301. 3(3-0) F. Stresses and strains at a point; rosette analysis; stress theories, stress concentration and fatigue; plasticity; inelastic, composite and curved beams; prestress energy methods; shear deflections; buckling problems and column design; and membrane stresses in shells. Gurley

EM 552 Elastic Stability. Prerequisites: EM 551, MA 301, MA 405. 3(3-0) S. A study of elastic and plastic stability. The stability criterion as a determinant. The energy method and the theorem of stationary potential energy. The solution of buckling problems by finite differences and the calculus of variations. The application of successive approximations to stability problems. Optimization applied to problems of aeroelastic and civil engineering structures. Gurley

EM 555 Dynamics I. Prerequisites: EM 301, MA 405. 3(3-0) F. The theory of vibrations from the Lagrangian formulation of the equations of motion. Free and forced vibrations with and without damping, multiple degrees of freedom, coupled motion, normal mode vibrations, wave propagation in solid bodies.
Clayton, Maday

EM 556 Dynamics II. Prerequisites: EM 301, MA 405. 3(3-0) S. The dynamics of particles and rigid bodies by the use of formulations of the laws of mechanics due to Newton, Euler, Lagrange and Hamilton. Accelerated reference frames, constraints, Euler's angles, the spinning top, the gyroscope, precession, stability, phase space and nonlinear oscillatory motion. Clayton, Maday

EM 590 (PHI 590, REL 590) Technology and Human Values. Prerequisites: A baccalaureate degree in a recognized field of engineering, liberal arts, science or social science; or, for advanced undergraduates in these fields, two or more courses such as HI 341, UNI 301, 302, UNI 401, or six hours in philosophy. 3(3-0) F. An exploration from two or more disciplinary perspectives (notably those of ethical theory and cybernetic information theory) of the range of ways of conceptualizing the relationship between the technologies of a society and the values of that society,

and in areas of particular interest to students, a detailed analysis of contemporary instances of the interrelation of technology and human values.

McDonald, Shriver

FOR GRADUATES ONLY

EM 601, 602 Unifying Concepts in Mechanics I, II. Prerequisite: PY 503 or EM 501. 3(3-0) F,S. Generalized treatment of the fundamental equations and boundary value problems of continuous and noncontinuous media. Use is made of contemporary developments in irreversible thermodynamics, statistical mechanics and electrodynamics to provide a unified foundation for the development of principles governing the dynamic and thermodynamic behavior of elastic, plastic and viscoelastic solids, viscous fluids and rheological media. Chang, McDonald

EM 603 Theory of Elasticity II. Prerequisite: EM 503; Corequisite: MA 513. 3(3-0) S. An extension of EM 503 to include the Cauchy Integral methods for plane problems, three-dimensional problems, variational methods and the use of numerical methods. Ely, T. E. Smith

EM 604 Theory of Plasticity. Prerequisite: EM 503. 3(3-0) S. Analytical models are developed to represent the behavior of deformable solids in the plastic regime. Conditions of yielding and fracture which initiate and terminate plastic behavior are studied, with the special stress-strain relationships necessary in plasticity. The hyperbolic equations of slipline fields characteristic of plane strain theory are developed. Douglas, Horie

EM 605, 606 (MAS 605, 606; OY 605, 606) Advanced Geophysical Fluid Mechanics I, II. 3(3-0) F,S. (See physical oceanography, page 214.)

EM 611 Mechanics of Compressible Fluids II. Prerequisite: EM 506. 3 S. A continuation of EM 506. Linearized theory of two- and three-dimensional supersonic flow past bodies. Oblique shock waves and method of characteristics for two-dimensional supersonic flow. Unsteady supersonic flow and compressible flow with viscosity and heat transfer. Sorrell

EM 612 Mechanics of Viscous Fluids II. Prerequisite: EM 505. 3 F. Continuation of EM 505, phenomenological theories of turbulence, turbulent flow in ducts and pipes, turbulent boundary layer with and without pressure gradient, compressible boundary layer, boundary layer control and free viscous flow. Sorrell, Edwards

EM 613, 614 (MAS 613, 614; OY 613, 614) Perturbation Method in Fluid Mechanics I, II. 3(3-0) F,S. (See physical oceanography, page 214.)

EM 621 Properties of Materials at Low Temperatures. Prerequisites: EM 301, EM 521 or equivalent. 3(3-0) F,S. Recent developments in low-temperature theory and applications of materials are presented starting with the theory of atomic processes which govern low-temperature behavior. A study of the current models of the dominant physical processes at low temperatures is applied to mechanical, thermal and electrical behavior, including superconductivity and superfluidity. Results are applied toward prediction and correlation of properties at higher temperatures where the governing physical processes are more interrelated.

Horie

EM 631, 632 (OR 631, 632) Variational Methods in Optimization Techniques I, II. 3(3-0) F,S. (See operations research, page 212.)

EM 641 Optical Mechanics. Prerequisite: EM 312. 3(2-3) S. Concepts of crystal optics applied to continua deformed statically or dynamically by mechanical loading; optical interference and its use as a measuring technique of absolute and relative retardations in various types of interferometers; relative retardation measurements; deformation measurements with diffraction gratings; Moire (mechanical) interference measurements. Bingham

EM 656 Nonlinear Vibrations. Prerequisite: EM 555. 3(3-0) F,S. Free and forced vibrations of systems with nonlinear restoring forces and self-sustained oscillations. Approximation techniques applied to nonlinear differential equations. Comparisons with exact solutions when possible. Emphasis placed on understanding properties unique to nonlinear systems. Clayton

EM 695 Experimental Methods in Mechanics. Prerequisite: Consent of instructor. 3(2-3) S. A study of specialized experimental techniques utilized in contemporary research in the areas of mechanics. Messrs. Bingham, Douglas, Edwards

EM 697 Seminar in Mechanics. Prerequisites: Graduate standing, consent of adviser. 1(1-0) F,S. The discussion and development of theory relating to contemporary research in the frontier areas of mechanics. Chang, Douglas

EM 698 Special Topics in Mechanics. Credits Arranged. The study, by small groups of graduate students under the direction of members of the faculty, of topics of particular interest in various advanced phases of mechanics. Graduate Staff

EM 699 Research in Mechanics. Credits Arranged. Individual research in the field of mechanics. Graduate Staff

English

GRADUATE FACULTY

Professor L. S. CHAMPION, *Head*

Professor R. B. WHITE JR., *Assistant Head*

Associate Professor J. D. DURANT, *Director of the Graduate Program*

Professors: M. HALPEREN, H. G. KINCHELOE, A. S. KNOWLES, B. G. KOONCE JR., F. H. MOORE, G. OWEN JR., C. A. PARKER, W. B. TOOLE III, P. WILLIAMS JR.; *Professors Emeriti:* L. C. HARTLEY, R. G. WALSER; *Associate Professors:* L. J. BETTS JR., P. E. BLANK JR., E. P. DANDRIDGE JR., W. G. FRANKLIN, H. A. HARGRAVE, W. E. MEYERS, A. F. STEIN, T. N. WALTERS; *Assistant Professors:* R. A. LASSETER, M. S. REYNOLDS, D. D. SHORT, H. C. WEST, MARY CAMERON WILLIAMS

The Department of English offers instruction leading to the Master of Arts degree with specialization in English and American literature. The program is designed either to provide the student with a terminal course of study or to serve as the first year toward a doctorate.

A minimum of 30 semester hours of graduate credit is required, though the program may be expanded to meet the needs of individual students.

Assistantships for promising students are available. These students will take ENG 504 in the fall semester and devote half time in the fall and spring semesters to the teaching of courses in freshman composition under supervision.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ENG 504 Problems in College Composition. Prerequisite: Consent of instructor or graduate standing. 3(3-0) F. Directed study of the development of rhetorical skills in composition in classroom situations. Betts, Walters

ENG 524 Modern English Usage. Prerequisite: Consent of instructor or graduate standing. 3(3-0) S. An intensive study of English grammar, with attention to new developments in structural linguistics and with emphasis on current usage. Meyers, Short

ENG 526 History of the English Language. Prerequisite: Consent of instructor or graduate standing. 3(3-0) F,S. A survey of the growth and development of the language from its Indo-European beginnings to the present. Meyers, Short

ENG 561 Milton. Prerequisite: ENG 261 or equivalent. 3(3-0) S. An intensive reading of Milton with attention to background materials in the history and culture of seventeenth-century England. Moore, White

ENG 575 Southern Writers. Prerequisite: ENG 266 or equivalent. 3(3-0) S. A survey of the particular contribution of the South to American literature, with intensive study of selected major figures. Kincheloe, West

ENG 578 English Drama to 1642. Prerequisite: ENG 261 or equivalent. 3(3-0) F. Intensive study of the English drama from its liturgical beginnings to the closing of the theatres, excluding Shakespeare. Champion, Meyers

ENG 579 English Drama of the Restoration and Eighteenth Century. Prerequisite: ENG 261 or equivalent. 3(3-0) S. Intensive study of the English drama from 1660 to 1800. Durant, Moore

ENG 590 Literary Criticism. Prerequisite: ENG 261 or equivalent. 3(3-0) S. An examination of the critical process as it leads to the definition and analysis of literature, together with attention to the main literary traditions and conventions. Durant, P. Williams

FOR GRADUATES ONLY

ENG 608 Bibliography and Methodology. Prerequisite: Graduate standing. 3(3-0) F,S. An investigation of the materials of literary research and scholarship; an introduction to varying scholarly approaches to literary problems leading to development of the student's ability to evaluate and use with discrimination the work of scholars in his field. Graduate Staff

ENG 609 Old English Literature. Prerequisite: Graduate standing. 3(3-0) S. An introduction to the language and literature of the Old English period (450-1100). Readings will be in the original and will include both poetry and prose. Koonce, Short

ENG 610 Middle English Literature. Prerequisite: Graduate standing. 3(3-0) F.A study of major works of medieval English literature (exclusive of Chaucer) in the

light of dominant intellectual and artistic traditions; emphasis is on four works: *Piers Plowman, Pearl, Sir Gawain and the Green Knight,* and Malory's *Morte Darthur.* (Offered in 1974 and 1976.) Koonce, Short

ENG 615 American Literature of the Colonial Period. Prerequisite: Graduate standing. 3(3-0) F. A study of American literature and thought from the beginnings to the adoption of the Constitution. (Offered in 1975.) West

ENG 620 16th-Century Non-Dramatic English Literature. Prerequisite: Graduate standing. 3(3-0) F. A detailed survey of non-dramatic prose and verse of the sixteenth century against the background of Humanism with the consequent assimilation of classical and continental literary subjects and forms. Blank

ENG 630 17th-Century English Literature. Prerequisite: Graduate standing. 3(3-0) S. A close examination of the literature of England from 1600 to 1700 with emphasis on major literary figures and movements, the development of important literary forms and genres, and the intimate relationship between the literature of this period and its philosophical, political, and theological backgrounds. Moore, White

ENG 650 19th-Century English Literature: The Romantic Period. Prerequisite: Graduate standing. 3(3-0) F. A detailed study of the six major romantic poets—Blake, Wordsworth, Coleridge, Byron, Shelley, and Keats; some attention as well to the political, social, and literary background and to a few minor writers and critics. Hargrave, P. Williams

ENG 651 Studies in Chaucer. Prerequisite: ENG 451 or equivalent. 3(3-0) F. An intensive study of the Chaucer canon requiring independent research. Koonce

ENG 655 19th-Century American Literature: The Romantic Period. Prerequisite: Graduate standing. 3(3-0) F. A study of the selected works of Poe, Hawthorne, Melville, Emerson, and Thoreau, with emphasis on their varied contributions to the literature and thought of the American romantic movement. Kincheloe, Stein

ENG 658 Studies in Shakespeare: The Tragedies. Prerequisite: Graduate standing. 3(3-0) F. An intensive study—textual and critical—of Shakespeare's tragedies. Blank, Champion

ENG 659 Studies in Shakespeare: The Comedies. Prerequisite: Graduate standing. 3(3-0) S. An intensive study—textual and critical—of Shakespeare's comedies. Blank, Champion

ENG 660 Victorian Poetry. Prerequisite: Graduate standing. 3(3-0) S. Studies in the poetry of Victorian England: 1837-1901; the major poets, movements, and questions in their historical contexts, religious, political, and aesthetic. (Offered in 1974 and 1976.) Hargrave, Lasseter

ENG 661 Victorian Prose. Prerequisite: Graduate standing. 3(3-0) S. Studies in the non-fiction prôse of Victorian England: 1830-1900. The major essayists and intellectual movements of the Victorian period in their religious, social and aesthetic contexts. (Offered in 1975.) Hargrave, Lasseter

ENG 662 18th-Century English Literature. Prerequisite: Graduate standing. 3(3-0) F. The major figures in English literature between 1660 and 1790 against the background of social, cultural and religious change. Durant, White

ENG 665 19th-Century American Literature: Realism and Naturalism. Prerequisite: Graduate standing. 3(3-0) S. Concentration on Whitman, Dickinson, Twain,

James, and Dreiser, with briefer attention to Howells, Crane, Norris, and other realists and naturalists. Kincheloe, Stein

ENG 670 20th-Century British Prose. Prerequisite: Graduate standing. 3(3-0) S. An examination of the works of the major British writers and literary movements of this century and their historical context, religious, political, and aesthetic. (Offered in 1974 and 1976.) Halperen, Knowles

ENG 671 20th-Century British Poetry. Prerequisite: Graduate standing. 3(3-0) S. The development of English poetry from the rebellion against Victorian and Pre-Raphaelite verse to the present post-war scene; special attention to Hardy, Yeats, Eliot, Auden, and Thomas. (Offered in 1975.) Owen

ENG 675 20th-Century American Prose. Prerequisite: Graduate standing. 3(3-0) F. An examination of representative American writers of the novel and short fiction. (Offered in 1974 and 1976.) Knowles

ENG 676 20th-Century American Poetry. Prerequisite: Graduate standing. 3(3-0) F. The development of modern American poetry from the rebellion against the romantic and genteel verse of the 1890's; special attention to Robinson, Frost, Pound, Williams, Stevens, and Ransom. (Offered in 1975.) Owen

ENG 680 20th-Century British Drama. Prerequisite: Graduate standing. 3(3-0) S. A survey of modern British drama from its beginnings at the turn of the century to the present. (Offered in 1974 and 1976.) Halperen

ENG 681 20th-Century American Drama. Prerequisite: Graduate standing. 3 (3-0) S. A survey of modern American drama centering on major figures. (Offered in 1975.) Halperen

ENG 692 Special Topics in American Literature. Prerequisite: Consent of seminar chairman. 3(3-0) F,S. An intensive study, involving independent research and centering on some limited topic from American literature. Graduate Staff

ENG 693 Special Topics in English Literature. Prerequisite: Consent of seminar chairman. 3(3-0) F,S. An intensive study, involving independent research and centering on some limited topic from English literature. Graduate Staff

ENG 699 Research in Literature (Thesis). Prerequisite: Consent of graduate adviser. Credits Arranged F,S. Independent investigation of an advanced literary or linguistic problem leading to the writing of a master's thesis. Graduate Staff

Entomology

GRADUATE FACULTY

Professor K. L. KNIGHT, *Head*

Professors: R. C. AXTELL, C. H. BRETT, W. V. CAMPBELL, W. C. DAUTERMAN, M. H. FARRIER, F. E. GUTHRIE, E. HODGSON, W. J. MISTRIC JR., H. H. NEUNZIG, R. L. RABB, T. J. SHEETS, C. F. SMITH, D. A. YOUNG JR.; *Professor Emeritus:* T. B. MITCHELL; *Adjunct Professors:* J. R. FOUTS, LOUISE M. RUSSELL, C. W. SABROSKY; *Extension Professors:* R. L. ROBERTSON, G. T.

WEEKMAN; *Associate Professors:* J. R. BRADLEY, W. M. BROOKS, H. B. MOORE, G. C. ROCK, C. G. WRIGHT, R. T. YAMAMOTO; *Adjunct Associate Professor* A. L. CHASSON; *Extension Assistant Professors:* J. R. BAKER, K. A. SORENSEN; *Visiting Assistant Professor:* R. E. STINNER

The Department of Entomology offers graduate training leading to the Master of Agriculture, Master of Science and Doctor of Philosophy degrees. Major areas of specialization are: acarology, agricultural entomology, behavior, biochemistry and toxicology, ecology, extension entomology, invertebrate pathology, medical and veterinary entomology, nutrition, pesticide analysis, pest management and taxonomy.

Opportunities exist for training in both applied and fundamental phases of entomology and invertebrate biology. Population management concepts are emphasized in the applied entomology and pest management programs. The applied phases are influenced by the state's agriculture, in which tobacco, cotton, peanuts, soybeans, fruit, vegetables, livestock and forestry are important components. The rapidly expanding tourist industry and the diverse habitats of the state, extending from the mountains to the sea, provide unique opportunities for research on insects and related arthropods affecting man. A cooperative arrangement with the School of Forest Resources provides a major in forest entomology. The program in medical and veterinary entomology includes both applied and fundamental research and provides the opportunity for training at the School of Public Health, Chapel Hill, North Carolina.

Fundamental areas of particular interest are biochemistry and toxicology, physiology and behavior, and taxonomy. The program in biochemistry and toxicology is interdepartmental involving faculty from the departments of Biochemistry, Crop Science, Entomology, Statistics and Genetics. Taxonomy is particularly strong in the aphids, leafhoppers, mites and mosquitoes. Invertebrate pathology emphasizes protozoan diseases. Ecology, population dynamics, behavior and nutrition are emphasized in several programs.

The departmental research and training programs are supported by a complex of modern facilities including: a pesticide residue analysis laboratory, pesticide research laboratory, comparative biochemistry and toxicology laboratories, a behavior laboratory, insect rearing rooms, greenhouses and field stations. An adjacent phytotron or bioclimatic facility provides an opportunity for ecological and behavioral studies under controlled conditions. Ultrastructural investigations are conducted in the Institute of Biological Sciences Electron Microscope Facility. Extensive nuclear reactor and computer facilities and statistical services are available on campus.

See page 24 for an account of the Pesticide Residue Research Laboratory and page 26 for the Insect Pest Management Program.

FOR ADVANCED UNDERGRADUATES

ENT 401 (ZO 401) Bibliographic Research in Biology. 1(1-0) F.

ENT 410 (BS 410) Biology of Insects. Prerequisite: ZO 201. 3(2-2) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ENT 502 Insect Diversity. Prerequisites: Twelve hours of biology. 4(2-4) F. An introduction to the external morphology of insects and a survey of the biology and identification of immature and adult insects. Evolutionary relationships of insects and other arthropods, speciation, nomenclature, and classical and recent approaches to systematics are also considered. Baker, Neunzig, Young

ENT 503 Functional Systems of Insects. Prerequisites: Twelve hours in biology, nine hours in chemistry, three hours of biochemistry, ENT 301 or equivalent. 4(2-6) S. Structure and morphological variations of organ systems in insects including considerations of their histology and function. Sensory and general physiology will then lead into basic elements of insect orientation and behavior.
Campbell, Hodgson, Yamamoto

ENT 504 Insect Morphology. Prerequisite: ENT 502. 3(1-4) F. Concerned with external morphology, primary and comparative phases, with emphasis on knowledge and techniques which can be applied to specific problems. (Offered fall 1975 and alternate years.) Young

ENT 511 Systematic Entomology. Prerequisite: ENT 301 or ENT 312 or equivalent. 3(1-4) F. A somewhat detailed survey of the orders and families of insects, designed to acquaint the student with those groups and develop in the student some ability in the use of the taxonomic literature. (Offered fall 1974 and alternate years.)
Young

ENT 520 Insect Pathology. Prerequisite: Introductory entomology and introductory microbiology. 3(2-3) S. A treatment of the noninfectious and infectious diseases of insects, the etiological agents and infectious processes involved, immunological responses, and applications. (Offered spring 1975 and alternate years.) Brooks

ENT 531 Insect Ecology. Prerequisite: ENT 502. 3(2-2) F. The environmental relations of insects, including insect development, habits, distribution and abundance. (Offered fall 1975 and alternate years.) Rabb

ENT 541 Immature Insects. Prerequisite: ENT 502 or equivalent. 2(1-3) F. An advance study of the immature stages of selected orders of insects with emphasis on generic and specific taxa. Primary consideration is given to the larval stage, but a brief treatment of eggs and pupae is also included. (Offered fall 1974 and alternate years.) Neunzig

ENT 542 Acarology. Prerequisite: ENT 301 or ENT 312 or ZO 201. 3(2-3) S. A systematic survey of the mites and ticks with emphasis on identification, biology and control of the more common and economic forms attacking material, plants and animals including man. (Offered spring 1975 and alternate years.) Farrier

ENT 550 Fundamentals of Insect Control. Prerequisites: ENT 312 or ENT 301. 3 (2-2) F. The course is divided into two phases. The first deals with the basic causes of insect problems, an evaluation of the biological and economic aspects of insect attack and the fundamental methods employed in insect control. The second part deals with the critical chemical, physical and biological properties of compounds used for insect control. The material presented in the course is directed toward obtaining fundamental knowledge of the scientific principles underlying modern methods of protection of food, clothing, shelter and health from arthropods.
Guthrie

ENT 562 Agricultural Entomology. Prerequisites: ENT 301 or ENT 312. 3(2-3) S. A study of the taxonomy, biology, and ecology of beneficial and injurious insects and

arachnids of agricultural crops. Advantages and limitations of the advanced concepts for controlling insect and mite populations on different crops will be emphasized. (Offered spring 1975 and alternate years.) Bradley, Rock

ENT 575 (PHY) 575, ZO 575) Physiology of Invertebrates. 3(3-0) F. (See physiology, page 220.)

ENT 582 (ZO 582) Medical and Veterinary Entomology. Prerequisites: ENT 301 or ENT 312 and ZO 315 or equivalent. 3(2-3) S. A study of the morphology, taxonomy, biology and control of the arthropod parasites and disease vectors of man and animals. The ecology and behavior of vectors in relation to disease transmission and control will be emphasized. (Offered spring 1974 and alternate years.) Axtell

ENT 590 Special Problems. Prerequisite: Consent of instructor. Credits Arranged F,S. Original research on special problems in entomology not related to a thesis problem, but designed to provide experience and training in research. Graduate Staff

FOR GRADUATES ONLY

ENT 602 Principles of Taxonomy. Prerequisite: ENT 511. 3(1-4) S. A course introducing the methods and tools used in animal taxonomy, designed to promote a better understanding of taxonomic literature, and provide a foundation for taxonomic research. (Offered spring 1974 and alternate years.) Young

ENT 611 Biochemistry of Insects. Prerequisite: BCH 551 or equivalent. 3(3-0) F. The biochemistry of insects will be considered with primary emphasis on intermediate metabolism. Aspects in which insects show specialization will be treated in greater detail. The comparative treatment used necessitates some consideration of other animal groups. (Offered fall 1975 and alternate years.) Hodgson

ENT 622 Insect Toxicology. Prerequisites: ENT 550, BCH 551 or equivalent. 3 (2-3) S. The relation of chemical structure to insect toxicity, the mode of action of toxicants used to kill insects, the metabolism of insecticides in plant and animal systems, the selectivity within the cholinesterase inhibitors and other selective mechanisms and the analysis of insecticide residues will be discussed. (Offered spring 1974 and alternate years.) Dauterman, Guthrie

ENT 690 Seminar. Prerequisite: Graduate standing in entomology or closely allied fields. 1(1-0) F,S. Discussion of entomological topics selected and assigned by seminar chairman. Graduate Staff

ENT 699 Research. Prerequisite: Graduate standing. Credits Arranged F,S. Original research in connection with thesis problem in entomology. Graduate Staff

Fiber and Polymer Science

ASSOCIATED GRADUATE FACULTY

Professors: J. F. Bogdan, K. S. Campbell, D. M. Cates, D. W. Chaney, R. D. Gilbert, G. Goldfinger, D. S. Hamby, S. P. Hersh, P. R. Lord, H. A. Rutherford, V. T. Stannett, C. F. Zorowski; *Adjunct Professors:* H. F. Mark, A. M. Sookne; *Associate Professors:* J. A. Cuculo, A. H. M. El-

SHIEKH, T. W. GEORGE, T. H. GUION, B. S. GUPTA, R. MCGREGOR, T. G. ROCHOW, M. H. THEIL, W. K. WALSH; *Research Associate:* C. E. BRYAN; *Assistant Professors:* P. BROWN, R. E. FORNES

Fiber and Polymer Science is a multidisciplinary program bringing together the disciplines of mathematics, chemistry and physics and the application of engineering principles for the development of independent scholars versed in the field of fiber materials science. The program is administered by the School of Textiles and leads to the degree of Doctor of Philosophy. Students majoring in the physical sciences, mathematics, textiles or engineering and having at least a "B" grade in their undergraduate major will normally qualify for admission.

Fiber and Polymer Science is concerned with polymeric materials, fibers produced from them, and fiber assemblies in one, two and three dimensional forms. This broad field of study permits a wide range of specializations. The candidate is expected to penetrate deeply into one area of specialization and to acquire a reasonable perspective in other relevant subject matter. Generally these specialities occur within the areas of polymer chemistry and synthesis; fiber and polymer physics and physical chemistry; or textile mechanics and technology.

The student's research is based upon a chosen area of specialization and constitutes his contribution of new knowledge to society.

Ample laboratory space is available and there are a number of specialized laboratories equipped to support doctoral investigations. Other facilities and research equipment are available in cooperating departments on campus which may be used in fiber and polymer science research programs. The Burlington Textiles Library houses one of the most complete collections of polymer, fiber and textile literature.

DEGREE REQUIREMENTS

Doctor of Philosophy—An advisory committee chaired by a member of the fiber and polymer science faculty is formed as soon as possible in order to develop with the student a plan of study designed to enable him to acquire the comprehensive knowledge required to pass the qualifying cumulative examinations.

There are no definite requirements in credit hours for the Doctor of Philosophy degree. A student's program of study is designed around the student's special interests, while maintaining the coherence and breadth essential for professional development and excellence in research.

Doctor of Philosophy Minor—Ph.D. candidates who designate a named minor in Fiber and Polymer Science will be required to pass the common part of the cumulative examination.

Communications concerning this program should be directed to the Chairman of the Graduate Studies Committee, School of Textiles, North Carolina State University.

COURSE OFFERINGS*

(See departmental listing for descriptions.)

* Extensive use may be made of graduate course offerings in other Schools on campus when developing the minor field.

GENERAL COURSES

TC 461 (CH 461) Chemistry of Fibers.
TC 504 Fiber Formation—Theory and Practice.
TC 562 (CH 562) Physical Chemistry of High Polymers—Bulk Properties.
TX 465 Mechanics of Yarn Formation.
TX 561 Mechanical and Rheological Properties of Fibrous Material.

COURSES IN AREAS OF SPECIALIZATION

Polymer Chemistry and Synthesis

TC 561 Organic Chemistry of High Polymers.
TC 671 (CHE 671) Special Topics in Polymer Science.

Polymer Physics and Physical Chemistry

TC 505 Theory of Dyeing.
TC 662 Physical Chemistry of High Polymers—Solution Properties.
T 500 Advanced Microscopy.
TX 560 Structural and Physical Properties of Fibers.
TX 691 (TC 691) Special Topics in Fiber Science.
T 501 Resinography.
CHE 569 (TC 569) Polymers, Surfactants, and Colloidal Materials.
CHE 669 (TC 669) Diffusion in Polymers.

Food Science

GRADUATE FACULTY

Professor W. M. ROBERTS, *Head*

Professors: I. W. AURAND, T. N. BLUMER, H.B. CRAIG, M. W. HOOVER, M. L. SPECK—*Graduate Administrator*, H. E. SWAISGOOD, F. G. WARREN; *Extension Professors:* ELOISE S. COFER, F. B. THOMAS; *Professors USDA:* T. A. BELL, J. L. ETCHELLS, A. E. PURCELL; *Professor Emeritus:* I. D. JONES; *Associate Professors:* D. E. CARROLL JR., S. E. GILLILAND, D. D. HAMANN, A. P. HANSEN, V. A. JONES, N. B. WEBB; *Extension Associate Professor:* F. R. TARVER JR.; *Associate Professors USDA:* H. P. FLEMING, W. M. WALTER JR.; *Assistant Professors:* D. M. ADAMS JR., H. R. BALL JR., G. G. GIDDINGS, B. R. JOHNSON; *Adjunct Assistant Professor:* W. Y. COBB; *Visiting Assistant Professor:* B. RAY

Programs of study leading to the Master of Agriculture, Master of Science and Doctor of Philosophy degrees are offered by the Department of Food Science.

Areas of study and research include food chemistry, food microbiology, food engineering, and food process and product development. These areas involve all foods including dairy products, fruits, meats, poultry products, seafoods, nutmeats and vegetables. Supporting course work and cooperative research are offered in areas such as biochemistry, chemistry, economics, engineering, genetics, microbiology, nutrition, physics and statistics.

The department participates in interdepartmental graduate student training programs. One is the training program in Industrial Waste Control and Abatement with the Department of Civil Engineering. Specialization in industrial water use, water supply and pollution control is stressed in water resources graduate programs. Particular emphasis is given to the processes used in food plant operations. The Marine Sciences Program provides research training in the technology of seafood processing and product development. The School of Public Health, University of North Carolina at Chapel Hill, offers courses for a minor or for enriching Food Science programs with studies in environmental sciences.

FOR ADVANCED UNDERGRADUATES

FS 400 Foods and Nutrition. Prerequisite: CH 220. 3(3-0) S.

FS 402 Food Chemistry. Prerequisite: CH 220 or CH 221. 3(3-0) F.

FS 404 (PO 404) Poultry Products. Prerequisites: CH 220 or CH 221. 3(2-3) F.

FS 405 (MB 405) Food Microbiology. Prerequisite: MB 301 or MB 401. 3(2-3) F.

FS 409 (ANS 409) Meat and Meat Products. Prerequisite: CH 220. 3(2-3) S.

FS 432 (BAE 432) Food Engineering II. Prerequisite: FS 331 (BAE 331). 3(2-3) S.

FS 490 Food Science Seminar. Prerequisite: Senior standing. 1(1-0) S.

FS 491 Special Topics in Food Science. Prerequisite: Senior standing or consent of instructor. Maximum 6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

FS 503 Food Analysis. Prerequisites: CH 315, BCH 351, FS 402. 3(1-6) S. A study of the principles, methods and techniques necessary for quantitative physical and chemical analyses of food and food products. Results of analysis evaluated in terms of quality standards and governing regulations. Johnson

FS 504 Advanced Food Chemistry. Prerequisite: BCH 551. 3(3-0) F. Studies on the molecular properties of food components, their interactions and reactions and the physiochemical alterations occuring in the maturation, harvest, process and storage stages. Aurand

FS 506 (MB 506) Advanced Food Microbiology. Prerequisite: FS 405 (MB 405) or equivalent. 3(1-6) S. The interactions of microorganisms in foods and their roles in food spoilage and bioprocessing. Cellular and molecular relationships in bacterial injury, repair and aging resulting from environmental stresses. Bacterial sporulation, germination and physiological properties of bacterial spores. Speck

FS 511 Food Research and Development. Prerequisites: FS 331 (BAE 331), FS 402, FS 405 (MB 405). 3(2-3) S. A study of the scientific principles underlying the development of new and improved food products and processes. The study of specific food industry problems by the case method. Special emphasis on the application of research and development principles to meat, poultry and fisheries industries. Webb

FS 516 Quality Control of Food Products. Prerequisites: FS 331 (BAE 331), FS 402, FS 405 (MB 405). 3(2-3) S. A study of quality control fundamentals in the food industry including specifications and standards, testing procedures, sampling, statistical and quality control, and organization. Food products and industry problems with special emphasis on dairy products. Hansen

FS 521 (HS 521) Food Preservation. Prerequisites: MB 401 or FS 405 (MB 405), FS 402, or BO 421. 3(2-3) F. An examination of principles and methods employed in the preservation of foods. Major emphasis on thermal, freezing, drying and fermentation processes and their relationship to physical, chemical and organoleptic changes in product. The relationship of these preservation techniques to the development of an overall processing operation. Carroll

FS 562 (HS 562) Post-Harvest Physiology. 3(3-0) S. (See horticultural science, page 169.)

FS 591 Special Problems in Food Science. Prerequisite: Graduate or senior standing. Maximum 6 F,S. Analysis of scientific, engineering and economic problems of current interest in foods. The problems are designed to provide training and experience in research. Graduate Staff

FOR GRADUATES ONLY

FS 601 Theory of Physical Measurements of Biopolymers. Prerequisite: CH 525 or BCH 551. 3(2-3) S. The theory and interpretation of various physical parameters of polymers and the theoretical basis for the measurement of the parameter and its limitations. Particular emphasis on the experimental design and interpretation of data yielding maximum information. Swaisgood

FS 690 Seminar in Food Science. 1(1-0) F,S. Preparation and presentation of scientific papers, progress reports and research and special topics of interest in foods. Graduate Staff

FS 691 Special Research Problems in Food Science. Credits Arranged. Directed research in a specialized phase of food science designed to provide experience in research methodology and philosophy. Graduate Staff

FS 699 Research in Food Science. Credits Arranged. Original research preparatory to the thesis for the Master of Science or Doctor of Philosophy degree. Graduate Staff

Forestry

GRADUATE FACULTY

Professor C. B. DAVEY, *Head*

Professors: F. S. BARKALOW, A. W. COOPER (on leave), E. B. COWLING, J. W. DUFFIELD, M. H. FARRIER, J. W. HARDIN, J. O. LAMMI, T. E. MAKI, T. O. PERRY, L. C. SAYLOR, R. R. WILKINSON, B. J. ZOBEL; *Professor USDA:* C. S. HODGES; *Professor USFS:* G. NAMKOONG; *Professors Emeriti:* W. D. MILLER, R. J. PRESTON; *Adjunct Professors:* G. H. HEPTING, N. E. JOHNSON, L. J. METZ, C. G. WELLS; *Associate Professors:* L. F. GRAND, W. L. HAFLEY, D. H. J.

STEENSEN; *Associate Professor USFS:* B. F. SWINDEL; *Adjunct Associate Professors:* J. W. KOENIGS, E. G. KUHLMAN; *Assistant Professors:* D. L. HOLLEY, R. C. KELLISON

ASSOCIATE MEMBER OF THE DEPARTMENT:

Professor (USDA): D. E. MORELAND

The Department of Forestry offers graduate work leading to the degrees of Master of Forestry, Master of Science and Doctor of Philosophy.

The professional degree, Master of Forestry, is designed for students interested in the advanced applications of the principles of one of the fields in forestry. The course program emphasizes professional specialization; a thesis is not required.

The Master of Science degree requires the student to become broadly educated in the scholarly disciplines in the field of forestry. Independent research and a thesis are required for this degree.

Students with a bachelor's degree in forestry may complete either of the master's programs in two academic years or less, provided they have met the undergraduate curriculum requirements in mathematics and the biological, physical and social sciences. Candidates who do not hold an undergraduate degree in forestry usually are required to extend their program an extra semester.

The Doctor of Philosophy degree is available to students who demonstrate high intellectual capacity and the ability to conduct original research and scholarly work at the highest levels.

Joint and associate faculty appointments with other departments provide exceptional opportunities for graduate studies in the forestry-related aspects of biometry, botany, ecology, economics, entomology, genetics, hydrology, plant pathology, soil science and wildlife science. Students who are concerned with the problems of restoring and improving the quality of our environment may find meaningful graduate study in the Department of Forestry.

The department is housed in the modern facilities of Biltmore Hall. Facilities for forest biological research include a phytotron, greenhouses, a small experimental nursery and an off-campus laboratory equipped for the study of carbon and water metabolism of tree seedlings. The experimental and production forests of the school total more than 80,000 acres. The Hofmann Forest on the coastal plain, the Goodwin Forest at the edge of the sandhills, and the Schenck, Hope Valley and Hill forests in the Piedmont provide a variety of forest types and problems in the management of timber, water, wildlife and recreational resources. The Hill and Schenck forests include natural areas, excluded from normal management operations, for the study of forest ecology.

The department has exceptionally close working relations, including three cooperative programs of research and development, with public agencies and the forest industries of the southeastern United States.

FOR ADVANCED UNDERGRADUATES

FOR 405 Forest Land Management. Prerequisites: FOR 272, FOR 452. 5(2-6-2) F.

FOR 406 Forest Land Inventory and Planning. Prerequisite: FOR 405. 6(2-12) S.

FOR 423 (WPS 423) Logging and Milling. 3(2-3) F. (See wood and paper science, page 274.)

FOR 435 (WPS 435) Systems Analysis in Forest Products. 3(3-0) S. (See wood and paper science, page 274.)

FOR 452 Silvics. Prerequisite: BO 200, CH 103, PY 221 or PY 212, mathematics through calculus. 4(3-2) S.

FOR 462 Artificial Forestation. 2(1-2) S.

FOR 472 Renewable Resource Management. Prerequisites: A basic course in biology and economics; junior or senior standing. 3(3-0) S.

FOR 491 (WPS 491) Senior Problems in Forest Resources. Prerequisite: Consent of department. Credits Arranged.

FOR 492 (WPS 492) Senior Problems in Forest Resources. Prerequisite: Consent of department. Credits Arranged.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

FOR 501 Forest Influences and Watershed Management. Prerequisite: Advanced undergraduate or graduate standing. 3(3-0) F. Study of the effects of woody vegetation on climate, water, and soil, with applications of the knowledge of forest influences to management of forest land resources, including conservation and yield of water, stabilization of streamflow and soils, reduction of sedimentation and general improvement of the environment. Maki

FOR 512 Forest Economics. Prerequisite: Basic course in economics. 3(3-0) S. Economics and social value of forests; supply of, and demands for forest products; land use; forestry as a private and a public enterprise; economics of the forest industries. Holley

FOR 571 Advanced Forest Mensuration. Prerequisites: FOR 272, ST 311. 3(2-2) S. Study of the development of mathematical models to describe forest resources phenomena; criteria for evaluating the "goodness" of such models; and methods of data collection for use in the elevation. Hafley

FOR 572 Conservation Policy Issues. Prerequisite: Advanced undergraduate or graduate standing. 3(3-0) S. Analysis of the attitudes of selected private groups and public agencies toward multiple resource development. Special attention given to forest resource policies, timber management objectives, private industry activity, recreation and multiple use, education, research, watersheds, governmental activity, interaction in international forestry affairs and the role of professional foresters in multiple use resource management. Lammi

FOR 591 Forestry Problems. Prerequisite: Advanced undergraduate or graduate standing. Credits Arranged. Assigned or selected problems in the field of silviculture, harvesting operations, lumber manufacturing, wood science, pulp and paper science, wood chemistry or forest management. Staff

FOR 599 Methods of Research in Forestry. Prerequisite: Advanced undergraduate or graduate standing. Credits Arranged. Research procedures, problem analysis, working plan preparation, interpretation and presentation of results; evaluation of selected studies by forest research organizations; techniques and constraints in the use of sample plots. Staff

FOR GRADUATES ONLY

FOR 611 (GN 611) Forest Genetics. Prerequisites: GN 411 and permission of instructor. 3(3-0) S. Application of genetic principles to silviculture, management and wood utilization. Emphasis is on variation in wild populations, the bases for selection of desirable qualities, and fundamentals of controlled breeding.
Saylor, Zobel

FOR 612 (GN 612) Advanced Topics in Quantitative Genetics. Prerequisites: GN 611 (FOR 611), GN 626 (ST 626) or GN 603 (ANS 603) or consent of instructor. 3(3-0) F. Advanced topics in statistics and population genetics pertinent to current research problems in genetics with special applications to forestry. Basic statistical and genetic theory is reviewed as bases for intensive study of selection theory and experimental and mating design evaluation. The genetics of natural populations are studied for evolutionary interest as well as for their implications to breeding theory.
Namkoong

FOR 613 Special Topics in Silviculture. Prerequisite: One course in silviculture or consent of instructor. 3(2-1) F. Critical examination of selected topics, with special emphasis on concepts and phenomena which distinguish forests from other biotic communities and silviculture from other fields of applied biology. Duffield

FOR 614 Advanced Topics in Forest Land Management. Prerequisite: FOR 405 or equivalent. 3(3-0) F. A collation of the disciplines in silvics, forest growth estimation, growing stock regulation, forest soil management and site quality evaluation, forest influences, and silviculture, with emphasis on the interrelationships of these disciplines in the management of forest land resources and the applications to forest management systems. Maki

FOR 691 (WPS 691) Graduate Seminar. Prerequisite: Graduate standing. 1(1-0) F,S. Presentation and discussion of progress reports on research, special problems and outstanding publications in forestry and related fields. Graduate Staff

FOR 692 Advanced Forest Management Problems. Prerequisite: Graduate standng. Credits Arranged. Directed studies in forest management. Graduate Staff

FOR 699 Problems and Research. Prerequisite: Graduate standing. Credits Arranged. Specific forestry problems that will furnish material for a thesis.
Graduate Staff

Genetics

GRADUATE FACULTY

Professor T. J. MANN, *Head*

Professors: D. S. GROSCH, W. D. HANSON, C. S. LEVINGS III, D. F. MATZINGER, L. E. METTLER, R. H. MOLL, T. MUKAI, B. W. SMITH, S. G. STEPHENS, A. C. TRIANTAPHYLLOU; *Professor Emeritus:* C. H. BOSTIAN; *Professor USFS:* G. NAMKOONG; *Adjunct Professor:* H. V. MALLING; *Associate Professors:* L. G. BURK (USDA), W. E. KLOOS, H. E. SCHAFFER, C. W. STUBER (USDA); *Assistant Professors:* F. M. JOHNSON, W. H. MCKENZIE

ASSOCIATE MEMBERS

Professors: J. L. Apple, F. B. Armstrong, F. D. Cochran, C. C. Cockerham, J. W. Duffield, D. A. Emery, G. J. Galletta, D. U. Gerstel, E. W. Glazener, W. C. Gregory, P. H. Harvey, F. L. Haynes Jr., T. T. Hebert, J. E. Legates, B. T. McDaniel, P. A. Miller, T. O. Perry, L. L. Phillips, N. T. Powell, J. O. Rawlings, L. C. Saylor, D. H. Timothy, E. A. Wernsman, B. J. Zobel; *USDA Professors:* C. A. Brim, J. F. Chaplin, W. A. Cope, J. A. Lee, D. L. Thompson; *Associate Professors:* E. U. Dillard, E. J. Eisen, M. M. Goodman, C. F. Murphy, O. W. Robison; *USDA Associate Professors:* G. R. Gwynn; *Associate Professor Emeritus:* W. L. Blow; *Assistant Professors:* D. M. Briggs; *USDA Assistant Professor:* C. Tester; *Visiting Assistant Professor:* P. M. Burrows

Graduate study under the direction of the genetics faculty may enable the student to qualify for the Master of Science or the Doctor of Philosophy degrees. A candidate for the Master's degree must acquire a thorough understanding of genetics and its relation to other biological disciplines and must present a thesis based upon his own research. In addition to a comprehensive knowledge of the field, a candidate for the doctorate must demonstrate capacity for independent investigation and scholarship in genetics.

At North Carolina State University there are no sharp divisions along departmental lines or between theoretical and applied aspects of genetics research. The members and associate members of the genetics faculty are located in six different departments of the School of Agriculture and Life Sciences, the School of Forest Resources and the School of Physical and Mathematical Sciences. They are studying a wide range of genetic problems and are utilizing not only the "classic" laboratory material (arabidopsis, rumex, bacteria, *Drosophila*, *Habrobracon*, and mice) but also farm animals and agricultural and forest plants of the region. A student has, therefore, a wide choice of research problems in any of the following fields: cytology and cytogenetics, microbial and biochemical genetics, physiological and developmental genetics, evolution and speciation, quantitative and population genetics, and the application of genetics to breeding methodology.

The offices and laboratories of the department are located in Gardner Hall with greenhouse facilities adjacent to the building. A genetics garden for use in the intensive research with plants and teaching functions is located three miles from the departmental offices. The departmental staff and the associate faculty members in animal science, biochemistry, crop science, horticultural science, poultry science, plant pathology, experimental statistics and the School of Forest Resources are fortunate in being able to draw upon the extensive facilities of the North Carolina Agricultural Experiment Station.

FOR ADVANCED UNDERGRADUATES

GN 411 The Principles of Genetics. Prerequisite: BS 100 (Junior standing). 3(3-0) F,S.

GN 412 Elementary Genetics Laboratory. Prerequisite or corequisite: GN 411. 1 (0-2) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

GN 504 Human Genetics. Prerequisites: GN 301 or GN 411, or the equivalent. 3 (3-0) S. Basic principles and methods of research in human genetics will be presented. Current knowledge and important areas of research will be studied. This course is intended to serve the needs of advanced undergraduates and graduates in the social and biological sciences. Bostian, McKenzie, Schaffer

GN 505 Genetics I. Prerequisite: GN 411 or its equivalent. 4(3-2) F. Part I of a course sequence designed to serve as a foundation for graduate programs in genetics. As such, a balanced and comprehensive survey of each of the major fields of genetics must be presented in integrated form. Concepts based upon family analysis and a study of individual organisms will be presented here. Coverage will include general plant and animal genetics, biochemical and microbial genetics and physiological and developmental genetics. Grosch, Kloos

GN 506 Genetics II. Prerequisite: GN 505 or consent of instructor. 4(3-2) S. This course represents the second portion of a two-semester sequence in "General Genetics", which is presented at the intermediate level and directed primarily to beginning graduate students. Emphasis is placed on the basic principles and modern concepts of cytogenetics, population genetics, and quantitative genetics. These subjects each represent about one-third of the course and are integrated with those of the first semester course as much as possible, with the primary synthesis being directed toward the dynamic aspects of evolutionary theory, including both intra- and interpopulational phenomena. Mettler, Graduate Staff

GN 508 (ANS 508) Genetics of Animal Improvement. 3(3-0) S. (See animal science, page 69.)

GN 513 Cytogenetics. Prerequisite: GN 506, or consent of instructor. 4(3-2) F. Classical and contemporary problems of chromosome structure, behavior and transmission. Euchromatin and heterochromatin. Recombination. Structural and numerical aberrations of chromosomes and the effects upon breeding systems of plants and animals. Interspecific hybridization. Polyploidy. Lectures and Laboratory. Galletta, Gerstel

GN 520 (PO 520) Poultry Breeding. 3(2-2) F. (See poultry science, page 232.)

GN 532 (ZO 532) Biological Effects of Radiations. Prerequisite: BS 100, or GN 301, or consent of instructor. 3(3-0) S. Qualitative and quantitative effects of radiations (other than the visible spectrum) on biological systems, to include both morphological and physiological aspects in a consideration of genetics, cytology, histology, and morphogenesis. Grosch

GN 540 (ZO 540) Evolution. Prerequisite: GN 411; undergraduates need consent of instructor. 3(3-0) F. The facts and theories of evolution in plants and animals. The causes and consequences of organic diversity. Smith

GN 541 (CS 541, HS 541) Plant Breeding Methods. 3(3-0) F. (See crop science, page 104.)

GN 542 (CS 542, HS 542) Plant Breeding Field Procedures. 2(0-4) Sum. (See crop science, page 104.)

GN 545 (CS 545) Origin and Evolution of Cultivated Plants. 2(2-0) S. (See crop science, page 104.)

GN 550 (ZO 550) Experimental Evolution. Prerequisite: GN 506, or consent of instructor. 3(3-0) F. A survey of studies on experimental and natural populations of plants, animals, and man in relation to the theoretical aspects of evolution and speciation; a descriptive rather than rigorous mathematical review. (Offered 1975-76 and alternate years.) Mettler

GN 561 (BCH 561, MB 561) Biochemical and Microbial Genetics. Prerequisites: BCH 351 or BCH 551, GN 411 or GN 505, MB 401 or equivalent. 3(3-0) S. The course will include the development of the fields of biochemical and microbial genetics and will emphasize both the techniques and concepts utilized in current research. Armstrong

FOR GRADUATES ONLY

GN 603 (ANS 603) Population Genetics in Animal Improvement. 3(3-0) F. (See animal science, page 70.)

GN 611 (FOR 611) Forest Genetics. 3(3-0) S. (See forestry, page 156.)

GN 612 (FOR 612) Advanced Topics in Quantitative Genetics. 3(3-0) F. (See forestry, page 156.)

GN 613 (CS 613, HS 613) Plant Breeding Theory. 3(3-0) S. (See crop science, page 104.)

GN 626 (ST 626) Statistical Concepts in Genetics. 3(3-0) S. (See statistics, page 257.)

GN 631 Mathematical Genetics. Prerequisites: GN 506, ST 511, or consent of instructor. 3(3-0) F. Mathematical models of genetic systems, including probabilistic and deterministic formulations. Theory of survival of mutations, genetic linkage and dynamics of populations. (Offered in 1974-75 and alternate years.) Schaffer

GN 633 Physiological Genetics. Prerequisite: GN 505 or equivalent. 3(3-0) S. Recent advances in physiological genetics. Attention will be directed to literature on the nature and action of genes, and to the interaction of heredity and environment in the expression of the characteristics of higher organisms. Grosch

GN 641 Colloquium in Genetics. Prerequisite: Graduate standing; consent of instructor. 2(2-0) F,S. Informal group discussion of prepared topics assigned by the instructor. Graduate Staff

GN 691 Seminar. Prerequisite: Graduate standing. 1(1-0) F,S.

GN 695 Special Problems in Genetics. Prerequisite: Advanced graduate standing, consent of instructor. 1-3 F,S. Special topics designed for additional experience and research training. Graduate Staff

GN 699 Research. Prerequisite: Graduate standing, permission of adviser. Credits Arranged. Original research related to the student's thesis problem. A maximum of six credits for the master's degree; by arrangement for the doctorate. Graduate Staff

Geology

(For a listing of graduate faculty and departmental information, see Geosciences, immediately following, page 162.)

FOR ADVANCED UNDERGRADUATES

GY 400 Environmental Geology. Prerequisites: GY 120 and senior standing. 3(2-1) F.

GY 415 Mineral Exploration and Evaluation. Prerequisites: GY 440, GY 452. 3(2-3) S.

GY 440 Igneous and Metamorphic Petrology. Prerequisite: GY 331. 4(3-3) F.

GY 452 Sedimentary Petrology. Prerequisite: GY 331. 4(3-3) S.

GY 461 Engineering Geology. Prerequisite: GY 120. 3(3-0) F.

GY 462 Geological Surveying. Prerequisite: GY 120. 3(1-5) S.

GY 465 Geological Field Procedures. Prerequisites: GY 351, GY 440, GY 462. 6 Sum.

GY 491, 492 Seminar on Selected Geologic Topics. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

GY 500 Regional Geology of North America. Prerequisites: GY 101 or 120, and senior standing. 1-6. The study, in the field, of classic geologic localities and geomorphic processes not indigenous to North Carolina. Typical areas for the field trip are New England and adjacent Canada, northern Mexico and southwestern United States, and the Pacific Northwest. Representative subjects include the Canadian Shield, Precambrian mineral deposits, the San Andreas fault, desert geomorphology, Grand Canyon stratigraphy, modern and ancient reefs, and glaciated volcanoes. Mineral, rock, and fossil collecting. Student reports required. Graduate Staff

GY 522 Petroleum Geology. Prerequisite: GY 452. 3(3-0) S. Properties, origin and modes of occurrence of petroleum and natural gas. Geologic and economic features of the principal oil and gas fields, mainly in the United States. (Offered 1975-76 and alternate years.) Leith

GY 524 Continental Evolution. Prerequisites: GY 222, GY 351, GY 440, GY 452. 3(3-0) F. Study of the stratigraphic and tectonic events which have shaped the continents with emphasis upon North America; field trips. (Offered 1974-75 and alternate years.) Welby

GY 532 Ore Microscopy. Prerequisite: GY 331. 3(0-6) F. The theory and technique of microscopic investigation of opaque ore minerals, ores and mill products produced by beneficiation of ores. Studies of compositions and textures of materials in polished surfaces are based on observations of optical and physical properties, etch reactions and microchemical tests. (Offered 1975-76 and alternate years.) Brown

GY 542 Microscopic Petrography. Prerequisite: GY 440. 3(1-4) S. Systematic study by microscopic techniques of the constitution and origin of consolidated rocks. Bartholomew

GY 545 Advanced Igneous Petrology. Prerequisite: GY 440. 3(2-2) F. Study of physico-chemical principles related to igneous petrogenesis; consideration of general principles and specific problems including the origin, differentiation and emplacement of magmas and the possible relationships of igneous processes to global tectonics. (Offered 1975-76 and alternate years.) Spence

GY 546 Advanced Metamorphic Petrology. Prerequisite: GY 440. 3(2-2) F. The petrogenesis of metamorphic rocks including factors of metamorphism, metamorphic facies concept, metamorphic facies series, contact metamorphism, regional dynamothermal metamorphism, burial metamorphism, ACF-AKF diagrams and feldspars of metamorphic rocks. (Offered 1974-75 and alternate years.) Spence

GY 552 Exploratory Geophysics. Prerequisites: GY 351, PY 208 or PY 212. 3(3-0) S. Fundamental principles underlying all geophysical methods; procedure and instruments involved in gravitational, magnetic, seismic, electrical and other methods of studying geological structures and conditions. Spontaneous potential, resistivity, radioactivity, temperature and other geophysical logging methods. Study of applications and interpretations of results. (Offered 1974-75 and alternate years.) Leith

GY 563 Applied Sedimentary Analysis. Prerequisites: GY 452, ST 361. 3(2-2) F. Extension of GY 452, with emphasis on coarser grained detrital and chemical sedimentary rocks. Sampling of sedimentary population, critical study of assumptions underlying standard measurement techniques; treatment, testing and evaluation of sedimentary data; application to problems in sedimentology. (Offered 1974-75 and alternate years.) Cavaroc

GY 564 Sedimentary Environments of Deposition. Prerequisite: GY 452 or graduate standing. 3(2-3) S. Fabric of large sedimentary basins in terms of the spatial distribution of component major rock facies; current litho-genetic models illustrating internal lithic relationships, variability and predictability; evolution of lithogenetic units; comparison with recent equivalents; field trips. Cavaroc

GY 565 Hydrogeology. Prerequisite: GY 452. 3(3-0) S. Occurrence and sources of surface and subsurface water. Relationships of surface water to subsurface water. Rock properties affecting infiltration, movement, lateral and vertical distribution, and quality of ground water. Determination of permeability, capacity, specific yield and other hydraulic characteristics of aquifers. Principles of well design, legal aspects of water supplies. (Offered 1974-75 and alternate years.) Welby

GY 567 Geochemistry. Prerequisite: CH 331 or CH 433. 3(3-0) F. The quantitative distribution of elements in the earth's crust, the hydrosphere and the atmosphere. Application of the laws of chemical equilibrium and resultant chemical reactions to natural earth systems. Geochemical application of Eh-pH diagrams. Geochemical cycles. Isotope geochemistry. (Offered 1974-75 and alternate years.) Brown

GY 581 Geomorphology. Prerequisites: GY 120 plus appropriate background. 3(2-3) F. The study of land forms and their relations to processes, stages of development, and adjustments to structure. Emphasis on mass-wasting, fluvial geomorphology of humid and arid climates, coasts, karst, and eolian processes. Lectures, map interpretations, and field trips. Carson

GY 582 Quaternary Geology. Prerequisites: GY 120, senior standing. 3(3-0) S. Glaciology, glacial geology, Pleistocene stratigraphy, periglacial geomorphology; Quaternary volcanism, tectonism, and sea-level fluctuations; late Cenozoic climate changes; field trips. (Offered 1974-75 and alternate years.) Carson

GY 583 Photogeology. Prerequisite: GY 120. 3(2-2) F. The stereoscopic study of aerial photographs to obtain geologic information. The construction of bedrock and surficial geologic maps from aerial photographs. Aspects of remote sensing useful in geologic interpretation. Carson

GY 584 (MAS 584) Marine Geology. Prerequisites: GY 452 or GY 120 plus appropriate background. 3(3-0) S. Morphology, structure and origin of ocean basins with their diverse features and their relations to the continents. Physical and chemical properties of the oceans, sedimentation in the marine environment and near-shore features. The economic potential of mineral resources derived from oceanic areas. (Offered 1975-76 and alternate years.) Welby

GY 593 Advanced Topics in Geology. Prerequisite: Consent of staff. 1-6 F,S. Special study of some advanced phases of geology. Graduate Staff

FOR GRADUATES ONLY

GY 611, 612 Advanced Economic Geology. Prerequisites: GY 440, GY 452. 3(3-0) F,S. Detailed study of the origin and occurrence of specific mineral deposits. Brown

GY 630 Geotectonics. Prerequisites: GY 351, GY 440, GY 452. 3(3-0) F. Philosophical and historical development of major geologic concepts. Concepts include: orogeny and epeirogeny; oroclines and geosynclines; plate tectonics, ocean basin development, and continental drift; magmatic cycles in orogeny; expanding and contracting earth theories, and energy sources for earth deformation. (Offered 1975-76 and alternate years.) Bartholomew

GY 695 Seminar. Prerequisite: Graduate standing. 1(1-0) F,S. Scientific articles, progress reports and special problems of interest to geologists and geological and mining engineers discussed. Graduate Staff

GY 699 Geological Research. Prerequisite: Consent of instructor. Credits Arranged. Lectures, reading assignments and reports; special work in geology to meet the needs and interests of the students. Thesis problem. Graduate Staff

Geosciences

GRADUATE FACULTY

Professor C. J. LEITH, *Head*

Professors: H. S. BROWN, E. G. DROESSLER, W. J. SAUCIER; *Professor Emeritus:* J. M. PARKER III; *Associate Professors:* N. E. HUANG, W. H. SPENCE, A. H. WEBER, C. W. WELBY; *Adjunct Associate Professor:* J. R. SMITH; *Assistant Professors:* M. J. BARTHOLOMEW, R. J. CARSON III, V. V. CAVAROC JR., C. E. KNOWLES, L. J. PIETRAFESA, G. F. WATSON; *Adjunct Assistant Professors:* W. D. BACH, J. T. PETERSON

The Department of Geosciences offers graduate programs leading to the Master of Science degree in geology and, as its input into the interdepartmental graduate program in Marine Sciences, also offers graduate and advanced undergraduate courses in meteorology and physical oceanography. The Master of Science and Doctor of Philosophy degrees in geological, meteorological, and physical oceanography are granted through the University Marine Sciences Program (page 178).

Candidates for admission to the graduate program in geology should hold a bachelor's degree in geology or a satisfactory equivalent, preferably with a strong background in physics, chemistry and mathematics. For graduate study in meteorological oceanography the required background includes chemistry, physics, mathematics, and basic knowledge of atmospheric physics and mechanics. For a graduate program in physical oceanography a bachelor's degree in one of the physical sciences or engineering with a strong background in physics and mathematics is required. In each of the three disciplines the master's degree program includes a minimum of 30 semester hours credit divided between major and minor fields, and a research thesis. The general requirements for a Ph.D. program in marine sciences are described on page 179.

Facilities are available for research in mineralogy, petrology, hydrogeology, economic geology, engineering geology, meteorology, physical oceanography and geophysical fluid dynamics. Excellent collections of geoscience literature are available in the University library and elsewhere in the Research Triangle area. Consultations with scientists of the federal and state agencies in Raleigh as well as with the staffs of the neighboring universities are encouraged.

Financial aid is available through laboratory teaching assistantships and assistantships on faculty research projects. Government agencies and industrial concerns provide part-time employment from time to time. Small grants from the state sometimes are available to help with thesis expenses.

Guidance and Personnel Services

(For a listing of graduate faculty and departmental information, see Guidance and Personnel Services under Education, page 117.)

History

GRADUATE FACULTY

Professor B. WISHY, *Head*

Professor M. S. DOWNS, *Assistant Head*

Professors: B. F. BEERS, M. L. BROWN JR., R. W. GREENLAW, DORIS E. KING, S. NOBLIN; *Associate Professors:* R. N. ELLIOTT, W. C. HARRIS, J. P. HOBBS, J. M. RIDDLE, S. SUVAL, MARY E. WHEELER; *Adjunct Associate Professor:* T. W. MITCHELL; *Assistant Professors:* C. H. CARLTON, C. W. HARPER JR., R. H. SACK, EDITH DUDLEY SYLLA

The history department offers a program leading to the Master of Arts degree in history. Although no specific courses are stipulated for admission to the program, preference will be given to those students with at least 18 hours in history and a total of 30 hours in the social sciences. Candidates are expected to have taken the Aptitude portion of the Graduate Record Examination, or if admitted provisionally must do so before the end of their first semester. It is helpful if candidates will forward a brief statement of their objective in entering the program along with their application.

Normally a degree candidate will concentrate work in either European or American history with the required total of 30 hours being made up of nine to twelve hours of course work at the 500 level or above; six hours of research seminar (600 level); up to six hours of research and preparation of thesis (600 level); and six to nine hours of course work in a field related to the candidate's area of concentration (500 or 600 level). Under special circumstances a candidate may be permitted to include a 400-level course in one's program if it has particular relevance to one's program objectives.

Candidates concentrating in American history have the advantage of the source materials available nearby at the State Department of History amd Archives. It should be noted that a candidate's degree program can include a two-semester sequence in the history and administration of archives, a field in which there is considerable demand for well-trained people at this time. For master's candidates interested in teaching in the public schools, the education and other courses required for the state certificate are available, but inclusion of these will in most cases extend the time needed for the degree to three or four semesters.

Although no fellowships are offered at this time, some limited financial assistance is available. Inquiry should be addressed to the head of the department, 161 Harrelson Hall.

FOR ADVANCED UNDERGRADUATES

NOTE: Prerequisite: (400 level) Three hours of history unless otherwise noted.

HI 400 Civilization of the Ancient Near East. 3(3-0)

HI 403 Ancient Greek Civilization. 3(3-0)

HI 404 Rome to 180 A.D. 3(3-0)

HI 406 From Roman Empire to Middle Ages. 3(3-0)

HI 410 Italian Renaissance. 3(3-0)

HI 411 The Protestant and Catholic Reformation of the Sixteenth Century. 3(3-0)

HI 414 The Age of Absolutism. 3(3-0)

HI 415 Revolutionary Europe. 3(3-0)

HI 418 Fascism in Germany and Italy, 1919-1945. 3(3-0)

HI 425 Tudor and Stuart England. 3(3-0)

HI 428 England in the Age of the American Revolution. 3(3-0)

HI 429 Twentieth Century Britain. 3(3-0)

HI 430 France Since the Revolution. 3(3-0)

HI 432 Germany Since 1848. 3(3-0)

HI 435 A Century of Nationalism: East-Central Europe, 1848-1948. 3(3-0)

HI 438 History of Russia to 1881. 3(3-0)

HI 439 History of Russia Since 1881. 3(3-0)

HI 442 United States: Revolution to Constitution. 3(3-0)

HI 443 The Age of Jefferson. 3(3-0)

HI 444 The Age of Jackson, 1815-1850. 3(3-0)

HI 446 Civil War and Reconstruction. 3(3-0)

HI 448 Populism and Progressivism. 3(3-0)

HI 452 Recent America. 3(3-0)

HI 454 U. S. Foreign Relations. 3(3-0)

HI 458 Significant Figures in 20th Century America. 3(3-0)

HI 461 Civilization of the Old South. 3(3-0)

HI 463 North Carolina to 1860. 3(3-0)

HI 464 North Carolina Since 1860. 3(3-0)

HI 467 Modern Mexico. 3(3-0)

HI 469 Twentieth-Century Latin American Revolutions. 3(3-0)

HI 471 Revolutionary China. 3(3-0)

HI 472 Modern Japan, 1850 to Present. 3(3-0)

HI 473 20th Century Asian Revolutionaries. 3(3-0)

HI 477 British Empire and Commonwealth. 3(3-0)

HI 492 Seminar in History. Required of all history majors. Open to other seniors and graduate students with departmental permission. 3(3-0) F,S. Staff

HI 498 Special Topics in History. 1-6

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NOTE: Prerequisite: (500 level) Six hours of advanced history or equivalent.

HI 515 The High Middle Ages. 3(3-0) An analysis of various aspects of medieval culture. Selected topics such as the revival of the Roman Empire, monastic and papal reform, the rise of universities, the evolution of representative bodies, the Gothic style, troubadour and goliardic poetry, scholasticism, and the revival of Roman law will be examined using source readings. Research techniques will also be discussed. Riddle

HI 530 Era of the French Revolution and Napoleon. 3(3-0) An examination of aspects of the French Revolution and the Napoleonic era which are currently subject to differing interpretations. Greenlaw

HI 532 History of Great Britain, 1820-1914. 3(3-0) A history of Great Britain from the Regency of George IV to the outbreak of World War I with special emphasis on studies in depth of the most significant developments in constitutional, religious, and economic ideas and institutions. Downs

HI 536 History of International Relations Since 1870. 3(3-0) A study of European diplomatic history and of the larger area of world international relations from the Franco-Prussian war through both World Wars up to the present. Emphasis on policies and attempts to solve international problems. Brown

HI 545 The American Civil War. 3(3-0) The course traces and analyzes events that led to the disruption of the union and provides an intensive study of the war, with emphasis upon its nonmilitary aspects. Only the major military campaigns are discussed. Harris

HI 546 Reconstruction of the American Union. 3(3-0) This course is an in-depth study of the difficulties involved in the restoration and readjustment of American society after the Civil War. Special attention is given to social and economical conditions in the defeated South, military reconstruction and Republican ascendacy in the region. Harris

HI 548 The American Response to Industrialism. 3(3-0) Focuses on the industrialization of the American economy and on efforts to deal with the ensuing transformation of American life through politics, social institutions and ideas. Noblin

HI 551 History and Principles of the Administration of Archives and Manuscripts. 3(3-0) F. A study of the nature, importance and use of original manuscript resources; the history and evolution of written records, and the institutions administering them. Mitchell

HI 552 Application of Principles of Administration of Archives and Manuscripts. Prerequisite: HI 551. 3(3-0) S. Internship training in the application of the principles and practices of archival management. Mitchell

HI 561 U. S. Far Eastern Relations. 3(3-0) A study of American expansion into the Pacific and involvement in Asian affairs. Both official diplomatic relations and unofficial contacts (by missionaries, educators, businessmen, and the like) which influenced Americans, are examined. Beers

HI 565 The History of Urban Life in the U.S., 1607-1865. 3(3-0) The history of urban life in the United States, 1607-1865. This course is designed primarily to give the student an understanding of the historical background of today's urban problems. King

HI 566 The History of Urban Life in the U.S., 1865-Present. 3(3-0) The history of urban life in the United States, from 1865 to present. This course is designed primarily to give the student an understanding of the historical background of today's urban problems. King

HI 572 History of Soviet Russia Since 1930. 3(3-0) Analysis of the domestic and foreign policies of the Soviet Union since 1930 with special emphasis on the position of the Soviet Union in the world since 1945. Wheeler

HI 598 Special Topics in History. 1-6 F,S. An investigation of topics of particular interest to advanced students under the direction of faculty members on a tutorial basis. Staff

FOR GRADUATES ONLY

NOTE: Prerequisite: (600 level) Six hours of advanced history or equivalent.

HI 601 Historiography and Historical Method. 3(3-0) F. A study of the major steps in the development of historical investigation and writing from classical times to the present, as well as an analysis of the elements of good historical research and writing with some discussion of methodology used by the contemporary scholarly historian. Graduate Staff

HI 602 Seminar in American History. 3(3-0) S. A small research seminar on special topics in American history. Graduate Staff

HI 604 Seminar in European History. 3(3-0) S. A small research seminar on special topics in European history. Graduate Staff

HI 606 Seminar in Diplomatic History. 3(3-0) S. A small research seminar on topics in diplomatic history. Brown

HI 699 Research in History. Credits Arranged, 1-6. Individual research under graduate thesis supervisor. Graduate Staff

Horticultural Science

GRADUATE FACULTY

Professor: _____,* *Head*

Professors: W. E. Ballinger, F. D. Cochran, F. E. Correll, G. J. Galletta, F. L. Haynes Jr., R. A. Larson, C. H. Miller, P. V. Nelson; *Research Professor:* D. T. Pope; *Extension Professors:* J. W. Love, W. A. Skroch; *Professor (USDA):* L. J. Kushman; *Adjunct Professor:* R. L. Sawyer; *Associate Professors:* T. F. Cannon, R. G. Halfacre, W. R. Henderson, T. R. Konsler, R. L. Lower, T. J. Monaco, W. B. Nesbitt, C. R. Unrath, D. C. Zeiger;

* Head to be named.

Extension Associate Professor: C. M. MAINLAND; *Assistant Professors:* L. K. HAMMETT, D. M. PHARR; *Extension Assistant Professor:* D. C. SANDERS

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: R. AYCOCK, R. J. DOWNS, R. H. MOLL, T. J. SHEETS, R. J. VOLK

Graduate study under the direction of the Horticultural Science faculty may lead to the Master of Science and the Doctor of Philosophy degrees. Areas of study include plant physiology, plant breeding and genetics, post-harvest physiology, plant nutrition, growth regulators, and weed science. The Master of Agriculture, a professional degree, can be earned by substituting additional course work for research requirements of graduate study.

Facilities for graduate studies include a 41,400 square foot greenhouse (21 sections, each with separately-controlled light and temperature); the Phytotron (available for controlled environment studies on horticultural crops); 18 well-equipped laboratories (seven analytical, one chromatography, one soil-testing, one seed handling and storage, three cytological/anatomical, one radioisotope, one tissue culture, one postharvest handling, and one landscape); 14 controlled-temperature storage rooms; an extensive collection of plant materials; and a variety of climates and soils from coast to mountains in North Carolina on 10 outlying research stations.

Opportunities for employment after graduate study include teaching and research faculty positions in state and private universities; research and regulatory positions with the United States Department of Agriculture, both foreign and domestic; extension specialists and county agents; research, production and promotional work with agri-business, concerned with production of horticultural crops or services to horticultural industries.

Graduate teaching and research assistantships (commercial, NDEA, Agricultural Foundation, or Experiment Station) for promising students are available. Students are encouraged to apply for assistantships at least six months prior to the anticipated enrollment date.

FOR ADVANCED UNDERGRADUATES

HS 411 Nursery Management. Prerequisites: BS 100, SSC 200. 3(2-3) F.

HS 414 Residential Landscaping. Prerequisites: SSC 200, HS 211, HS 212. 4(2-6) F.

HS 421 Fruit Production. Prerequisites: BS 100, SSC 200. 3(2-3) F.

HS 432 Vegetable Production. Prerequisites: BS 100, SSC 200. 3(2-3) F.

HS 441 Floriculture I. Prerequisites: BS 100, SSC 200. 3(2-3) F.

HS 442 Floriculture II. Prerequisites: BS 100, SSC 200. 3(2-3) S.

HS 471 Arboriculture. Prerequisites: BS 100, SSC 200. 3(2-3) S.

HS 491 Senior Seminar in Horticultural Science. Prerequisite: Consent of department. 1(1-0) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

HS 514 (CS 514) Principles and Methods in Weed Science. Prerequisite: CS 414 or equivalent. 3(2-2) S. Studies on the losses caused by weeds, the ecology of weeds, biological control, basic concepts of weed management, herbicide-crop relationships and herbicide development. Introduction to greenhouse and bioassay techniques used in herbicide work and to field research techniques supplemented by laboratory and field exercises. Monaco

HS 521 (FS 521) Food Preservation. 3(2-3) F. (See food science, page 153.)

HS 541 (CS 541, GN 541) Plant Breeding Methods. 3(3-0) F. (See crop science, page 104.)

HS 542 (CS 542, GN 542) Plant Breeding Field Procedures. 2(0-4) Sum. (See crop science, page 104.)

HS 552 Growth of Horticultural Plants. Prerequisite: BO 421. 3(2-3) F. Exercises in tissue culture principles and techniques as they relate to horticulture. Emphasis on endogenous controls of plant growth and the role of growth regulating compounds in horticultural research and production. Graduate Staff

HS 562 (FS 562) Postharvest Physiology. Prerequisite: BO 421. 3(3-0) S. A study of chemical and physiological changes that occur during handling, transportation and storage which affect the quality of horticultural crops. Consideration will be given to preharvest and postharvest conditions which influence these changes.
Graduate Staff

HS 599 Research Principles. Prerequisite: Permission of instructor. Credits Arranged, Maximum 6. Investigation of a problem in horticulture under the direction of the instructor. The students obtain practice in experimental techniques and procedures, critical review of literature and scientific writing. The problem may last one or two semesters. Credits will be determined by the nature of the problem, not to exceed a total of three hours for any one problem. A written report and final oral exam required for completion of course.
Graduate Staff

FOR GRADUATES ONLY

HS 613 (CS 613, GN 613) Plant Breeding Theory. 3(3-0) S. (See crop science, page 104.)

HS 614 (CS 614, SSC 614) Herbicide Behavior in Plants and Soils. 3(3-0) F. (See crop science, page 105.)

HS 621 Methods and Evaluation of Horticultural Research. Prerequisite: Graduate standing. 3(3-0) F. Critical study and evaluation of technical writings and research presentation, research design and evaluation, photography, and basic electronics related to horticultural research. Graduate Staff

HS 622 Mineral Nutrition in Plants. Prerequisites: BO 551, BO 552. 3(2-3) S. A comprehensive study of the functional roles of nutrients essential to plant growth, their interrelationships and their mode of influence on quality indices of horticultural crops. Considerations of the complexity of mineral nutrition experimentation and evaluation of results. Recent developments in nutrient sources. A detailed look at the establishment and application of foliar analysis, foliar fertilization, and the nutrient uptake process in plants. (Offered 1974-75 and alternate years.)
Nelson

HS 691 Seminar. Prerequisites: Graduate standing. Required of all horticultural science graduate students. 1(1-0) F,S. Presentation of scientific articles and special lectures. Students will be required to present one or more papers. Graduate Staff

HS 699 Research. Prerequisites: Graduate standing in horticulture, consent of advisory committee chairman. Credits Arranged. A maximum of six credits is allowed toward the Master of Science degree; no limitation on credits in doctoral program. Original research on specific problems in fruit, vegetable and ornamental crops. Graduate Staff

Industrial Engineering

GRADUATE FACULTY

Professor W. A. SMITH JR., *Head*

Professors: C. A. ANDERSON, J. R. CANADA, R. G. CARSON JR., S. E. ELMAGHRABY, R. W. LLEWELLYN, R. G. PEARSON; *Associate Professors:* R. E. ALVAREZ, R. H. BERNHARD, J. J. HARDER, A. M. KAMAL, H. L. W. NUTTLE, A. L. PRAK, S. M. SOLIDAY; *Assistant Professors:* G. E. BENNINGTON, M. J. MAGAZINE; *Visiting Assistant Professor:* M. A. AYOUB

Industrial engineering is concerned with solutions to problems relating to design and control of organizational systems, such as industrial and commercial corporations, government agencies, and other institutions which provide goods or services for public consumption. Interests include the management of operations, planning and scheduling, manufacturing engineering, allocation of resources, dynamic system design, man-machine relationships and occupational safety and health.

The department offers the degrees of Master of Industrial Engineering, Master of Science and Doctor of Philosophy. The focal points of study are quantitative decision-making, human factors and work systems design. Typical minors are taken in statistics, economics, mathematics, psychology, and other engineering disciplines.

The thesis work for the Master of Science degree may account for as many as six semester hours. No thesis is required for the MIE degree. A departmental brochure is available, which details the orientation and requirements for all degrees. No foreign language is required at the master's level and a foreign language is optional with the student's advisory committee at the doctoral level.

The University provides access to an outstanding computer capability (the IBM System/370, Model 165 with a Model 40 remote terminal on campus and several conveniently located input terminals). Facilities for human factors research are also excellent for the study of environmental factors, biomechanics and work physiology, and performance assessment display systems evaluation.

FOR ADVANCED UNDERGRADUATES

IE 401 Industrial Engineering Analysis I. Prerequisites: IE 361, MA 405. 3(3-0) F,S.

IE 402 Industrial Engineering Analysis II. Prerequisite: IE 401. 3(3-0) F.

IE 403 Industrial Engineering Analysis III. Prerequisite: IE 401. 3(3-0) S.

IE 408 Production Control. Prerequisites: IE 361, IE 401. 3(3-0) S.

IE 421 Data Processing and Production Control Systems. Prerequisites: IE 352, CSC 111. 3(3-0) S.

IE 453 Operations Planning and Plant Layout. Prerequisite: IE 352. 3(2-3) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

IE 505 (MA 505, OR 505) Mathematical Programming I. Prerequisite: MA 405. 3(3-0) F,Sum. A study of mathematical methods applied to problems of planning. Linear programming will be covered in detail. This course is intended for those who desire to study this subject in depth and detail. It provides a rigorous and complete development of the theoretical and computational aspects of this technique as well as a discussion of a number of applications. Graduate Staff

IE 509 (OR 509) Dynamic Programming. Prerequisites: MA 405, ST 421. 3(3-0) S,Sum. An introduction to the theory and computational aspects of dynamic programming and its application to sequential decision problems.
Nuttle, Elmaghraby

IE 511 Advanced Engineering Project Analysis. Prerequisites: IE 311, ST 421. 3(3-0) F. Analysis of project economy models with certainty assumed, advantages and limitations of models, effects of income tax and depreciation methods. Risk analyses employing probability concepts, sensitivity studies and measures of utility. Estimation techniques and use of accounting information, time series analysis and judgment factors. Planning and uses of capital funds. Bernhard, Canada

IE 515 Process Engineering. Prerequisites: IE 328, IE 443. 3(3-0) F. The technical process of translating product design into a manufacturing program. The application of industrial engineering in the layout, tooling, methods, standards, costs and control functions of manufacturing. Laboratory problems covering producer and consumer products. Harder

IE 517 Automatic Processes. Prerequisites: IE 328, IE 443. 3(3-0) S. Principles and methods for automatic processing. The design of product, process and controls. Economic, physical and sociological effects of automation. Harder

IE 521 Control Systems and Data Processing. Prerequisite: IE 421. 3(3-0) S. This course presents the problems and techniques required for systematic control of the production process and the business enterprise. This includes the determination of control factors, the collection and recording of data, and the processing, evaluation and use of data. The course will illustrate the applications and use of data processing equipment and information machines in industrial processes. Case problems will be used extensively. Llewellyn

IE 522 (OR 522) Dynamics of Industrial Systems. Prerequisite: IE 421. 3(3-0) F. A study of the dynamic properties of industrial systems; introduction to servomechanism theory as applied to company operations. Simulation of large nonlinear, multiloop, stochastic systems on a digital computer; methods of determining modification in systems design and/or operating parameters for improved system behavior. Llewellyn

IE 523 Inventory Control Methods I. Prerequisites: ST 421, ST 515, OR 501. 3(3-0) S. A study of inventory policy with respect to reorder sizes, minimum points and production schedules. Simple inventory models, models with restrictions, price breaks, price changes, analysis of slow-moving inventories. Introduction to the smoothing problems in continuous manufacturing. Applications of linear and dynamic programming. Alvarez

IE 540 (PSY 540) Human Factors in Systems Design. Prerequisites: IE 338 (PSY 338) or IE 354; Corequisites: ST 507 or ST 515. 3(3-0) F. Introduction to problems of the systems development cycle, including man-machine function allocation, military specifications, display-control compatibility, the personnel subsystem concept and maintainability design. Detailed treatment is given to man as an information processing mechanism. Pearson

IE 541 Research Methods in Accident Study. Prerequisites: IE 338 (PSY 338), ST 421. 3(2-2) F. Consideration of the methods used in accident-injury study, including field investigation, experimental engineering and biomedical research, statistical studies and computer simulation. Ayoub

IE 542 Physiological Criteria in Work Measurement. Prerequisite: Graduate status. 3(3-0) F. Emphasis is placed on basic endocrine and autonomic nervous system anatomy and physiology; measures reflecting sympathetic nervous system activity; concepts applicable to work measurement studies including a discussion of arousal theory and the concept of autonomic balance; and survey of current literature on equipment design and use. (Offered in alternate years.) Ayoub

IE 544 Occupational Biomechanics. Prerequisite: Graduate standing in engineering. 3(2-2) F. General concepts and techniques of understanding the anatomical and physiological bases of human motion. Characteristics and limitations of human motor capabilities, body mechanics, and use of biomedical instrumentation for monitoring and quantifying human performance. Applications of biomechanics in work, industry, rehabilitation, sports, space research and safety are also considered. (To be offered in alternate years.) Ayoub

IE 546 Advanced Quality Control. Prerequisites: IE 353, ST 421. 3(3-0) S. The statistical foundations of quality control are emphasized as well as its economic implications. Mathematical derivations of most of the formulas used are given. Sampling techniques are treated extensively and many applications of this powerful technique are explained. Graduate Staff

IE 547 Engineering Reliability. Prerequisites: IE 353, ST 421. 3(3-0) F. The methodology of reliability including application of discrete and continuous distribution models and statistical designs; reliability estimation, reliability structure models, reliability demonstration and decision, and reliability growth models. Example of reliability evaluation and demonstration programs. Magazine

IE 561 (OR 561) Queues and Stochastic Service Systems. Prerequisite: MA 421. 3(3-0) F. General concepts of stochastic processes are introduced. Poisson processes, Markov processes and renewal theory are presented. These are then used in the analysis of queues, starting with a completely memoryless queue to one with general parameters. Applications to many engineering problems will be considered. Magazine

IE 586 (OR 586) Network Flows. Prerequisite: IE 505 (OR 505, MA 505) or equivalent. 3(3-0) S. This course will study problems of flows in networks. These problems will include the determination of the shortest chain, maximal flow and minimal cost flow in networks. The relationship between network flows and linear

programming will be developed as well as problems with nonlinear cost functions, multicommodity flows and the problem of network synthesis. (Offered in alternate years.) Bennington

IE 591 Project Work. Prerequisite: Graduate or senior standing. 2-6. Investigation and report on an assigned problem for students enrolled in the fifth-year curriculum in industrial engineering. Graduate Staff

FOR GRADUATES ONLY

IE 608 Linear Programming Applications. Prerequisite: IE 505 (MA 505, OR 505) or EC 555. 3(3-0) S. The application of linear programming to large problems of a practical nature; product mix, diet, scheduling and blending problems; problem generation, control of accuracy, report generation. Stress is laid on post-optimal studies, multiple-objective functions and right-hand sides; parametric programming on the right hand side, the objective function, the rim and the interior. Decomposition of various types of problems will receive considerable attention with extensions into some nonlinear systems. (Offered in alternate years.) Bennington

IE 611 The Design of Production Systems. Prerequisites: IE 505 (MA 505, OR 505), OR 501. 3(3-0) F. The study of production systems: the model, the criterion, decision making and optimization, levels of decision. The graphic representation of systems: signal flow graphs, activity analysis, networks of flow models. The machine assignment problem, scheduling and sequencing, line balancing location-allocation of new facilities. The use of computers in the design of production systems. (Offered in alternate years.) Elmaghraby

IE 622 Inventory Control Methods II. Prerequisite: IE 523. 3(3-0) F. A continuation of IE 523; stochastic inventory systems of lot sized-reorder type; periodic review and single period models. Application of dynamic programming theory to deterministic and stochastic cases. Nuttle

IE 640 (PSY 640) Skilled Operator Performance. Prerequisites: PSY 545, ST 507, or ST 515. 3(3-0) S. Theories of the human operator are considered with regard to the classical problems of monitoring, vigilance and tracking. Factors such as biological rhythm. Sleep loss, sensory restriction, environmental stress and time-sharing are considered as they interact with and determine overall systems efficiency. (Offered in alternate years.) Pearson

IE 641 Environmental Factors and Human Performance. Prerequisites: IE 540 (PSY 540) and IE 542 or other equivalent. 3(3-0) S. Study of major problem areas, methodology, theory and experimental work in biotechnology; interaction among engineering, biological and behavioral factors in design for safety and survival; physiology and biomechanics of acceleration, deceleration and pressure altitude; consideration of operator effectiveness in submarine, extraterrestrial, arctic and desert environments; techniques in evaluation of crash dynamics and pathology; closed-ecological systems. (Offered in alternate years.) Pearson, Ayoub

IE 651 Special Studies in Industrial Engineering. Prerequisite: Graduate standing. Credits Arranged. The purpose of this course is to allow individual students or small groups of students to undertake studies of special areas in industrial engineering which fit into their particular program and which may not be covered by existing industrial engineering graduate level courses. The work would be directed by a qualified staff member who has particular interest in the area covered by the problem. Such problems may require individual research and initiative in the application of industrial engineering training to new areas or fields.

Graduate Staff

IE 692 (OR 692, MA 692) Special Topics in Mathematical Programming. Prerequisite: IE 505 (MA 505, OR 505). 3(3-0) F,S,Sum. The study of special advanced topics in the area of mathematical programming. New techniques and current research in this area will be discussed. The faculty responsible for this course will select the areas to be covered during the semester according to their preference and interest. This course will not necessarily be taught by an individual faculty member but can, on occasion, be a joint effort of several faculty members from this University as well as visiting faculty from other institutions. To date, a course on Theory of Networks and another on Integer Programming have been offered under the umbrella of this course. It is anticipated that these two topics will be repeated in the future together with other topics. Graduate Staff

IE 693 Seminar in Systems Safety Engineering. Prerequisites: IE 540 (PSY 540), ST 515. 1(1-0) S. Discussion of contemporary issues involving the systems approach to accident prevention and injury control. History of safety research; federal health, industrial and military activities in safety; current centers of safety research and their activity. Pearson, Ayoub

IE 694 Advanced Problems in Human Factors Engineering. Prerequisites: IE 540 (PSY 540), ST 515. 3(3-0) F,S,Sum. Exploration in depth of a problem area of contemporary interest involving the man-machine-environment interface. Class discussion and analysis of research and theory, with special focus on the human factors aspects of systems design and operation. Pearson, Ayoub

IE 695 Seminar. 1(1-0) F,S. Seminar discussion of industrial engineering problems for graduate students. Case analyses and reports. Elmaghraby, Magazine

IE 699 Industrial Engineering Research. Credits Arranged F,S,Sum. Graduate research in industrial engineering for thesis credit. Graduate Staff

Industrial and Technical Education
Industrial Arts Education

(For a listing of graduate faculty and departmental information, see Industrial and Technical Education and Industrial Arts Education both under Education, pages 118, 119.)

International Development

Professor JACKSON RIGNEY, *Dean*

There is no question that America's need for trained personnel for service in foreign countries will increase greatly during the coming years. The world is moving inexorably toward greater interchange of people and greater volume of commerce between nations, and the number of Americans going abroad each year for business and pleasure is increasing at a fantastic rate. This growing interchange among nations requires the services of skilled persons in all walks of life, but they must be persons who have the capability to move and work effectively between our culture and others. The demand is heavy for persons who are well qualified in a particular profession or discipline and who also have language and cultural background in other parts of the world.

The degree of Master of Technology in International Development is offered to train students with the above background and interest.

The degree of Master of Technology in International Development is designed to give an international orientation and perspective to the master's degree that is sought in any of the scientific and professional fields represented at this University. It is designed to provide specialized training for students who are interested in utilizing their skills in international activities, whether technical, consultative or administrative in character. It is also available to foreign students who are training for leadership roles in their own country.

A wide selection of courses is available relating to the developmental, cultural and political aspects of Europe, Latin America and Asia. A number of seminars in different schools relating to international development are conducted each year and they are available to this program. The modern language department has one of the most complete language laboratories in the area and can use all phases of audio-aural-visual instruction in developing language competence.

Application for admission to the Graduate School to pursue studies leading to the Master of Technology in International Development is processed through the office of the Graduate Dean and the respective department in which the major course work will be taken.

Requirements for admission are the same as for the Master of Science degree; namely, the applicant must have a bachelor's degree from a college or university that is recognized as standard by a regional or general accrediting agency, and the student must have at least a "B" grade average in his undergraduate major.

The program of work for this degree includes the following:

1. A total of 36 semester credits is required, not less than half of which must be in the field of the undergraduate major or closely related areas. The remainder stresses course work providing special orientation and training that prepares the student for accepting technical, consulting or administrative responsibilities. In the area of the minor, 12 semester credits may be drawn from courses at the 300 and 400 levels, of which no more than six credits may be taken from the 300 level.
2. A minimum field experience of 12 weeks in a foreign country, or for foreign students, equivalent field experience in this country that is closely related to his major (no formal credit allowed toward the degree).
3. A report on the field experience will replace the research thesis requirement of the Master of Science degree.
4. Conversational facility in one language (no formal credit allowed toward the degree).

In all other respects the requirements are the same as for the Master of Science degree. For further information contact the Office of International Programs, 209 Daniels Hall.

Landscape Architecture

GRADUATE FACULTY

Professor R. R. WILKINSON, *Head*

Professors: J. H. COX, C. E. MCKINNEY, T. O. PERRY, D. R. STUART, E. G. THUR-

LOW; *Visiting Associate Professors:* D. H. ENSIGN, W. G. ROBERTS; *Assistant Professors:* R. T. HESTER JR., J. PORTER

The program leading to the Master of Landscape Architecture degree provides a structure for students to explore the complexity of changing environmental situations and develop more comprehensive techniques in analysis and synthesis. The program requires four semesters of academic work built around a core of four workshops comprising 18 semester hours. As a means to focus workshop activity on a common matrix, an area of North Carolina with complex environmental problems will serve as a laboratory, comprising a complex of public and private activity to both observe and engage in the process of physical change.

A series of professional electives are required to study the existing methods and techniques of environmental design. These courses function to integrate the many unrelated approaches to environmental manipulation and design.

There are electives in the basic sciences that support effective employment of each student's program. These courses may be elected in any of three universities in the Triangle area: North Carolina State University, Duke, or University of North Carolina at Chapel Hill. These afford an opportunity for the student to gain a structured insight to another discipline and be conversant with its methodology and content.

The degree requirement, in addition to the 48 hours of academic work, is a seminar delivered in the terminal semester that relates the methods of environmental design to a student's elective path. Constraints posed by the program are the requirements that the student develop his worked examples within the laboratory area and that he focus both design skills and supporting knowledge on the final worked example.

Students will be admitted to the program from a variety of disciplines to ensure an adequate mixture of student involvements.

Design Core—This series of workshops treats the region as a group of related systems. The sequence of problems begins with simple congruencies and evolves to a complete synthesis of environmental systems in the terminal case study. Courses included in this section are LAR 503, LAR 504, LAR 603 and LAR 604.

Analytical and Integrative Core—This series of courses relates regional landscape design to other design professions and the information sources supporting large-scale design activities.

The courses, LAR 521 and LAR 611, represent a commitment on the part of the landscape architecture faculty to the environmental design and planning disciplines in general. The integrative core courses are not specifically required of the LAR graduate student but can be elected with consent of one's adviser as part of the 12 hours required for this phase of the program. Other courses presently existing within established programs at the Raleigh and Chapel Hill campuses can be elected to meet the students' particular needs.

Minor Programs—This series of electives in areas of study provides a critical information source. Students will elect courses in these areas under the direction of

their minor adviser. Counseling will be conducted by the associated faculty, and students will be expected to demonstrate a level of proficiency comparable to others developing academic minors in these areas.

FOR ADVANCED UNDERGRADUATES

LAR 400 Intermediate Landscape Architecture Design (Series). Prerequisite: DN 202 or equivalent or consent of department. 4(1-9) F,S.

LAR 411, 412 Landscape Technology. Prerequisite: Junior standing. 3(1-6) F,S.

LAR 491 Special Projects in Landscape Architecture. Prerequisites: Senior standing and 3.0 G.P.A. 2-4 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

LAR 503 Regional Design Workshop I. Prerequisite: Graduate standing. 3(0-9) F,S. Study of current literature in regional design and planning with emphasis on extracting a number of premises, theoretical structures and information handling techniques as a basis for seminar discussions and activities.

LAR 504 Regional Design Workshop II. Prerequisite: Graduate standing. 3(0-9) F,S. Case study projects designed to explore the relationship between the resource base and the development intentions with the purpose of evolving clear statements of problems involved and their susceptibility to solution problem situations will be developed from differing viewpoints and levels of complexity.

LAR 512 Physical Systems. Prerequisite: Consent of instructor. 3(2-2) S. Analysis of physical systems and methods of determining relationships between systems with particular reference to natural systems, managed resource systems, development systems and their relationship to development objectives.

LAR 521 Introduction to Regional Design. Prerequisite: Consent of instructor. 3(2-2) F. A perspective of the measures man has taken to ensure his relation to the general environment. Ecologic determinism, economic and political functionalism and aesthetic movements will be developed in an historical context.

LAR 591, 592 Special Projects. Prerequisite: Graduate standing. 4(2-6) F,S. Student-evolved projects with emphasis on utilization and expansion of technical processes and techniques to reinforce design solutions. Introduction and investigation of experimental methodology. Development of student-evolved interest in specific areas. Open to graduate students in related fields. Evaluation of nonmajors based on contributions of their discipline to group effort.

FOR GRADUATES ONLY

LAR 603 Regional Design III. Prerequisites: LAR 503, LAR 504. 3(0-9) F. Course will be directed at a synthesis of information handling methods and environmental design theory within an institutional context. The procedure will be to clarify environmental problems, generate alternative solutions to problems, illustrate the physical implications of alternatives and evaluate the alternative on the basis of their capacity to be implemented through established institutions and agencies. The course will be structured around existing situations which have the capacity to be abstracted into prototypical situations.

LAR 604 Regional Design IV. Prerequisites: LAR 503, LAR 504, LAR 603. 3-6 S. Terminal project for regional design degree students. Projects will be selected and developed by individual students under the direction of major and minor professors.

LAR 611 Physical Design Policy. Prerequisite: LAR 503 and consent of instructor. 3(2-2) F,S. Course will be directed at a detailed examination of public policy regarding control of the physical environment. Emphasis will be focused on policies which are directed at control of land use, such as road, utilities, water, etc. and their relationship to policies regarding less tangible commodities such as public health, education, recreation, etc.

LAR 691 Degree Seminar. Prerequisites: LAR 503, LAR 504, LAR 603; Corequisite: LAR 604. 0. Each student in his terminal semester and in conjunction with his terminal case study will prepare and submit to his committee a presentation on the relevance of his minor to the design process with particular reference to his case study.

Marine Sciences

GRADUATE FACULTY

Professor L. J. LANGFELDER, *Chairman*

Professors: M. AMEIN, A. W. COOPER, B. J. COPELAND, J. A. EDWARDS, W. W. HASSLER, J. E. HOBBIE, C. J. LEITH, I. S. LONGMUIR, W. J. SAUCIER, J. C. WILLIAMS III; *Associate Professors:* N. E. HUANG, L. H. ROYSTER, F. Y. SORRELL, N. B. WEBB, A. H. WEBER, C. W. WELBY; *Adjunct Associate Professor:* J. R. SMITH; *Assistant Professors:* J. DAGGERHART, C. E. KNOWLES, J. L. MACHEMEHL, L. J. PIETRAFESA, T. WOLCOTT

The oceans are perhaps man's last great frontier on earth. Further understanding of the oceans and effective utilization of their resources depends upon a thorough knowledge of the geography of the sea and its logistics, the mineral resources of the sea and their extraction, the biological resources of the sea and their utilization, ocean pollution, and deep sea and coastal engineering. North Carolina is richly endowed with marine environments and resources. The state has over 300 miles of shoreline which enclose about 2,500 square miles of shallow sounds and associated habitats. In addition, an extensive continental shelf and proximity to the Gulf Stream and cold northern waters make for rich and varied opportunities for the study of marine science.

The curriculum in marine sciences brings together the faculties and facilities of both the University of North Carolina at Chapel Hill and North Carolina State University to offer broad graduate training in the various areas of marine sciences. The program gives students a wide choice of faculty advisers, marine science courses and potential research projects. Departments on the North Carolina State campus involved in this curriculum include biochemistry, biological and agricultural engineering, botany, chemical engineering, chemistry, civil engineering, economics, engineering mechanics, food science, genetics, geosciences, mechanical and areospace engineering, microbiology, physics, soil science and zoology.

A variety of facilities are available to students wishing to do research in marine sciences. North Carolina State University has the Pamlico Marine Laboratory at Aurora and another lab at Hatteras administered by the Department of Zoology. The Harbor Island Marine Science Center at Wrightsville Beach is available for use as a field research station. Students may also use the facilities of the Institute of Marine Science of the University of North Carolina at Chapel Hill and the Bureau of Commercial Fisheries Lab at Beaufort. Individuals with special interests in coastal engineering and protection, coastal geology and coastal ecology may participate in the research of members of the North Carolina Research Program.

For admission to the curriculum in marine sciences, an undergraduate degree is required in a basic science such as bacteriology, biology, botany, chemistry, engineering, geology, physics or zoology. A graduate student may choose to major in marine sciences or he may major in a field represented by a regular department and minor in marine sciences. A major in marine sciences is normally expected to be familiar with other areas of marine sciences in addition to the area in which one specializes. In order to provide for some breadth within the program, physical oceanography, biological oceanography, geological oceanography, chemical oceanography, and meteorological oceanography have been designated as core areas. It is normally expected that the graduate student will take two or more of these courses outside the area of specialization. Requirements for the minor, the thesis, the language, admission to candidacy, residence and final examinations are as specified in the regulations of the Graduate School.

MAS 471 (MAE 471) Undersea Vehicle Design. 3(3-0) S. (See mechanical and areospace engineering, page 194.)

MAS 487 (CE 487, OY 487) Physical Oceanography. 3(3-0) S. (See physical oceanography, page 214.)

MAS 529 (ZO 529) Biological Oceanography. 3(3-0) S. (See zoology, page 278.)

MAS 541 (OY 541, CE 541) Gravity Wave Theory I. 3(3-0) S. (See physical oceanography, page 214.)

MAS 551 (OY 551) Ocean Circulation. 3(3-0) S. (See physical oceanography, page 214.)

MAS 581 (CE 581) Introduction to Oceanographic Engineering. 3(3-0) F. (See civil engineering, page 97.)

MAS 584 (GY 584) Marine Geology. 3(3-0) S. (See geology, page 162.)

MAS 591, 592 Marine Sciences Seminar. 1(1-0) S. A seminar designed to give perspective in the field of marine science. Topics vary from semester to semester. In order to obtain credit a student must deliver a seminar.

MAS 601, 602 (OY 601, 602) Advanced Physical Oceanography I, II. 3(3-0) F,S. (See physical oceanography, page 214.)

MAS 605, 606 (OY 605, 606; EM 605, 606) Advanced Geophysical Fluid Mechanics I, II. 3(3-0) F,S. (See physical oceanography, page 214.)

MAS 613, 614 (OY 613, 614; EM 613, 614) Perturbation Method in Fluid Mechanics I, II. 3(3-0) F,S. (See physical oceanography, page 214.)

MAS 693 Special Topics in Marine Sciences. Prerequisites: Graduate standing and consent of staff. 1-3. This course will provide the opportunity for advanced graduate students to study in special problem areas in marine sciences. Various areas in the program may use this course concurrently in their areas.

MAS 699 (OY 699) Research in Physical Oceanography. Credits Arranged. F,S. (See physical oceanography, page 214.)

UNC-CH MAS 101 General Oceanography. 3(3-0) F. A study of the seas and their processes.

UNC-CH MAS 105 (ESE 128) Chemical Oceanography. 3(3-0) S. A variation and abundance of sea water constituents. The chemical, physical and biological processes contributing to the distribution and problems of dispersion of conservative and nonconservative substances are considered.

RECOMMENDED COURSES IN PARTICIPATING DEPARTMENTS

Biological Marine Science

BO 360 (ZO 360) Introduction to Ecology
BO 560 (ZO 560) Principles of Ecology
BO 574 (MB 574) Phycology
MB 401 General Microbiology
ZO 420 Fishery Science
ZO 441 Ichthyology
ZO 515 Growth and Reproduction of Fishes
ZO 517 Population Ecology
ZO 519 Limnology
ZO 619 Advanced Limnology
ZO 621 Fishery Science

Geological Marine Science

GY 452 Sedimentary Petrology
GY 552 Exploratory Geophysics
GY 563 Applied Sedimentary Analysis
GY 564 Sedimentary Environments of Deposition
GY 567 Geochemistry
SSC 553 Soil Mineralogy

Physical Marine Science

CE 517 Water Transportation
CE 548, 549 Engineering Properties of Soils I, II
CE 641, 642 Advanced Soil Mechanics
EM 504 Mechanics of Ideal Fluids
EM 505 Mechanics of Viscous Fluids I
EM 612 Mechanics of Viscous Fluids II
MAE 651 Principles of Fluid Motion

Materials Engineering

GRADUATE FACULTY

Professor W. W. AUSTIN, *Head*

Professors: J. R. BEELER JR., R. B. BENSON JR., A. A. FAHMY, J. K. MAGOR, C. R. MANNING JR., K. L. MOAZED; *Research Professors:* H. PALMOUR III, H. H. STADELMAIER, R. F. STOOPS; *Professor Emeritus:* W. W. KRIEGEL; *Adjunct Professor:* H. M. DAVIS; *Associate Professors:* J. V. HAMME, G. O. HARRELL; *Adjunct Associate Professor:* G. MAYER; *Assistant Professor:* R. F. DAVIS; *Adjunct Assistant Professor:* J. C. HURT

The Department of Materials Engineering offers graduate programs leading to the degrees of Master of Science and Doctor of Philosophy. Graduate courses in materials science and engineering are also offered for the benefit of students majoring in other areas who may wish to obtain a minor in materials fields.

Financial assistance is available to qualified graduate students in materials engineering. Graduate assistantships permit half-time studies toward advanced degrees, and half time to be devoted to teaching or research. Sponsored fellowships and traineeships that permit full-time graduate study are available on a competitive basis. Applications should be made to the department.

During the past decade rapid developments in aerospace, electronics and nuclear technologies, and an array of societal problems and their attendant materials problems have resulted in increased emphasis on graduate study and research on the fundamental properties and behavior of materials, as well as on applications-oriented research.

Graduate programs in materials engineering are highly flexible. The department refrains from establishing a rigidly formalized sequence of courses for advanced degree candidates and recognizes flexibility as of utmost importance regardless of the candidate's prior specialization. Emphasis may be placed upon fundamental research or upon the application of basic concepts in materials science to various engineering and societal problems.

Therefore, the programs of study for graduate students majoring in materials are determined by the candidate in consultation with his adviser and graduate committee, and depend on the background and the needs of the candidate.

The departmental faculty is strong in metallurgical engineering and ceramic engineering. A cooperative program with the Department of Chemical Engineering provides for graduate study and research in polymeric materials.

FOR ADVANCED UNDERGRADUATES

MAT 401 Materials Processing. Prerequisites: MAT 301, MAT 450, MAT 412. 3 (3-0).

MAT 411, 412 Physical Principles in Materials Science I, II. Prerequisites: (411) MAT 201; (412) MAT 411. 3(3-0).

MAT 417 Ceramic Subsystem Design. Prerequisite: MAT 312. 3(2-3).

MAT 423, 424 Materials Factors in Design I, II. Prerequisites: (423) MAT 450; (424) MAT 423; Corequisites: (423) MAT 431. (423) 3(3-0), (424) 3(3-0).

MAT 431, 432 Physical Metallurgy I, II. Prerequisites: (431) MAT 412; (432) MAT 431. 3(3-0).

MAT 435, 436 Physical Ceramics I, II. Prerequisites: (435) MAT 412; (436) MAT 435. (435) 3(3-0), (436) 3(2-3).

MAT 437 Introduction to the Vitreous State. Prerequisite: MAT 301. 3(3-0).

MAT 450 Mechanical Properties of Materials. Prerequisite: MAT 201 and EM 205. 3(3-0).

MAT 491 Materials Engineering Seminar. Prerequisite: Senior standing. 1(1-0).

MAT 493, 494 Ceramic Field Exercises I, II. Prerequisite: Senior standing. 1(0-3).

MAT 495 Materials Engineering Projects. Prerequisite: Junior or senior standing. Credits Arranged, 1-3.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MAT 500 Modern Concepts in Materials Science. Prerequisite: MAT 412. 3(3-0) F. Applications of current theories of materials such as crystal theory, continuum and quasi-continuum theories, phenomenological theories, etc., to the solution of materials problems.

MAT 503 Ceramic Microscopy. Prerequisite: GY 331. 3(2-3) F. Transmitted and reflected light techniques for the systematic study of ceramic materials and products.

MAT 509 High Vacuum Technology. Prerequisite: CH 433 or MAE 301. 3(2-3) S. Properties of low-pressure gases and vapors. Production, maintenance and measurement of high vacuum; design, construction and operation of high vacuum, high temperature facilities. Properties and reactions of materials which are processed, tested and/or utilized in high vacuum environments.

MAT 510 Structure of Crystalline Materials. Prerequisite: MAT 411; Corequisite: MAT 500. 3(3-0) F. The lattice structure of crystals, including group theory applications, reciprocal lattice concept and the study of crystal structure as related to bonding.

MAT 520 Theory and Structure of Materials. Prerequisite: MAT 510. 3(3-0) F. Structure of liquids, and crystalline and amorphous solids used in engineering systems. Crystallinity and thermal properties. Ionic crystals in ceramic systems. The metallic state and alloy behavior. Emphasis is placed on the relation between fundamental materials parameters and engineering properties.

MAT 527 Refractories in Service. Prerequisite: MAT 411. 3(3-0) S. A study of the physical and chemical properties of the more important refractories in respect to their environment in industrial and laboratory furnaces.

MAT 529 Properties of High Temperature Materials. Prerequisite: MAT 201. 3 (3-0) S. Effects of temperature on the physical, mechanical and chemical properties

of inorganic materials; relationships between microstructure and high temperature properties; applications of ceramics, metals and composites at elevated temperatures.

MAT 530 Phase Transformation in Materials I. Corequisite: MAT 500. 3(3-0) F. Kinetic theory of transformations, nucleation theory, homogeneous and heterogeneous nucleation, growth of crystals, epitaxial thin films.

MAT 533, 534 Advanced Ceramic Engineering Design I, II. Prerequisite: MAT 417. 3(2-3) F,S. Advanced studies in analysis and design of ceramic products, processes and systems leading to original solutions of current industrial problems and the development of new concepts of manufacturing.

MAT 540 Glass Technology. Prerequisite: MAT 437. 3(3-0) F. Fundamentals of glass manufacture including compositions, properties and application of the principal types of commercial glasses.

MAT 541, 542 Principles of Corrosion I, II. Prerequisite: MAT 431 or CH 431. 3 (2-3) F,S. The fundamentals of metallic corrosion and passivity. The electro-chemical nature of corrosive attack, basic forms of corrosion, corrosion rate factors, methods of corrosion protection. Laboratory work included.

MAT 550 Dislocation Theory. Prerequisite: MAT 450. 3(3-0) F. Structure, energetics, stress and strain fields, interactions and motion of dislocations in solids.

MAT 556 Composite Materials. Prerequisite: MAT 450. 3(3-0) F. Basic principles underlying the properties of composite materials as related to properties of the individual constituents and their interaction. Emphasis is placed on the design of composite systems to yield desired combinations of properties.

MAT 562 (NE 562) Materials Problems in Nuclear Engineering. Prerequisite: PY 410 or consent of instructor. 3(3-0) F. Reactor component design considerations determined by materials properties as well as by nuclear function are covered. Emphasis is placed on radiation effects and other concepts pertinent to the selection of materials for nuclear reactors for either terrestrial or space applications.

MAT 573 (NE 573) Computer Experiments in Materials Engineering. Prerequisites: PY 407, MA 301. 3(3-0) F. The basic techniques for constructing both statistical (Monte Carlo) and deterministic computer experiments are explained and discussed from the standpoint of immediate use in the solution of current engineering research and development problems.

MAT 595 Advanced Materials Experiments. Prerequisite: MAT. 411. Credits Arranged, 1-3. Advanced engineering principles applied to a specific experimental project dealing with materials. A seminar period is provided and a written report is required.

FOR GRADUATES ONLY

MAT 601 Ceramic Phase Relationships. Prerequisite: Consent of instructor. 3 (3-0) S. Heterogeneous equilibrium phase transformations, dissociation, fusion, lattice energy, defect structure, thermodynamic properties of ionic phases and silicate melts.

MAT 603 Advanced Ceramic Reaction Kinetics. Prerequisite: MAT 510. 3(3-0) S. Fundamental study of the kinetics of high temperature ceramic reactions such as

diffusion, nucleation, grain growth, recrystallization, phase transformation, vitrification and sintering.

MAT 610 X-ray Diffraction. Prerequisite: MAT 510. 3(3-0) F. The properties and scattering behavior of X-rays by electrons, ions and atoms. Theory and applications of X-ray diffraction techniques such as Laue back reflection, the rotating crystal and powder methods, texture studies and residual stress analysis.

MAT 615 Electron Microscopy. Prerequisites: MAT 550, MAT 610. 3(3-0) F. Theory of imaging and diffraction of electrons. Analysis of structures using electron microscopy.

MAT 621 Theory and Structure of Amorphous Materials. Prerequisite: MAT 520. 3(3-0) S. Bond types and structure of amorphous solids, relations of bond types and structure to flow mechanisms, electrical, optical and thermal properties.

MAT 622 Theory and Structure of Ceramic Materials. Prerequisite: MAT 520. 3 (3-0) F. Electrical and optical properties of non-conducting materials, ferro-electric behavior and materials parameters, magnetic properties of non-metallics, semi-conducting materials.

MAT 623 Theory and Structure of Metallic Materials. Prerequisite: MAT 520. 3 (3-0) F. The metallic state, its atomic and electronic structure. Electron theory of metals and alloys. Advanced methods of determining electronic structure in metallic materials.

MAT 630 Phase Transformation in Materials II. Prerequisites: MAT 510, MAT 530, MAT 550. 3(3-0) F. Formal theories of solid-solid transformations, transformation mechanisms, transformation morphologies.

MAT 631, 632 Advanced Physical Ceramics I, II. Corequisites: MAT 510, 610 or MAT 530, 630 or EM 501, 502 or PY 503, 552. 3(2-3) F,S. Lattice structures and lattice energies in crystalline ceramics; relationships with elastic, optical and thermal properties. Effects of constitution and microstructure on lattice-sensitive properties. The defect crystalline state in ceramics; vacancies, color centers; dislocations, boundaries. Crystal growth. Plastic deformation processes, including creep and fatigue; the ductile-brittle transition. Structure-sensitive properties of crystalline, vitreous and composite ceramics; effects of constitution, microstructure and nonstoichiometry.

MAT 633 Advanced Mechanical Properties of Materials. Prerequisite: MAT 630. 3(3-0) F. The theories of yield strength, work hardening, creep, fracture, and fatigue of crystalline materials will be developed in terms of dislocation theory.

MAT 661 Diffraction Theory. Prerequisite: MAT 610. 3(3-0) F. The diffraction of light, X-rays, electrons and neutrons by matter is represented in Fourier space, and the known methods of generating the Fourier transform (usually atomic structure) are reviewed. Exploration, by high and low angle scattering techniques, of crystals, paracrystals, liquids, polydispersed aggregates, and fibers is treated. The feasibility of direct analysis by convolution integrals is studied.

MAT 691, 692 Special Topics in Materials Engineering. Prerequisite: Graduate standing. Credits Arranged, 1-3. Special studies of advanced topics in materials engineering.

MAT 695 Materials Engineering Seminar. 1(1-0) F,S. Reports and discussion of special topics in materials engineering and allied fields.

MAT 699 Materials Engineering Research. Credits Arranged. Independent investigation of an appropriate research problem. A report on this investigation is required as a graduate thesis.

Mathematics

GRADUATE FACULTY

Professor N. J. Rose, *Head*

Professors: J. W. Bishir, E. E. Burniston, J. M. A. Danby, W. J. Harrington, K. Koh, J. Levine, P. E. Lewis, J. Luh, H. M. Nahikian, P. A. Nickel, H. V. Park, H. Sagan, H. E. Speece, R. A. Struble, H. R. Van der Vaart, O. Wesler, L. S. Winton; *Professor Emeritus:* R. C. Bullock; *Associate Professors:* R. E. Chandler—*Graduate Administrator*, W. G. Dotson Jr., R. O. Fulp, J. E. Huneycutt Jr., J. R. Kolb, J. A. Marlin, C. D. Meyer, E. L. Stitzinger, J. B. Wilson; *Assistant Professors:* S. L. Campbell, H. J. Charlton, D. E. Garoutte, R. Gellar, D. J. Hansen, R. E. Hartwig, R. H. Martin Jr., L. B. Page, C. V. Pao, R. T. Ramsay, J. A. Roulier, R. Silber, J. L. Sox Jr., D. F. Ullrich, W. M. Waters Jr.

The Mathematics Department offers programs leading to the degrees of Master of Science and Doctor of Philosophy with a major in either Mathematics or Applied Mathematics.

Applicants for admission should have an undergraduate degree in mathematics or its equivalent. This should include a year of mathematical analysis (or advanced calculus) and a year of modern algebra, including linear algebra. All applicants are requested to take the Graduate Record Examination including the Advanced Test in Mathematics.

A number of teaching assistantships are available. A student carrying a half-time assistantship is allowed to carry a course load of nine semester hours.

The requirements for the Master of Science degree include 30-33 semester hours of approved credits and a comprehensive examination. A masters thesis is optional. Foreign languages are not required for the Masters Degree.

There is no prescribed minimum number of courses for the degree of Doctor of Philosophy. Normally a student will take approximately 60 semester hours of course credits including certain core courses in algebra, analysis, topology and applied mathematics. Independent reading and participation in seminars constitute an indispensable part of the doctoral program.

All doctoral students are required to have a reading knowledge of two modern foreign languages or a knowledge in depth of one. Comprehensive examinations are also required. These consist of a written examination designed to test basic knowledge of algebra, analysis, topology and applied mathematics, and an oral examination on material related to the field of proposed thesis work.

The heart of the doctoral program is the dissertation. It must be original research resulting in a significant contribution in some area of mathematics or its applica-

tions and should be worthy of publication in the current literature. The doctoral dissertation must be defended at the final oral examination.

A detailed statement of requirements for graduate degrees is available on request from the graduate administrator.

FOR ADVANCED UNDERGRADUATES

MA 401 Applied Differential Equations II. Prerequisite: MA 301 or MA 312. 3 (3-0) F,S

MA 403 Introduction to Modern Algebra. Prerequisite: One year of calculus. 3 (3-0) F,S.

MA 404 Affine and Projective Geometry. Prerequisites: MA 231 and MA 403. 3 (3-0) S.

MA 405 Introduction to Matrices and Linear Transformations. Prerequisite: One year of calculus. 3(3-0) F,S.

MA 408 Foundations of Euclidean Geometry. Prerequisite: MA 403. 3(3-0) F.

MA 410 Theory of Numbers. Prerequisite: One year of calculus. 3(3-0) S.

MA 421 Introduction to Probability. Prerequisite: One year of calculus. 3(3-0) F, S.

MA 425 Mathematical Analysis I. Prerequisite: MA 232. 3(3-0) F,S.

MA 426 Mathematical Analysis II. Prerequisite: MA 425. 3(3-0) F,S.

MA 430 Introduction to Applied Mathematics. Prerequisites: MA 426, MA 421, or MA 214. 3(3-0) S.

MA 433 History of Mathematics. Prerequisite: One year of calculus. 3(3-0) S.

MA 491 Reading in Honors Mathematics. Prerequisites: Membership in honors program, consent of department. 2-6 F,S.

MA 493 Special Topics in Mathematics. Prerequisite: Consent of department. 1-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MA 504 (NE 504) Mathematical Methods in Engineering. Prerequisite: MA 301 or MA 312. 3(3-0) F. Survey of mathematical methods for engineers. Topics include ordinary differential equations, matrices, partial differential equations, difference equations, numerical methods, elements of statistics. Techniques and applications to engineering are stressed. This course cannot be taken for credit by mathematics majors.

MA 505 (IE 505, OR 505) Mathematical Programming I. 3(3-0) F,Sum. (See industrial engineering, page 171.)

MA 511 Advanced Calculus I. Prerequisite: MA 301 or MA 312. 3(3-0) F,S. Fundamental theorems on continuous functions; convergence theory of sequences, series and integrals; the Riemann integral.

MA 512 Advanced Calculus II. Prerequisite: MA 301 or MA 312. 3(3-0) F,S. General theorems of partial differentiation; implicit function theorems; vector calculus in 3-space; line and surface integrals; classical integral theorems.

MA 513 Introduction to Complex Variables. Prerequisite: MA 511 or MA 425. 3 (3-0) F,S. Operations with complex numbers, derivatives, analytic functions, integrals, definitions and properties of elementary functions, multivalued functions, power series, residue theory and applications, conformal mapping.

MA 514 Methods of Applied Mathematics. Prerequisite: MA 511 or MA 425. 3 (3-0) S. Introduction to integral equations, the calculus of variations and difference equations.

MA 515 Linear Functional Analysis I. Prerequisite: MA 426. 3(3-0) F. Metric Spaces; Lebesgue measure and integration; L^p and 1^p spaces; Riesz-Fischer and Riesz representation theorems; normed linear spaces and Hilbert spaces.

MA 516 Linear Functional Analysis II. Prerequisite: MA 515. 3(3-0) S. Basic theorems in Banach spaces, dual spaces, weak topologies; basic theorems in Hilbert spaces, and detailed theory of linear operators on Hilbert spaces; spectral theorem for self-adjoint completely continuous linear operators.

MA 517 Introduction to Topology. Prerequisite: MA 426. 3(3-0) F,S. Sets and functions, metric spaces, topological spaces, compactness, separation, connectedness.

MA 518 Calculus on Manifolds. Prerequisite: MA 426. 3(3-0) S. Calculus of several variables from a modern viewpoint. Differential and integral calculus of several variables, vector functions, integration on manifolds, Stoke's and Green's theorems, vector analysis.

MA 520 Linear Algebra. Prerequisite: MA 231 or MA 405. 3(3-0) F. Vector spaces, linear mappings and matrices, determinants, inner product spaces, bilinear and quadratic forms, canonical forms, spectral theorem.

MA 521 Fundamentals of Modern Algebra. Prerequisites: MA 403 and MA 520. 3 (3-0) S. Groups, normal subgroups, quotient groups, Cayley's theorem, Sylow's theorem. Rings, ideals and quotient rings, polynomial rings. Fields, extension fields, elements of Galois theory.

MA 523 Topics in Applied Mathematics. Corequisites: MA 515, MA 520. 3(3-0) F. Formulation of scientific problems in mathematical terms, interpretation and evaluation of the mathematical analysis of the resulting models. The course will discuss problems in behavioral and biological sciences as well as problems in mechanics of discrete and continuous systems. Some discussion of optimization and the calculus of variations.

MA 524 Mathematical Methods in the Physical Sciences I. Prerequisites: MA 405, MA 512. 3(3-0) F. Green's functions and two-point boundary value problems; elementary theory of distributions; generalized Green's functions. Finite and infinite dimensional inner product spaces; Hilbert spaces; completely continuous operators; integral equations; the Fredholm alternative; eigenfunction expansions; applications to potential theory. Nonsingular and singular Sturm-Lioville problems; Weil's theorem.

MA 525 Mathematical Methods in the Physical Sciences II. Prerequisite: MA 524. 3(3-0) S. Distribution theory in n-space; Fourier transforms; partial differential equations, generalized solutions, fundamental solutions, Cauchy problem, wave and heat equations, well-set problems. Laplace's equation, the Dirichlet and Neumann problems, integral equations of potential theory, Green's functions, eigenfunction expansions.

MA 527 (CSC 527) Numerical Analysis I. Prerequisites: CSC 101 or CSC 111, MA 301 or MA 312, and MA 231 or MA 405. 3(3-0) F,S. Theory of interpolation, numerical integration, iterative solutions of non-linear equations, numerical integration of ordinary differential equations, matrix inversion and solution of simultaneous linear equations.

MA 528 (CSC 528) Numerical Analysis II. Prerequisite: MA 527 (CSC 527). 3 (3-0) F,S. Least squares data approximation, expansions in terms of orthogonal functions, Gaussian quadrature, economization of series, minimax approximations, Pade approximations, eigenvalues of matrices.

MA 532 Theory of Ordinary Differential Equations. Prerequisites: MA 301 or MA 312, MA 405, advanced calculus. 3(3-0) S. Existence and uniqueness theorems, systems of linear equations, fundamental matrices, matrix exponential, series solutions, regular singular point; plane autonomous systems, stability theory.

MA 536 Logic for Digital Computers. Prerequisite: MA 405. 3(3-0) F. Introduction to symbolic logic and Boolean algebra; finite state-valued calculus and its application to combinational networks; sequential finite-state machines and their mathematical formulation; analysis and synthesis problems of sequential machines.

MA 537 Mathematical Theory of Digital Computers. Prerequisite: MA 536. 3(3-0) S. The sequential machine and its characteristic semigroup; micro-programmed computers; general purpose computers and special-purpose computers; Turing machine and infinite-state machines; nondeterministic switching system and probabilistic automata.

MA 541 (ST 541) Theory of Probability I. Prerequisite: MA 425 or MA 511. 3 (3-0) F. Axioms, combinatorial analysis, conditional probability, independence, random variables, expectation, special discrete and continuous distributions, probability and moment generating functions, central limit theorem, laws of large numbers, branching processes, recurrent events, random walk.

MA 542 (ST 542) Theory of Probability II. Prerequisites: MA 405, MA 541. 3 (3-0) S. Markov chains and Markov processes, Poisson process, birth and death processes, queuing theory, renewal theory, stationary processes, Brownian motion.

MA 545 Set Theory and Foundations of Mathematics. Prerequisite: MA 403. 3 (3-0) S. Logic and the axiomatic approach, the Zermelo-Fraenkel axioms and other systems, algebra of sets and order relations, equivalents of the Axiom of Choice, one-to-one correspondences, cardinal and ordinal numbers, the Continuum Hypothesis.

MA 555 (PY 555) Mathematical Introduction to Celestial Mechanics. Prerequisite: One year of advanced calculus. 3(3-0) F. Central orbits, N-body problem, 3-body problem, Hamilton-Jacobi theory, Perturbation theory, applications to motion of celestial bodies.

MA 556 (PY 556) Orbital Mechanics. Prerequisites: MA 301, MA 405, knowledge of elementary mechanics and computer programming. 3(3-0) S. Keplerian motion,

interative solutions, numerical integration, differential corrections and space navigation, elements of probability, least squares, sequential estimation, Kalman filter.

MA 571 (BMA 571, ST 571) Biomathematics I. 3(3-0) F. (See biomathematics, page 80.)

MA 572 (BMA 572, ST 572) Biomathematics II. 3(3-0) S. (See biomathematics, page 80.)

MA 581 Special Topics. Prerequisite: Consent of department. 1-6 F,S.

FOR GRADUATES ONLY

MA 600 Advanced Differential Equations I. Prerequisites: MA 513, MA 518, MA 520. 3(3-0) F. Analytical theory of ordinary differential equations, stability theory, perturbations, asymptotic behavior, nonlinear oscillations.

MA 601 Advanced Differential Equations II. Prerequisite: MA 600. 3(3-0) S. Qualitative theory of ordinary differential equations, general properties of dynamical systems, limit sets, integral invariants, global theory.

MA 602 Partial Differential Equations I. Prerequisites: MA 426, MA 520, MA 532 or MA 600. 3(3-0) F. First order equations, initial value problems; theory of characteristics; existence and uniqueness theorems; hyperbolic equations.

MA 603 Partial Differential Equations II. Prerequisite: MA 602. 3(3-0) S. Elliptic and parabolic equations; approximation methods; generalized solutions.

MA 604 Topology. Prerequisites: MA 515, MA 520. 3(3-0) S. Topological spaces: separation axioms, compactness, connectedness, local topological properties; continuous mappings, and convergence; product and quotient spaces; compactification; homotopy equivalence of mappings, fundamental groups, covering spaces, universal coverings, deck transformations.

MA 605 Homology and Manifolds. Prerequisite: MA 604. 3(3-0) F. Homology; either simplicial or singular theory, excision theorem, homotopy theorem, Mayer-Vietroris theorem and computation of groups, topology and geometry of differentiable manifolds, vector fields, Lie derivations, and differential equations; smooth partiations of unity, integration, differential forms and Stokes theorem; the DeRham cohomology and the DeRham theorem.

MA 606 (ST 606, OR 606) Mathematical Programming II. 3(3-0) S. (See statistics, page 256.)

MA 611 Analytic Function Theory I. Prerequisite: MA 426. 3(3-0) F,S. A rigorous introduction to the theory of functions of a complex variable. The complex plane, functions, Möbius transformations, the exponential and logarithmic functions, trigonometric functions, infinite series, integration in the complex plane, Cauchy's theorem and its consequences.

MA 612 Analytic Function Theory II. Prerequisite: MA 611. 3(3-0) F,S. A continuation of MA 611. Taylor and Laurent series, the residue theorem, the argument principle, harmonic functions and the Dirichlet problem, analytic continuation and the monodromy theorem, entire and meromorphic functions, the Weierstrass product representation and the Mittag-Leffler partial fraction representation, special functions, conformal mapping and the Picard theorem.

MA 613 Techniques of Complex Analysis. Prerequisite: MA 513 or MA 611. 3 (3-0) S. A course dealing with the applications of complex analysis to mathematical problems in physical science in the setting of the potential equation and other partial differential equations: contour integrals, special functions of mathematical physics from the line integral point of view, solution of problems in potential theory, asymptotic methods including WKB, and Wiener-Hopf techniques.

MA 615 Theory of Functions of a Real Variable. Prerequisité: MA 517. 3(3-0) S. Real functions, semicontinuity, upper and lower limits, sequences; Lebesgue measure and integration, absolute continuity and differentiation.

MA 617 (ST 617) Measure Theory and Advanced Probability. 3(3-0) F. (See statistics, page 256.)

MA 618 (ST 618) Measure Theory and Advanced Probability. 3(3-0) S. (See statistics, page 256.)

MA 619 (ST 619) Topics in Advanced Probability. 3(3-0) Sum. (See statistics, page 256.)

MA 620 Modern Algebra I. Prerequisite: MA 521. 3(3-0) F. A study of groups, rings and modules. Elements of homology. Polynomials, Noetherian rings, Algebraic extensions, Galois Theory.

MA 621 Modern Algebra II. Prerequisite: MA 620. 3(3-0) S. A study of linear maps, bilinear forms, representations, multilinear products, semisimplicity and the representation of finite groups.

MA 622 Linear Transformations and Matrix Theory. Prerequisite: MA 405. 3(3-0) F. Vector spaces, linear transformation and matrices, minimal polynomials, elementary divisors, canonical forms, quadratic forms, functions of matrices.

MA 623 Theory of Matrices and Applications. Prerequisite: MA 622. 3(3-0) S. Generalized inverses, matrix equations, variational methods for eigenvalues, matrix norms, perturbation of linear systems, computational methods, applications to differential equations, Markov chains.

MA 626 Algebraic Topology. Prerequisite: MA 605. 3(3-0) S. Simplicial and singular homology and cohomology, the Eilenberg-Steenrod axioms, duality, cohomology operations; higher homotopy groups, Hurewicz homomorphisms.

MA 628 General Topology. Prerequisite: MA 604. 3(3-0) F. Comparisons of topologies on function spaces; Ascoli Theorems; Stone-Weierstrass Theorems; uniform spaces and completions; paracompactness and partitions of unity; an introduction to a special topic such as topological vector spaces or topological groups.

MA 632 Operational Mathematics I. Prerequisite: MA 513 or MA 611. 3(3-0) F. Laplace transform with theory and application to ordinary and partial differential equations arising from problems in engineering and physics.

MA 633 Operational Mathematics II. Prerequisite: MA 632. 3(3-0) S. Extended development of the Laplace and Fourier transforms and their application to the solution of ordinary and partial differential equations, integral equations and difference equations; Z-transforms, other infinite and finite transforms and their applications.

MA 634 Theory of Distributions. Prerequisite: MA 632 or consent of instructor. 3 (3-0) F. Basic definitions and properties of testing functions and distributions in one or more variables, convergence and calculus of distributions, test functions of rapid descent and distributions of slow growth, convolution, Fourier transforms, applications in the area of differential and difference equations, etc.

MA 635 Numerical Analysis III. Prerequisites: MA 405, MA 528 (CSC 528). 3 (3-0) S. Topics in advanced numerical analysis such as approximation and evaluation of functions, numerical solution of integral and other operator equations, and numerical solutions of boundary value problems for partial differential equations. Particular attention is given to procedures suitable for implementation on a digital computer, and the computer is used for the solution of selected problems.

MA 637 Differentiable Manifolds. Prerequisites: MA 405, MA 521; Corequisite: MA 604. 3(3-0) F. An introduction to the topology and geometry of differentiable manifolds. Multilinear algebra, exterior differential forms, differentiable manifolds, theory of connexions, Riemannian manifolds.

MA 641 Calculus of Variations and Theory of Optimal Control I. Prerequisites: MA 512 or MA 426, MA 532. 3(3-0) F. Normed linear function spaces and Frechet differential, theory of the first variation, theory of fields and Weierstrass' excess function, Hamilton-Jacobi theory and dynamic programming, terminal control problems and the maximum principle.

MA 642 Calculus of Variations and Theory of Optimal Control II. Prerequisite: MA 641. 3(3-0) S. The homogeneous problem, the general control problem of Mayer, isoperimetric problems, theory of the second variation, existence of extrema, direct methods of the calculus of variations.

MA 647 Functional Analysis I. Prerequisite: MA 516. 3(3-0) F. Banach spaces; linear functionals; linear operators, uniform boundedness, open mapping and closed graph theorems; dual spaces; weak topologies.

MA 648 Functional Analysis II. Prerequisite: MA 647. 3(3-0) S. Advanced topics in functional analysis such as linear topological spaces; Banach algebra, spectral theory and abstract measure theory and integration.

MA 655 (PY 655) Qualitative Methods in Celestial Mechanics. Prerequisites: MA 532, MA 513. 3(3-0) F. Transformation theory in Lagrangian and Hamiltonian mechanics, singularities in N-body problem, regularization, Hill's equation, periodic orbits, fixed point methods, stability.

MA 656 (PY 656) Perturbation Theory in Celestial Mechanics. Prerequisites: MA 555 (PY 555) or MA 532 and PY 503. 3(3-0) S. Hamilton-Jacobi equation; canonical perturbation theory; resonance problems; adiabatic invariants, asymptotic properties.

MA 661 Differential Geometry and Tensor Analysis I. Prerequisite: MA 426 or MA 512. 3(3-0) F. Concepts of classical and modern differential geometry presented from the point of view of tensor analysis and differential forms. Topics to include: theory of curves, tensor analysis and differential forms, intrinsic and extrinic geometry of surfaces, Riemannian geometry.

MA 662 Differential Geometry and Tensor Analysis II. Prerequisite: MA 661. 3 (3-0) S. Continuation of MA 661.

MA 681 Special Topics in Real Analysis. 1-6.

MA 682 Special Topics in Complex Analysis. 1-6.

MA 683 Special Topics in Algebra. 1-6.

MA 684 Special Topics in Combinatorial Analysis. 1-6.

MA 685 Special Topics in Numerical Analysis. 1-6.

MA 686 Special Topics in Topology. 1-6.

MA 687 Special Topics in Geometry. 1-6.

MA 688 Special Topics in Differential Equations. 1-6.

MA 689 Special Topics in Applied Mathematics. 1-6.

The subject matter in the special topics courses varies from year to year. The topics and instructors are announced well in advance by the department.

MA 692 (IE 692, OR 692) Special Topics in Mathematical Programming. 3(3-0) F,S,Sum. (See industrial engineering, page 174.)

MA 699 Research. Credits Arranged. Individual research in mathematics.

Mathematics and Science Education

(For a listing of graduate faculty and complete departmental description, see Education, page 120.)

Mechanical and Aerospace Engineering

GRADUATE FACULTY

Professor C. F. Zorowski, *Head*

Professor J. C. Williams III, *Associate Head*

Professors: J. A. Bailey, R. F. Barrett, F. R. DeJarnette—*Graduate Administrator*, B. H. Garcia Jr., F. J. Hale, F. D. Hart, H. A. Hassan, R. B. Knight, M. N. Ozisik, J. N. Perkins, F. O. Smetana, J. K. Whitfield, J. Woodburn; *Professor Emeriti:* N. W. Conner, J. S. Doolittle; *Adjunct Professors:* R. W. Graham, E. A. Saibel, J. E. Sunderland; *Associate Professors:* E. M. Afify, C. J. Moore Jr., J. C. Mulligan, L. H. Royster; *Adjunct Associate Professor:* E. C. Yates Jr.; *Assistant Professors:* J. R. Bailey, J. A. Daggerhart Jr.; *Adjunct Assistant Professor:* G. L. Smith

The Department of Mechanical and Aerospace Engineering offers graduate study leading to the Master of Mechanical Engineering, Master of Science and

Doctor of Philosophy degrees. Entrance to the various programs in the department is normally based upon a pertinent, accredited baccalaureate degree.

Graduate study and research are available in the thermal sciences including classical and statistical thermodynamics, transport phenomenon, energy conversion, heat and mass transfer, and thermal pollution; in acoustical technology including acoustic radiation, industrial and community noise control, transportation noise, and hearing conservation; in gas dynamics including subsonic, transonic, supersonic, and hypersonic aerodynamics, rarefied gasdynamics, plasmadynamics, aerothermochemistry, and dynamics of viscous fluids; in the mechanical sciences including machine vibrations, mechanical transients, materials processing, photoelasticity and experimental stress analysis, transportation systems and vehicle safety, and air pollution control, in the aerospace sciences including flight vehicle design, inertial navigation, and all aspects of aerospace propulsion; and in mechanical design including practical team effort experience in mechanical device and process design encompassing problem selection, data collection, preliminary and detailed design, performance evaluation, and redesign.

Extensive laboratory facilities are available in most of the above areas. These include subsonic, transonic, supersonic and hypersonic wind tunnels; cryogenic and vacuum facilities; extensive vibration and acoustic laboratories including anechoic chambers, a large reverberation room and field test and analysis instrumentation; a fiber and composite mechanics laboratory, a materials processing laboratory, an experimental stress analysis and photoelasticity laboratory, a particulate collection laboratory, a spectrophotometry laboratory and a heat transfer laboratory. In addition to these laboratories, the department operates a Graduate Systems Design Facility for carrying out multidisciplinary design projects in a variety of societal problem areas. These and other experimental facilities coupled with the availability of an IBM Model 370/165 computer provide graduate students with outstanding research tools.

The objective of the department is to provide graduate education both in rigorous experimental and theoretical research training and practitioner oriented engineering design involving mission directed problem solving.

FOR ADVANCED UNDERGRADUATES

MAE 401 Energy Conversion. Prerequisite: MAE 302. 3(3-0) F,S.

MAE 402 Heat and Mass Transfer. Prerequisites: MAE 302, MA 301. 3(3-0) F,S.

MAE 403 Air Conditioning. Prerequisite: MAE 302. 3(3-0) F.

MAE 404 Refrigeration. Prerequisite: MAE 302. 3(3-0) F.

MAE 405 Mechanical Engineering Laboratory III. Prerequisite: MAE 306. 1(0-3) F.

MAE 409 Particulate Control in Industrial Atmospheric Pollution. Prerequisite: MAE 301 or equivalent. 3(3-0) S.

MAE 411 Mechanical Design I. Prerequisites: MAE 315, MAE 316. 3(3-0) F.

MAE 415 Mechanical Engineering Analysis. Prerequisites: MAE 302, MAE 315, MAE 316, EE 331. 3(3-0) F.

MAE 416 Mechanical Engineering Design. Prerequisite: MAE 415. 4(3-2) S.

MAE 422 Direct Energy Conversion. Prerequisites: MAE 301, EE 202, or EE 332. 3(3-0)S.

MAE 431 Thermodynamics of Fluid Flow. Prerequisites: MA 301, MAE 302, EM 303, or MAE 355. 3(3-0) F.

MAE 435 Principles of Automatic Control. Prerequisite: MA 301. 3(3-0) F,S.

MAE 462 Flight Vehicle Stability and Control. Prerequisite: MAE 361. 3(3-0) F.

MAE 467 Rocket Propulsion. Prerequisite: MAE 365. 3(3-0) F.

MAE 471 (MAS 471) Undersea Vehicle Design. Prerequisite: MAE 355 or EM 303. 3(3-0) S.

MAE 472 Aerospace Vehicle Structures II. Prerequisite: MAE 371. 4(3-3) F.

MAE 474 Matrix Stress and Deformation Analysis. Prerequisite: MAE 316 or MAE 371 or EM 307 or EM 301. 3(3-0) S.

MAE 479 Aerospace Vehicle Design. Prerequisites: MAE 356, MAE 462, MAE 467, MAE 472, EE 332. 4(2-6) S.

MAE 495 Technical Seminar in Mechanical and Aerospace Engineering. Prerequisite: Senior standing. 1(1-0) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MAE 501 Steam and Gas Turbines. Prerequisites: MAE 302, EM 303, or MAE 355. 3(3-0) F,S. Fundamental analysis of the theory and design of turbomachinery flow passages; control and performance of turbomachinery; gas-turbine engine processes.

MAE 507, 508 Internal Combustion Engine Fundamentals. Prerequisite: MAE 302. 3(3-0) F,S. The fundamentals common to internal combustion engine cycles of operation. The Otto engine: carburetion, fuel distribution, flame and spark timing, and altitude effects; the Diesel engine; injection knock, combustion, precombustion and scavenging as applied to reciprocating and rotary engines.

MAE 510 Theory of Particulate Collection in Air Pollution Control. Prerequisite: MAE 409 or graduate standing. 3(3-0) S. Particulate matter is classified and its properties are described. The motion of particles as applied to particulate collection is carefully analyzed. The elements of aerodynamic capture of particles are developed and applications in filteration and liquid scrubbing are considered. Fundamentals of acoustical, electrostatic and thermal precipitation are introduced. Sampling techniques and instrumentation are also considered.

MAE 513 Vibration and Noise Control. Prerequisite: MAE 315 or MAE 472. 3 (2-3) F. This course will be devoted to a study of the nature and origin of vibration

and noise in mechanical systems and design for their control. Considerations will include source reduction, isolation, transmission, damping and acoustic shielding techniques, through classroom discussions and laboratory demonstrations.

MAE 515 Experimental Stress Analysis. Prerequisite: MAE 316. 3(2-3) F. Theoretical and experimental techniques of strain and stress analysis with emphasis on electrical strain gages and instrumentation, brittle coatings, grid methods and an introduction to photoelasticity. Laboratory includes an investigation and complete report of a problem chosen by the student under the guidance of the instructor.

MAE 516 Photoelasticity. Prerequisite: MAE 316. 3(2-3) S. Theory and experimental techniques of two- and three- dimensional photoelasticity including photoelastic coatings, photoplasticity and an application of photoelastic methods to the solution of mechanical design problems. Laboratory includes an investigation and complete report of a problem chosen by the student under the guidance of the instructor.

MAE 517 Lubrication. Prerequisite: EM 303. 3(2-3) S. The theory of hydrodynamic lubrication; Reynold's equation, the Sommerfield integration, effect of variable lubricant properties and energy equation for temperature rise. Properties of lubricants. Application to design of bearings. Boundary lubrication. Solid film lubrication.

MAE 518 Acoustic Radiation I. Prerequisite: MA 301. 3(3-0) F,S. Discussion of the principles of acoustic radiation as related to acoustic sources and their related fields. The radiation of single sources (point, plane, line cylinder, spheres, etc.) and combinations thereof are considered.

MAE 521 Aerothermodynamics. Prerequisites: MAE 301, MAE 355 or EM 303. 3 (3-0) F,S. Review of basic thermodynamics pertinent to gas dynamics. Detailed development of the general equations governing gas motion in both differential and integral form. Simplification of the equations to those for specialized flow regimes. Similarity parameters. Applications to simple problems in various flow regimes.

MAE 531 Plasmagasdynamics I. Prerequisites: MAE 356, PY 414. 3(3-0) F,S. Study of basic laws governing plasma motion for dense and rarefied plasmas, hydromagnetic shocks, plasma waves and instabilities, simple engineering applications.

MAE 532 Plasmagasdynamics II. Prerequisite: MAE 531. 3(3-0) F,S. Quantum statistics and ionization phenomena. Charged particle interactions. Transport properties in the presence of electric and magnetic fields and nonequilibrium ionization.

MAE 535 (EE 535) Gas Lasers. Prerequisites: MAE 356 or equivalent, PY 407. 3(3-0) F,S. Study of the principles, design and potential applications of ion, molecular, chemical and atomic gas lasers.

MAE 541, 542 Aerodynamic Heating. Prerequisites: MA 511, MAE 521. 3(3-0) F, S. A detailed study of the latest theoretical and experimental findings of the compressible laminar and turbulent boundary layers with special attention to the areodynamic heating problem. Application of theory in the analysis and design of aerospace hardware.

MAE 543 Heat Transfer—Theory and Applications. Prerequisite: MAE 402 or equivalent. 3(3-0) F,S. Development of basic equations for steady and transient heat and mass transfer processes. Emphasis is placed on the application of the basic equations to engineering problems in the areas of conduction, convection, mass transfer and thermal radiation.

MAE 545, 546. Project Work in Mechanical Engineering I, II. 2(0-4) F,S. Individual or small group investigation of a problem stemming from a mutual student-faculty interest. Emphasis is placed on providing a situation for exploiting student curiosity.

MAE 550 Cryogenics I. Prerequisite: MAE 402. 3(3-0) F,S. A study of the thermodynamic processes required to produce cryogenic fluids. Properties of materials at cryogenic temperatures. Insulation of cryogenic vessels and lines. Design of cryogenic systems.

MAE 554 Advanced Aerodynamic Theory. Prerequisite: MAE 355. 3(3-0) S. Development of fundamental aerodynamic theory. Emphasis upon mathematical analysis and derivation of equations of motion, airfoil theory and comparison with experimental results. Introduction to supersonic flow theory.

MAE 555 Advanced Flight Vehicle Stability and Control. Prerequisite: MAE 462. 3(3-0) F. Preliminary analysis and design of flight control systems to include autopilots and stability augmentation systems. Study of effects of inertial cross-coupling and nonrigid bodies on vehicle dynamics.

MAE 562 Advanced Aircraft Structures. Prerequisite: MAE 371. 3(3-0) S. Development of methods of stress analysis for aircraft structures, special problems in structural design, stiffened panels, rigid frames, indeterminate structures, general relaxation theory.

MAE 571 Inertial Guidance, Design and Analysis. Prerequisites: MA 401, MAE 435 or MAE 462. 3(3-0) S. Engineering design and performance analysis of inertial guidance components, subsystems and systems. Development of transfer functions and application of linear system techniques to determine stability, transient response and steady-state errors of gyros, accelerometers, stable platforms and initial alignment subsystems. Error analysis and its significance. Preliminary design and analysis of typical inertial guidance systems for flight and marine vehicles.

MAE 581, 582 Hypersonic Aerodynamics. Prerequisites: MA 512, MAE 521 or equivalent. 3(3-0) F,S. A detailed study of the latest theoretical and experimental findings in hypersonic aerodynamics.

MAE 593 Special Topics in Mechanical Engineering. Prerequisite: Advanced undergraduate or graduate standing. 3(3-0) F,S. Faculty and student discussions of special topics in mechanical engineering.

FOR GRADUATES ONLY

MAE 601 Advanced Engineering Thermodynamics. Prerequisites: MAE 302; MA 401 or MA 511. 3(3-0) F. Thermodynamics of a general reactive system; conservation of energy and the principles of increase of entropy; the fundamental relation of thermodynamics; Legendre transformations; equilibrium and stability criteria in different representations; general relations; chemical thermodynamics; multireaction system; ionization; irreversible thermodynamics; the Onsager relation; applications to thermoelectric, thermomagnetic and diffusional processes.

MAE 602 Statistical Thermodynamics. Prerequisite: MAE 601. 3(3-0) S. Fundamental principles of kinetic theory, quantum mechanics, statistical mechanics and irreversible phenomena with particular reference to thermodynamics systems and processes. The conclusions of the classical thermodynamics are analyzed and established from the microscopic viewpoint.

MAE 603 Advanced Power Plants. Prerequisite: MAE 401. 3(3-0) F. A critical analysis of the energy balance of thermal power plants, thermodynamics and economic evaluation of alternate schemes of development; study of recent developments in the production of power.

MAE 605 Aerothermochemistry. Prerequisites: MA 511, MAE 601 or equivalent. 3(3-0) S. A generalized treatment of combustion thermodynamics including derivation of thermodynamic quantities by the method of Jacobians, criteria for thermodynamic equilibrium, computation of equilibrium composition and adiabatic flame temperature. Introduction to classical chemical kinetics. Conservation equations for a reacting system, detonation and deflagration. Theories of flame propagation, flame stabilization and turbulent combustion.

MAE 606 Advanced Gas Dynamics. Prerequisites: MA 511, MAE 521, MAE 601. 3(3-0) S. The general conservation equations of gas dynamics from a differential and integral point of view. Hyperbolic compressible flow equations, unsteady one-dimensional flows, the nonlinear problem of shock wave formation, isentropic flow, flow in nozzles and jets, turbulent flow.

MAE 608 Advanced Heat Transfer I. Prerequisites: MA 512, MAE 402. 3(3-0) F. A generalized treatment of the methods of solution of transient and steady heat conduction in finite and infinite regions involving internal heat generation. Approximate methods and similarity transformation in the solution of heat conduction problems involving change of phase, variable thermal properties and nonlinear thermal radiation boundary conditions. Heat conduction in multilayer regions and in anisotropic solids. Solutions with numerical methods.

MAE 609 Advanced Heat Transfer II. Prerequisite: MAE 608. 3(3-0) S. Advanced topics in steady and transient natural and forced convection heat transfer for laminar and turbulent flow of imcompressible fluid through conduits and over bodies. Problems involving variable properties and interaction with thermal radiation. Mass transfer in laminar and turbulent flow; simultaneous heat and mass transfer.

MAE 610 Advanced Topics in Heat Transfer. Prerequisite: MAE 609. 3(3-0) S. This course constitutes a study of recent developments in heat transfer and related areas. It is anticipated that the course content will change from semester to semester.

MAE 611, 612 Advanced Machine Design I, II. Prerequisite: MAE 416. 3(3-0) F,S. An advanced integrated treatment of stress analysis and materials engineering devoted to current rational methods of analysis and design applicable to mechanical components. Primary attention placed on the determination and prediction of strength, life and deformation characteristics of machine components as dictated by performance requirements.

MAE 613 Mechanics of Machinery. Prerequisites: MAE 315, MA 512. 3(3-0) F. Advanced applications of dynamics to the design and response analysis of dynamic behavior of machines and mechanical devices. Emphasis on developing competence in transforming real problems in dynamics into appropriate mathematical models whose analysis permits performance predictions of engineering value.

MAE 614 Mechanical Transients and Machine Vibrations. Prerequisites: MAE 315 or EM 555; MA 512. 3(3-0) S. A study of the forces and motions produced in mechanical systems by periodic and transient inputs including shock and impact loading. Particular attention devoted to the application of the principles of vibration theory to problems encountered in mechanical design.

MAE 615 Aeroelasticity I. Prerequisites: MA 511; MAE 411 or MAE 472, MAE 521. 3(3-0) F. Deformations of aerostructures under static and dynamic loads, natural mode shapes and frequencies; two- and three-dimensional incompressible flow, wings and bodies in unsteady flow; static aeroelastic phenomena.

MAE 617 Mechanical Systems Design Analysis. Prerequisites: MAE 611, MAE 613. 3(3-0) F. Lecture and project activity devoted to development of the ability to apply knowledge and experience in performing comprehensive design analysis of complete mechanical systems. Areas of interest to include critieal problem recognition, system modeling, performance determination, and optimization and reliability evaluation.

MAE 618 Mechanical System Design Synthesis. Prerequisite: MAE 617. 3(3-0) S. Application of the basic philosophy and methodology of the complete design process to advanced mechanical system design. Individual and group experience in the conception, synthesis, analysis, optimization and implementation phases of feasibility, preliminary and final design studies provided by means of comprehensive system design projects.

MAE 619 Random Vibration. Prerequisite: MAE 614. 3(3-0) F or S. Mathematical description of stochastic processes. The stationary and ergodic assumptions and response analysis of mechanical systems to random excitation. Simulation of and failure due to random environments.

MAE 622 Acoustic Radiation II. Prerequisite: MAE 518. 3(3-0) F or S. Introduction to the various numerical methods for determining near-and-far-field pressures for arbitrary shaped bodies. The methods of Chertock, Hess, Copley, Schenck and Pachner are considered.

MAE 625, 626 Direct Energy Conversion. Prerequisite: MAE 601. 3(3-0) F,S. An engineering study of the modern developments in the field of conversion of heat to power in order to meet new technology demands. Thermoelectric, thermomagnetic, thermionic, photovoltaic and magneto-hydrodynamic effects and their utilization for energy conversion purposes, static and dynamic response, limitations imposed by the first and the second laws of thermodynamics. Energy and entropy balances, irreversible sources, inherent losses, cascading, design procedures, experimental studies to determine the response and efficiency of various systems.

MAE 631 Applications of Ultrasonics to Engineering Research. Prerequisites: EE 332, MA 511. 3(3-0) F. The technique and theory of propagation of ultrasonics in liquids, gases and solids. Development of ultrasonic transducers, the elastic piezoelectric and dielectric relationships. Ultrasonic applications of asdic or sonar cavitation, emulsification, soldering, welding and acoustic properties of gases, liquids and solids.

MAE 651 Principles of Fluid Motion. Prerequisite: MAE 554; Corequisite: MA 511. 3(3-0) F. Fundamental principles of fluid dynamics. Mathematical methods of analysis are emphasized. Potential flow theory development with introduction to the effects of viscosity and compressibility. Two-dimensional and three-dimensional phenomena are considered.

MAE 652 Dynamics of Compressible Flow. Prerequisites: MA 511, MAE 521. 3 (3-0) F. Properties of compressible fluids, equation of motion in one-dimensional motion, channel flows, shock wave theory, methods of observation and flows at transonic speeds.

MAE 653 Supersonic Aerodynamics. Prerequisite: MAE 521. 3(3-0) S. Equations of motion in supersonic flow, Prandtl-Meyer turns, method of characteristics, hodograph plane, supersonic wind tunnels, supersonic airfoil theory and boundary layer shock interaction.

MAE 654 Dynamics of Viscous Fluids I. Prerequisite: MAE 521. 3(3-0) F. Exact solutions to the Navier-Stokes Equations. Approximate solutions for low Reynolds numbers. Approximate solutions for high Reynolds numbers—incompressible boundary layer theory. Laminar and turbulent boundary layers in theory and experiment. Flow separation.

MAE 655 Dynamics of Viscous Fluids II. Prerequisite: MAE 654. 3(3-0) S. A continuation of MAE 654. Compressible laminar and turbulent boundary layers. Laminar and turbulent jets. The stability of laminar boundary layers with respect to small disturbances, transition from laminar to turbulent flow.

MAE 657 Measurement in Rarefied Gas Streams. Prerequisite: MAE 602. 3(3-0) F. A study of the basis for measurement of flow properties in rarefied gas streams. Included will be ionization gauges, hot wire anemometers and temperature probes, pitot and static tubes, Langmuir probes, electron scattering and electron beam density gauges.

MAE 658, 659 Molecular Gas Dynamics. Prerequisites: MAE 521, MAE 602. 3(3-0) F,S. Statistical mechanics as applied to the derivation of the equations of gasdynamics from the microscopic viewpoint. Energy levels of atoms and molecules and their relation to equilibrium thermodynamic concepts, in particular, specific heats. Approximate solutions of the Boltzmann Equation. Treatments of viscosity, heat conduction and electrical conductivity. Collision processes. High-temperature behavior of multi-species gas mixtures.

MAE 661, 662 Aerospace Energy Systems. Prerequisites: MA 512, MAE 521, PY 407 or equivalent. 3(3-0) F,S. A study of energy systems appropriate to the varied requirements of space operations. Includes analysis of chemical, nuclear and solar energy sources and the theory of their adaptation to operational requirements for propulsion and auxiliary power, cooling requirements, coolants and materials.

MAE 663 (TX 663) Mechanics of Twisted Structures. 3(3-0) F. (See textile technology, page 265.)

MAE 664 (TX 664) Mechanics of Fabric Structures. 3(3-0) S. (See textile technology, page 265.)

MAE 671, 672 Advanced Air Conditioning Design I, II. Prerequisites: MAE 403, MAE 404. 3(3-0) F,S. The design of heating and air-conditioning systems; the preparation of specifications and performance tests on heating and air-conditioning equipment.

MAE 674, 675 Advanced Spacecraft Design. Prerequisites: MAE 542, MAE 582. 3(3-0) F,S. Analysis and design of spacecraft including system design criteria, acceleration tolerance, entry environment, thermal requirements, criteria for configuration design, aerodynamic design, heating rates, thermostructural design, boost phase, de-orbit, entry corridor, lift modulation, rolling entry, glide phase, maneuvering and landing, stability and control, thermal protection system, materials, instrumentation and life-support systems.

MAE 681 Introduction to Rocket Propulsion. Prerequisite: MAE 601. 3(3-0) F. Review of the exterior ballistics and performance of rocket-propelled vehicles. Thermodynamics of real gases at high temperature. Nonequilibrium flow in rocket nozzles.

MAE 682 Solid Propellant Rockets. Prerequisite: MAE 681. 3(3-0) S. A study of the design and performance of solid-propellant rockets; properties and burning characteristics of solid propellants. Internal ballistics of solid-propellant rockets. Design and design optimization. Combustion instabilities.

MAE 683 Liquid Propellant Rockets. Prerequisite: MAE 681. 3(3-0) S. The study and design of liquid-propellant rockets. Combustion of liquid fuels. Thrust chamber, propellant supply and injection system. Cooling of rocket motors. Low- and high-frequency instability in liquid rocket motors. Scaling laws.

MAE 684 Ion Propulsion. Prerequisite: MAE 531. 3(3-0) F or S. Study and design of ion motors, power sources and converters. Missions for ion-propelled vehicles.

MAE 693 Advanced Topics in Mechanical Engineering. Prerequisite: Graduate standing. 1-6 F or S. Faculty and graduate student discussions of advanced topics in contemporary mechanical engineering.

MAE 695 Mechanical Engineering Seminar. 1(1-0) F or S. Faculty and graduate student discussions centered around current research problems and advanced engineering theories.

MAE 699 Mechanical Engineering Research. Prerequisites: Graduate standing in mechanical engineering, consent of adviser. Credits Arranged. Individual research in the field of mechanical engineering.

Meteorology

(For a listing of graduate faculty and departmental information, see geosciences, page 162.)

FOR ADVANCED UNDERGRADUATES

MY 411 Introductory Meteorology. Prerequisites: PY 208 or PY 212; MA 201 or MA 212. 3(3-0) F.

MY 412 Atmospheric Physics. Prerequisite: MY 411 or consent of instructor. 3(3-0) S.

MY 421 Atmospheric Statics and Thermodynamics. Prerequisites: PY 208 or PY 212; MA 202. 3(3-0) F.

MY 422 Atmospheric Kinematics and Dynamics. Prerequisites: PY 207 or PY 208; MA 202; Corequisite: MY 421 or consent of instructor. 3(3-0) S.

MY 435 Measurements and Data Systems. Prerequisite: MY 421. 3(2-3) S.

MY 441 Meteorological Analysis I. Prerequisites: MY 422, MY 435. 3(3-0) F.

MY 443 Meteorological Laboratory I. Prerequisite: MY 435; Corequisite: MY 441. 4(0-10) F.

MY 444 Meteorological Laboratory II. Prerequisite: MY 443. 4(0-10) S.

MY 486 Weather and Climate. Prerequisites: MA 102 or MA 112, PY 211-212 or PY 221. 2(2-0) F.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MY 512 Micrometeorology. Prerequisite: MY 422. 3(3-0) F. Meteorology of the lowest hundred meters of the atmosphere with emphasis on the transport of momentum, heat, water vapor, and effluents and their transfer through the earth's surface. Weber

MY 521 The Upper Atmosphere. Prerequisite: MY 411 or consent of instructor. 3(3-0) S. Meteorological conditions in the upper atmosphere from the stratosphere to the ionosphere. Compositions, mean distributions and variabilities, and circulation and transport properties in the region. Physical theories. Watson

MY 555 Meteorology of the Biosphere. Prerequisites: PY 205 or PY 211, CH 103 or CH 107; MA 102 or MA 112. 3(3-0) F. A course designed for graduate students in the life sciences, presenting the physical principles governing the states and processes of the atmosphere in contact with earth's surface of land, water and life. Exchanges of heat, mass and momentum are analyzed for various conditions of the atmosphere and surface, and as a function of season, time and geographic location. Graduate Staff

MY 556 Air Pollution Meteorology. Prerequisite: MY 555 or equivalent. 3(3-0) S. The meteorological aspects of air pollution, especially for nonmeteorologists engaged in graduate training for work involving air pollution. Peterson

MY 593 Advanced Topics. Prerequisite: Consent of staff. 1-6 F,S. Special topics of advanced nature in the field of meteorology, provided to groups or assigned to individual students. Graduate Staff

FOR GRADUATES ONLY

MY 612 Atmospheric Radiative Transfer. Prerequisite: MY 412. 3(3-0) S. The study of solar and terrestrial radiation. Methods of actinometric measurements, radiation absorption in the atmosphere, scattering of radiation, the solar spectrum, infrared radiative transfer and methods of determining net radiation. Satellite measurement of radiation and determination of atmospheric properties from satellite measurements. Weber

MY 627 Atmospheric Turbulence and Diffusion. Prerequisite: MY 422. 3(3-0) F. Mechanics of turbulence in the atmosphere, spectra and scales of atmospheric turbulence, and magnitudes of turbulent fluctuations. Theories of diffusion in the atmosphere. Diffusion and transport experiments. Processes other than natural turbulence affecting concentration of effluents. Weber

MY 635 Dynamical Analysis of the Atmosphere. Prerequisites: MY 441, MY 443. 3(2-3) F. Theory and analysis of circulation and weather systems based on dynamical concepts; structure, movement and development of systems; evaluation of theoretical concepts in prognosis and forecasting. Saucier

MY 695 Seminar. Prerequisite: Graduate standing. 1(1-0) F,S. Presentation of scientific articles and special lectures. Each student is required to present or critically review one or more papers. Graduate Staff

MY 699 Research. Prerequisites: Graduate standing and consent of advisory committee. Credit Arranged F,S. Graduate research in fulfillment of requirements for a graduate degree. Graduate Staff

Microbiology

GRADUATE FACULTY

Professor J. B. EVANS, *Head*

Professors: W. J. DOBROGOSZ, G. H. ELKAN, P. B. HAMILTON, J. J. PERRY; *Adjunct Associate Professor:* J. J. TULIS; *Assistant Professor:* E. C. HAYES III; *Adjunct Assistant Professor:* P. H. RAY

ASSOCIATE MEMBERS OF THE DEPARTMENT

Professors: F. B. ARMSTRONG, J. G. LECCE, M. L. SPECK; *Professor USDA:* J. L. ETCHELLS; *Associate Professors:* W. E. KLOOS, J. J. MCNEILL, A. G. WOLLUM

The Department of Microbiology offers programs leading to the Master of Science and Doctor of Philosophy degrees. These are research oriented programs that require a dissertation based on personal research. For students wishing a more general education without the thesis requirement, the Master of Life Science degree is offered with an emphasis in microbiology.

Applicants should have a bachelor's degree in one of the biological or physical sciences including at least one course in microbiology and courses in organic chemistry and calculus. Deficiencies may be made up while in graduate school but will not be counted as credit toward a graduate degree.

There are no specific departmental requirements regarding courses of study. There is a core of basic courses in microbiology that will be in the programs of most graduate students who have not had equivalent courses previously. As many as half of the courses in most programs will be basic courses in related areas such as biochemistry, chemistry, genetics, or cell biology.

At least one semester of half-time teaching experience is required of all Ph.D. candidates. All graduate students are expected to attend and participate in the seminar program every semester they are in residence. As a general rule the M.S. program requires two full years (including summers) beyond the B.S. level and the Ph.D. program requires two or three full years beyond the M.S. level.

FOR ADVANCED UNDERGRADUATES

MB 401 General Microbiology. Prerequisites: BS 100, CH 223 or CH 220. 4(3-3) S. Credit will not be granted for both MB 301 and MB 401.

MB 405 (FS 405) Food Microbiology. 3(2-3) F. (See food science, page 152.)

FOR GRADUATES AND ADVANCED UNDERGRADUATES

MB 501 Advanced Microbiology. Prerequisite: MB 401. 4(3-2) F. A study in some depth of microbial structure and function, microbial ecology and characterization of important groups of microorganisms. Perry

MB 506 (FS 506) Advanced Food Microbiology. 3(1-6) S. (See food science, page 152.)

MB 507 (PP 507) Pathogenic Microbiology. Prerequisite: MB 401. 4(3-2) F. A study of pathogenic microorganisms and their interaction with susceptible hosts. Emphasis will be on the principles and processes of infection and immunity as they relate to common diseases of man, plants, and animals. Hayes

MB 514 Microbial Metabolism. Prerequisites: MB 301 or MB 401, BCH 351 or BCH 551. 3(3-0) S. A study of the physiology and metabolism of microorganisms and their regulatory mechanisms. Dobrogosz

MB 521 Microbial Ecology. Prerequisite: Senior or graduate standing. 1(1-0) S. A survey of the ecological role of microorganisms in our environment, their interaction with other living organisms and their function in biodegradation and recycling of organic matter in the ecosystem. Perry

MB 532 (SSC 532) Soil Microbiology. 3(3-0) S. (See soil science, page 250.)

MB 551 Immunology and Serology. Prerequisite: MB 401. 2(1-2) S. A study of the basic concepts and principles of antibody production, antigen-antibody interaction, and the laboratory techniques for their demonstration and study. Lecce

MB 555 (ZO 555) Protozoology. 4(2-6) S. (See zoology, page 278.)

MB 561 (BCH 561, GN 561) Biochemical and Microbial Genetics. 3(3-0) S. (See biochemistry, page 74.)

MB 570 (BAE 570, CE 570) Sanitary Microbiology. 3(2-3) S. (See biological and agricultural engineering, page 77.)

MB 571 Virology. Prerequisites: BCH 551, MB 401. 3(3-0) S. An introduction to the fundamental aspects of virus-cell interactions. These include virus attachment and penetration, intracellular virus replication, metabolic changes occurring in cells as a result of virus infection and virus-induced cellular transformations. Hayes

MB 574 (BO 574) Phycology. 3(1-4) S. (See botany, page 83.)

MB 575 (BO 575, PP 575) The Fungi. 3(3-0) F. (See botany, page 83.)

MB 576 (BO 576, PP 576) The Fungi—Lab. 1(0-3) F. (See botany, page 83.)

MB 590 Topical Problems. Prerequisite: Graduate standing, consent of instructor. Credits Arranged F,S. Graduate Staff

FOR GRADUATES ONLY

MB 632 (SSC 632) Ecology and Functions of Soil Microorganisms. 3(3-0) S. (See soil science, page 251.)

MB 690 Microbiology Seminar. 1(1-0) F,S. Graduate Staff

MB 692 Special Problems in Microbiology. Credits Arranged F,S. Graduate Staff

MB 699 Microbiology Research. Credits Arranged F,S. Graduate Staff

Modern Languages

GRADUATE FACULTY

Professor A. A. GONZALEZ, *Head*

Professors: G. W. POLAND, E. M. STACK; *Associate Professors:* MARY PASCHAL—*Assistant Head:* E. W. ROLLINS, H. TUCKER JR.

The Department of Modern Languages offers courses to assist graduate students in preparing themselves to use modern foreign languages in research and advanced study. Students are encouraged particularly to seek useful foreign research related to their thesis or other research in progress.

Certification may be obtained in languages not normally taught by the department with special permission of the Graduate School.

* **MLF 401 French for Graduate Students.** 3(3-0) F. Development of basic vocabulary, knowledge of structures and translation techniques necessary to a reading skill. This course is provided to assist graduate students to prepare for the foreign language reading certification. It does not provide instruction in original composition or in speaking. Students will be certified in the language after successfully passing the final examination. (No prerequisite.)

* **MLG 401 German for Graduate Students.** 3(3-0) F. This course seeks to teach the structures and patterns of the language as used in technical and scholarly writing, with emphasis on the acquisition of a basic vocabulary. Examples will be drawn from a variety of sources to reflect the interest of all students. Completion of the course, including the final examination, will certify the student in the language. (No prerequisite.)

* **MLS 401 Spanish for Graduate Students.** 3(3-0) F. A course designed to teach students to read Spanish as used in scholarly and technical writing. Material will be drawn from various sources reflecting student interest. Students completing the course, including the final examination, will be certified in the language. (No prerequisite.)

* These courses do not carry graduate language credit.

Nuclear Engineering

GRADUATE FACULTY

Professor R. L. MURRAY, *Head*

Professors: J. R. BEELER JR., T. S. ELLEMAN, R. P. GARDNER, R. F. SAXE, L. R. ZUMWALT; *Associate Professors:* J. R. BOHANNON JR., C. E. SIEWERT—*Graduate Administrator*, E. STAM, K. VERGHESE

The discipline of Nuclear Engineering is dedicated to the development of nuclear processes for energy needs and to the application of radiation for the benefit of society. The Department of Nuclear Engineering offers graduate study oriented toward careers related to the problems of energy and of the environment, providing courses and research leading to the Master of Science and Doctor of Philosophy degrees.

Topics of investigation include nuclear reactor safety, environmental aspects of nuclear energy, radiation detection and measurement, nuclear reactor theory, analysis, and design, properties of nuclear materials, economic power from nuclear reactors, and applications of radioisotopes and radiation in industry, medicine, and science.

The new one-megawatt PULSTAR reactor, which became operational in 1973, is similar in design, type of fuel, and performance to modern power reactors. It is used for teaching, research, and service in behalf of the university. Also available for student use in research are a 30,000 curie cobalt-60 gamma irradiation source, an IBM System 370 Model 165 computer, and a number of well-equipped laboratories.

Bachelor's degree graduates in any of the fields of engineering or physical sciences are usually qualified for successful advanced study in nuclear engineering. Prior experience or course work in nuclear physics, differential equations and basic reactor analysis is helpful, but may be gained during the first semester of graduate study.

Opportunities are available for graduate co-op work with utility companies and reactor manufacturers in the Raleigh area, providing a valuable combination of financial support and learning in the classroom, the research laboratory and on the job. Teaching and research assistantships are available for qualified applicants. Part-time work is available for graduate students with reactor operations and the activation analysis and radioisotope production laboratories.

Thirty semester hours, including four for research on a thesis, are required for the M.S. degree. Students may also work directly toward a Ph.D. degree. Interdisciplinary programs with other departments in the School of Engineering are available.

The advent of competitive nuclear power and the ever-increasing need for reliable clean energy has created a strong demand for nuclear engineers to participate in all phases of the nuclear power field—environmental studies, siting, design, construction, testing, operation, licensing, and evaluation. Graduates of the department find positions in industry, government and educational institutions, working

with reactors in the several categories—light water, gas-cooled, fast breeder and fusion.

FOR ADVANCED UNDERGRADUATES

NE 401 Reactor Analysis and Design. Corequisite: NE 302 or NE 419. 4(3-2) F.

NE 402 Reactor Engineering. Corequisite: NE 401. 4(3-2) S.

NE 403 Nuclear Engineering Design Projects. Prerequisite: NE 402. 2(1-3) S.

NE 419 Introduction to Nuclear Engineering. Prerequisite: PY 202 or PY 208. 3(3-0) F,S.

NE 491, 492 Nuclear Engineering Topics I and II. Prerequisite: Consent of instructor. 1-4 S. Typical offerings include:

NE 491A	*Radiation Applications.*	Gardner
NE 491B	*Nuclear Fuel Cycles and Isotope Production.*	Verghese
NE 492A	*Reactor Systems.*	Saxe
NE 492B	*Radiological and Reactor Safety.*	Elleman

FOR GRADUATES AND ADVANCED UNDERGRADUATES

NE 501 Reactor Analysis. Prerequisite: NE 302 or NE 419. 3(3-0) F. Provides a background on the principles of neutron motion in matter with emphasis on the analysis of the nuclear chain reactor. A discussion of neutron mechanics, flux distributions, critical mass calculations, time behavior, two group models, and reactivity calculation is presented for the fission reactor. Siewert

NE 502 Reactor Design. Prerequisite: NE 501. 3(3-0) S. Elements of nuclear reactor design and operation, including reactor materials, thermal and hydraulic analysis, control and safety, and thermal and fast reactor system. Saxe

NE 504 (MA 504) Mathematical Methods in Engineering. Prerequisite: MA 301 or 312. 3(3-0) F. Survey of mathematical methods for engineers. Topics include ordinary differential equations, matrices, partial differential equations, difference equations, numerical methods, elements of statistics. Techniques and applications to engineering are stressed.

NE 505 Experimental Methods in Nuclear Engineering. Prerequisites: NE 501 and NE(PY) 511. Corequisites: NE 502 and NE 512. 3(1-4) S. Laboratory experiments are performed to illustrate the principles and concepts covered in NE 501, NE 502, NE 511 and NE 512. Gardner

NE 511 (PY 511) Nuclear Physics for Engineers. Prerequisite: PY 410. 3(3-0) F. A study of the properties of atomic nuclei, of nuclear radiations and of the interaction of nuclear radiation with matter. Emphasis is placed on the principles of modern equipment and techniques of nuclear measurement and their application to practical problems. Waltner

NE 512 Radiation Applications. Prerequisite: NE 511 (PY 511). 3(3-0) S. Applications of radiation interaction principles to practical nuclear problems. Topics

include radiological safety, effects of radiation on biological and structural materials, and industrial applications of radioisotopes and radiation. Elleman

NE 562 (MAT 562) Materials Problems in Nuclear Engineering. Prerequisite: PY 410 or consent of instructor. 3(3-0) F. Reactor component design considerations determined by materials properties as well as by nuclear function are covered. Emphasis is placed on radiation effects and other concepts pertinent to the selection of materials for nuclear reactors for either terrestrial or space applications. Fahmy

NE 573 (MAT 573) Computer Experiments in Materials Engineering. 3(3-0) F. (See materials engineering, page 183.)

NE 574 (CE 574) Environmental Consequences of Nuclear Power. Prerequisite: Consent of instructor(s). 3(3-0) S. Evaluation of environmental consequences resulting from electrical power generation, with emphasis on siting, construction, and operation of nuclear power plants. Topics include: growth in electrical demand, alternative sources of power and their environmental aspects; fuel reprocessing; sources and treatment of solid, liquid, and gaseous wastes; sources and effects of waste heat; federal and state regulations, including Environmental Impact Statements. Kohl, Zumwalt, Smallwood

NE 591, 592 Special Topics in Nuclear Engineering I, II. Prerequisite: Permission of instructor. 3(3-0) F,S. Staff

FOR GRADUATES ONLY

NE 601 Reactor Theory and Analysis. Prerequisite: NE 501. 3(3-0) F. Theoretical aspects of neutron diffusion and transport related to the design computation and performance analysis of nuclear reactors. Principal topics are a unified view of the neutron cycle including slowing, resonance capture and thermalization; reactor dynamics and control; fuel cycle studies; and neutron transport methods. Background is provided for research in power and test reactor analysis. Murray

NE 602 Advanced Reactor Theory. Prerequisite: NE 601. 3(3-0) S. A complete presentation of the singular eigenfunction expansion technique as applied in neutron transport theory for the analysis of nuclear reactors and to radiative heat transfer problems for participating media. Siewert

NE 611 Radiation Detection. Prerequisite: NE 512. 3(2-2) F. Covers the advanced aspects of radiation detection such as computer methods applied to gamma-ray spectroscopy, absolute detector efficiencies by experimental and Monte Carlo techniques, the use and theory of solid state detectors, time-of-flight detection experiments, and Mossbauer and other resonance phenomena. Gardner

NE 620 Nuclear Radiation Attenuation. Prerequisite: NE 502. 3(3-0) F. The physical theory and mathematical analysis of the penetration of neutrons, gamma-rays and charged particles. Analytical techniques include point kernels, transport theory, Monte Carlo and numerical methods. Digital computers are employed in the solution of practical problems. Staff

NE 621 Radiation Effects on Materials. Prerequisite: NE 512. 3(3-0) F. Interactions of radiation with matter, with emphasis on the physical effects. Current theories and experimental techniques are discussed. Annealing of defects, radiation induced changes in physical properties, and effects in reactor materials are discussed. Elleman

NE 622 Transport of Matter in Nuclear Reactors. Prerequisite: NE 512. 3(3-0) S. Mechanisms of fission product migration in reactor solids and fluids. Emphasis is on absorption phenomena, thermodynamics of reversible processes, diffusion mathematics and experimental methods. Zumwalt

NE 631 Reactor Kinetics and Control. Prerequisite: NE 501. 3(3-0) S. A study of the control of nuclear reactor systems. Basic control theory is developed including the use of Bode, Nyquist, and S-plane diagrams, and state-variable methods. Reactor and reactor systems are analyzed by these methods and control methods and optimum-control methods are developed. Models for reactors and reactor-associated units, such as heat exchangers, are discussed. The effects of non-linearities are presented. Saxe

NE 641 Radioisotope Applications. Prerequisite: NE 511 (PY 511). 3(3-0) S. Principles and techniques of radioisotope applications are presented. Topics include radiotracer principles, radiotracer applications to engineering processes, radioisotope gauging principles and charged particle, gamma ray and neutron radioisotope gauges. Gardner

NE 653 Nuclear Reactor Design. Prerequisite: NE 601. 3(3-0) F. A comprehensive analysis and design of a nuclear system or facility suggested and advised on by department faculty will be performed. The class is organized under the project engineering scheme, with work taking the form of feasibility study, and conceptual, preliminary or parametric analysis and design. Interdisciplinary topics such as siting, safety analysis, shielding, engineered safety features, protection systems, economics, material selection, quality assurance and project management are key parts of the course. Results are reviewed by an interdepartmental board. Bohannon

NE 691, 692 Advanced Topics in Nuclear Engineering I, II. Prerequisite: Consent of instructor. 3(3-0) F,S. A study of recent developments in nuclear engineering theory and practice. Staff

NE 695 Seminar in Nuclear Engineering. 1(1-0) F,S. Discussion of selected topics in nuclear engineering. Staff

NE 699 Research in Nuclear Engineering. Prerequisite: Graduate standing. Credits Arranged. Individual research in the field of nuclear engineering. Staff

Nutrition

GRADUATE FACULTY

Professors: L. W. Aurand, E. R. Barrick, A. J. Clawson, Eloise S. Cofer, W. E. Donaldson, C. H. Hill, J. M. Leatherwood, J. G. Lecce, H. L. Lucas, G. Matrone, R. D. Mochrie, A. H. Rakes, H. A. Ramsey, H. A. Schneider, S. B. Tove, G. H. Wise; *Professor Emeritus:* F. H. Smith; *Associate Professors:* R. W. Harvey, E. E. Jones, J. J. McNeill; *Assistant Professor:* J. D. Garlich

Graduate study leading to a Master of Science or Doctor of Philosophy degrees may be taken under the direction of any of the graduate faculty for the nutrition program. This program is interdepartmental, and the student may reside and conduct research in any of the following departments which participate in the pro-

gram: animal science, poultry science, food science or biochemistry. The student will ordinarily reside in the department of his major adviser. The program involves various species of animals; therefore, the comparative approach to nutrition is emphasized.

Majors in the program may minor in biochemistry, microbiology, physiology, statistics or other approved fields.

Research facilities in each of the departments are extensive and the problems under investigation are many and varied.

This program is administered by the Nutrition Advisory Committee through its executive committee comprising the committee chairman and one member from each participating department. Additional information about the program may be obtained by writing to any one of the above graduate faculty members or to the Chairman, Nutrition Program, P.O. Box 5306, School of Agriculture and Life Sciences, N. C. State University, Raleigh, North Carolina 27607.

FOR ADVANCED UNDERGRADUATES

NTR 415 (ANS 415, PO 415) Comparative Nutrition. Prerequisite: CH 220 or CH 221. 3(3-0) F.

NTR 416 (ANS 416) Quantitative Nutrition. Prerequisite: BCH 351. 3(1-6) F.

NTR 490 Nutrition Seminar. Prerequisite: Senior standing. 1(1-0) F,S.

NTR 590 Topical Problems in Nutrition. Prerequisite: Graduate or senior standing. Maximum 6 F,S. Analysis of problems of current interest in nutrition. Credit for this course will involve the scientific appraisal and solution of a selected problem. The problems will be designed to provide training and experience in research.
Graduate Staff

FOR GRADUATES ONLY

NTR 601 Amino Acids, Vitamins, and Minerals in Nutrition. Prerequisites: BCH 551, ZO 421, and a 400-level nutrition course. 4(4-0) S. This course is designed to give the student knowledge in depth of the nutritional biochemistry of amino acids, vitamins and minerals. Nutritional principles are presented and interpreted from the viewpoint of metabolic pathways and biochemical reaction mechanisms.
Garlich

NTR 608 Energy Metabolism. Prerequisites: BCH 551 and an introductory nutrition course. 3(3-0) F. The course relates biochemical and physiological events within the cell, tissue, organ and system with the nutrient needs as sources of energy for productive animal life. Digestion, absorption and metabolism of carbohydrates under normal and pathological states will be discussed. Processes of energy transformations within living structures will be presented in relation to free energy, biological oxidations, coupled reactions, anabolic and catabolic systems, hormonal effects, metabolic control and efficiency. Leatherwood

NTR 690 Advanced Special Problems in Nutrition. Prerequisite: Graduate standing. Maximum 6 F,S. Directed research in a specialized phase of nutrition designed to provide experience in research methodology and philosophy. Graduate Staff

NTR 699 Research in Nutrition. Prerequisite: Graduate standing. Credits Arranged, Maximum 6 F,S. Original research preparatory to the thesis for the Master of Science or Doctor of Philosophy degree.

Associated courses related to nutrition are:

FS 400 Foods and Nutrition.

FS 402 Food Chemistry.

BCH 653 (ANS 653) Mineral Metabolism.

Operations Research

PROGRAM COMMITTEE

Professor: S. E. ELMAGHRABY, *Chairman*

Professors: B. B. BHATTACHARYYA, J. W. BISHIR, A. R. ECKELS; *Associate Professors:* R. H. BERNHARD, W. D. COOPER, R. M. FELDER, W. S. GALLER, W. L. HAFLEY, C. HARRELL, C. J. MADAY, H. L. W. NUTTLE; *Assistant Professors:* G. E. BENNINGTON, R. E. HARTWIG, T. L. HONEYCUTT, M. J. MAGAZINE

Operations Research is a graduate program of a multidisciplinary nature, governed by an Administrative Board and the Program Committee, and administered through the office of the program director.

The program offers the degrees of Master of Science and Doctor of Philosophy. Both are research degrees requiring thesis. A foreign language is not required at the Master's level and is optional with the student's advisory committee at the Doctoral level. A brochure is available which describes in more detail the orientation requirements for both degrees.

An advanced program of study in operations research implies intensive study in at least two of the following areas: mathematical optimization, control systems, stochastic systems, econometrics and economic decision theory, and information and cybernetics.

CENTRAL COURSES

OR 501 Introduction to Operations Research. Prerequisites: MA 405, MA 421. 3 (3-0) F,Sum. OR Approach: modeling, constraints, objective and criterion. The problem of Multiple criteria. Optimization, Model validation. The team approach. Systems Design. Examples, OR Methodology: mathematical programming; optimum seeking; simulation, gaming; heuristic programming. Examples. OR Applications; theory of inventory; economic ordering under deterministic and stochastic demand. The production smoothing problem; linear and quadratic cost functions. Waiting line problems: single and multiple servers with Poisson input and output. The theory of games for two-person competitive situations. Project management through PERT-CPM. Graduate Staff

OR 505 (IE 505, MA 505) Mathematical Programming I. Prerequisite: MA 405. 3(3-0) F,Sum. A study of mathematical methods applied to problems of planning. Linear programming will be covered in detail. This course is intended for those who desire to study this subject in depth and detail. It provides a rigorous and complete development of the theoretical and computational aspects of this technique as well as a discussion of a number of applications. Graduate Staff

OR 509 (IE 509) Dynamic Programming. Prerequisites: MA 405, ST 421. 3(3-0) S,Sum. An introduction to the theory and computational aspects of dynamic programming and its application to sequential decision problems. Elmaghraby, Nuttle

OR 520 Theory of Activity Networks. Prerequisites: OR 501, OR 505 (IE 505, MA 505). 3(3-0) S. Introduction to graph theory and network theory. A discussion in depth of the theory underlying (i) deterministic activity networks (CPM): optimal time-cost trade offs; the problem of scarce resources; (ii) probabilistic activity networks (PERT): critical evaluation of the underlying assumptions; (iii) generalized activity networks (GERT, GAN): applications of signal flow graphs and semi-Markov process to probabilistic branching; relation to the theory of scheduling. (Offered in alternate years.) Elmaghraby

OR 522 (IE 522) Dynamics of Industrial Systems. Prerequisite: IE 421. 3(3-0) F. A study of the dynamic properties of industrial systems; introduction to servo-mechanism theory as applied to company operations. Simulation of large nonlinear, multiloop, stochastic systems on a digital computer; methods of determining modifications in systems design and/or operating parameters for improved system behavior. Llewellyn

OR 527 (CHE 527) Optimization of Engineering Processes. Prerequisites: MA 511, CSC 111 or equivalent. 3(3-0) F. Mathematical methods for the optimization of engineering processes are developed, and illustrative applications of these methods are presented and discussed. Specific topics covered are drawn from a list which includes mathematical programming, geometric programming, sensitivity analysis, direct search and elimination techniques, variational techniques and the minimum principle, quasilinearization and dynamic programming. The emphasis throughout the course is on applications of the techniques discussed rather than fully rigorous development of the theory. Felder

OR 561 (IE 561) Queues and Stochastic Service Systems. Prerequisite: MA 421. 3(3-0) F. General concepts of stochastic processes are introduced. Poisson processes, Markov processes, and Renewal theory are presented. These are then used in the analysis of queues, starting with a completely memoryless queue to one with general parameters. Applications to many engineering problems will be considered. Magazine

OR 585 (CSC 585) Graph Theory. Prerequisite: MA 231 or MA 405. 3(3-0) F, Sum. Basic concepts of graph theory. Trees and forests. Vector spaces associated with a graph. Representation of graphs by binary matrices and list structures. Traversability. Connectivity. Matchings and assignment problems. Planar graphs. Colorability. Directed graphs. Applications of graph theory with emphasis on organizing problems in a form suitable for computer solution. Staff

OR 586 (IE 586) Network Flows. Prerequisites: OR 505 (IE 505, MA 505) or equivalent. 3(3-0) S. This course will study problems of flows in networks. These problems will include the determination of the shortest chain, maximal flow and minimal cost flow in networks. The relationship between network flows and linear pro-

gramming will be developed as well as problems with nonlinear cost functions, multicommodity flows, and the problem of network synthesis. (Offered in alternate years.) Bennington

OR 606 (MA 606, ST 606) Mathematical Programming II. Prerequisite: OR 505 (IE 505, MA 505). 3(3-0) S. This course is intended for those who desire to study linear and nonlinear programming from an advanced mathematical point of view. Special attention will be paid to the theoretical and computational aspects of current research problems in the field of linear and nonlinear programming, game theory, theory of graphs, discrete linear programming, linear programming, under uncertainty and dynamic programming. Bhattacharyya, Magazine

OR 609 Advanced Dynamic Programming. Prerequisites: OR 509, MA 541. 3(3-0) F. Introduction to measure theoretic concepts, review of finite state Markov processes, theory of Markovian programming, discrete decision processes, continuous time dynamic programming, relation to Calculus of Variation and the Maximum Principle. Emphasis throughout is on recent theoretical development in the field. (Offered in alternate years.) Elmaghraby

OR 631, 632 (EM 631, 632) Variational Methods in Optimization Techniques I, II. Prerequisites: (631) MA 511, MA 512; (632) OR 631. 3(3-0) F,S. Variational methods are applied to optimization problems in engineering, where examples are drawn from flight mechanics, operations research, heat transfer, structures and aerodynamics. The necessary conditions which follow from the general variation of a functional are developed. Solutions with corners and discontinuities are considered. Inequality constraints on control variables and constrained extreme are also considered. Gradient methods are described. Applications in operations research are made for problems with continuous function representation such as might be found in production scheduling, inventory control and process control. Maday

OR 691 Special Topics in Operations Research. Prerequisites: OR 501, OR 505 (IE 505, MA 505). 3(3-0) F,S,Sum. The purpose of this course is to allow individual students or small groups of students to take on studies of special areas in OR which fit into their particular program and which may not be covered by other OR courses. The work will be directed by a qualified faculty member and in some instances by visiting professors. The subject matter in any year is dependent on the students and the faculty members. Graduate Staff

OR 692 (IE 692, MA 692) Special Topics in Mathematical Programming. Prerequisite: OR 505 (IE 505, MA 505). 3(3-0) F,S,Sum. The study of special advanced topics in the area of mathematical programming. New techniques and current research in this area will be discussed. The faculty responsible for this course will select the areas to be covered during the semester according to their preference and interest. This course will not necessarily be taught by an individual faculty but can, on occasion, be a joint effort of several faculty members from this University as well as visiting faculty from other institutions. To date, a course on Theory of Networks and another in Integer Programming have been offered under the umbrella of this course. It is anticipated that these two topics will be repeated in the future, together with other topics. Graduate Staff

OR 695 Seminar in Operations Research. Prerequisite: Enrollment in operations research as a major or minor. 1(1-0) F,S. Seminar discussion of operations research problems. Case analyses and reports. Graduate students with minors or majors in operations research are expected to attend throughout the period of their residence. Graduate Staff

OR 699 Project in Operations Research. Prerequisites: Variable. 1-3 F,S,Sum. Individual research by graduate students minoring and majoring in operations research. Research may be done under the operations research faculty member meeting the interest need of the student. Graduate Staff

SUGGESTED COGNATE COURSES

Civil Engineering

CE 575 Civil Engineering Systems.

Economics

EC 550 Mathematical Models in Economics.
EC 650 Economic Decision Theory.
EC 651 (ST 651) Econometrics.
EC 652 (ST 652) Topics in Econometrics.

Electrical Engineering

EE 516 Feedback Control Systems.
EE 520 Fundamentals of Logic Systems.
EE 521 Digital Computer Technology and Design.
EE 613, 614 Advanced Feedback Control.
EE 642 Automata and Adaptive Systems.
EE 651 Statistical Communication Theory.

Industrial Engineering

IE 523 Inventory Control Methods I.
IE 547 Engineering Reliability.
IE 608 Linear Programming Applications.
IE 611 The Design of Production Systems.
IE 622 Inventory Control Method II.

Mathematics

MA 521 Fundamentals of Modern Algebra.
MA 536 Logic for Digital Computers.
MA 537 Mathematical Theory of Digital Computers.
MA 541, 542 (ST 541, 542) Theory of Probability I & II.
MA 617, 618 (ST 617, 618) Measure Theory and Advanced Probability.
MA 619 (ST 619) Topics in Advanced Probability.
MA 622 Linear Transformations and Matrix Theory.
MA 641, 642 Calculus of Variations and Theory of Optimal Control I & II.

Statistics

ST 613, 614 Time Series Analysis I & II.
ST 691 Advanced Special Problems. (A one-year course)

Physical Oceanography

(For a listing of graduate faculty and departmental information, see geosciences, page 162.)

FOR ADVANCED UNDERGRADUATES

OY 487 (CE 487, MAS 487) Physical Oceanography. Prerequisites: MA 202, PY 212. 3(3-0) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

OY 541 (MAS 541, CE 541) Gravity Wave Theory I. Prerequisite: EM 303 or PY 411. 3(3-0) S. Classical gravity wave theory with emphasis on the basic mechanics of wave motions, mass transport induced by waves and various conservation laws with their applications in wave study. Huang

OY 551 (MAS 551) Ocean Circulation. Prerequisite: EM 303 or PY 411. 3(3-0) S. Basic study of the mechanics of ocean circulation with emphasis on various simple models of circulation systems. Pietrafesa

FOR GRADUATES ONLY

OY 601, 602 (MAS 601, 602) Advanced Physical Oceanography I, II. Prerequisite: OY 487 (MAS 487, CE 487). 3(3-0) F,S. An in-depth discussion of physical oceanography—both geographic and hydrodynamical aspects. Topics discussed include relief of ocean floor; physical properties of sea water; distribution of temperature, salinity and currents; and kinematical and dynamical studies of motion of sea water turbulence. Knowles

OY 605, 606 (MAS 605, 606; EM 605, 606) Advanced Geophysical Fluid Mechanics I, II. Prerequisite: EM 504, 505 or equivalent. 3(3-0) F,S. An application of basic fluid mechanics principles in geophysical fluid mechanics studies with emphasis on the most important physical parameters encountered in the field of geophysical fluid mechanics, such as: mechanics of stratified fluids, rotating fluids, stratified and rotating fluid, stability and turbulence in ocean and atmosphere. (Offered 1975-76 and alternate years.) Huang

OY 613, 614 (MAS 613, 614; EM 613, 614) Perturbation Method in Fluid Mechanics I, II. Prerequisites: MA 401, EM 303. 3(3-0) F,S. Basic theory and application of perturbation methods in fluid mechanics including: regular and singular perturbations, matching principles, method of strained coordinate, two variable expansion and applications to partial differential equations. (Offered 1974-75 and alternate years.) Huang

OY 699 (MAS 699) Research in Physical Oceanography. Prerequisites: Graduate standing and consent of advisory committee. Credits Arranged F,S. Graduate research in fulfillment of requirements for a graduate degree. Graduate Staff

Physics

GRADUATE FACULTY

Professor L. W. SEAGONDOLLAR, *Head*

Professors: J. M. A. DANBY, W. R. DAVIS, W. O. DOGGETT, G. L. HALL, A. W. JENKINS JR., H. C. KELLY, J. T. LYNN—*Graduate Administrator*, E. R. MANRING, J. D. MEMORY, A. C. MENIUS JR., R. L. MURRAY, R. R. PATTY, D.L. RIDGEWAY, D. R. TILLEY, A. W. WALTNER; *Visiting University Professor:* L. H. THOMAS; *Professors Emeriti:* W. H. BENNETT, F. W. LANCASTER, J. S. MEARES; *Associate Professors:* G. C. COBB JR., G. H. KATZIN, D. H. MARTIN, G. E. MITCHELL, M. K. MOSS, J. Y. PARK; *Assistant Professors:* K. T. CHUNG, R. E. FORNES, C. R. GOULD, C. E. JOHNSON JR., F. LADO JR., G. W. PARKER III, J. F. SCHETZINA

Study in physics is available leading to the degrees Master of Science and Doctor of Philosophy. In addition to the areas of research listed below, thesis work may also be done in closely related departments in the fields of biophysics, environmental sciences, nuclear reactor theory and computer science. Available to the department are the computer facilities (including the IBM System 370/165 computer) of the nearby Triangle Universities Computation Center which is jointly operated by Duke University, the University of North Carolina at Chapel Hill and North Carolina State University. These three universities jointly staff the Triangle Universities Nuclear Laboratory located on the Duke campus. The major facilities are a 15 MeV Model FN Tandem Van de Graaff accelerator with a 15 MeV cyclotron injector and on-line computer facilities.

Experimental along with theoretical work is being done in atmospheric physics, atomic and molecular physics, magnetic resonance, nuclear physics, plasma physics and semiconductor physics. Theoretical work is in relativity and general field theory and in statistical and solid state theory.

Programs of study leading to the Master of Science degree require a minimum of 30 semester hours, including four credits of research and two of seminar. In addition, a thesis is required.

The Doctor of Philosophy degree is granted on successful completion of examinations, independent research and the submission of an acceptable dissertation. A minor area of study is required, mathematics usually being elected.

A large number of teaching and research assistantships are available. Depending upon the student's experience, these pay from $3,000 to $4,200 for half-time duties during the nine-month school year and allow the student to carry 60 percent of a full course load. A student holding such a half-time assistantship may be eligible for special tuition charges.

FOR ADVANCED UNDERGRADUATES

PY 401, 402 Modern and Quantum Physics I, II. Prerequisite: PY 411. 3(3-0) F,S.

PY 407 Introduction to Modern Physics. Prerequisites: MA 202, PY 208. 3(3-0) F,S.

PY 409 Ion and Electron Physics. Prerequisite: PY 414. 3(2-3) S.

PY 410 Nuclear Physics I. Prerequisite: PY 203 or PY 407. 4(3-2) F,S.

PY 411, 412 Mechanics I, II. Prerequisites: MA 301, PY 203 or PY 208. 3(3-0) F, S.

PY 413 Thermal Physics. Prerequisite: PY 202 or PY 208; Corequisite: MA 301. 3(3-0) S.

PY 414, 415 Electricity and Magnetism I, II. Prerequisite: PY 203 or PY 208; Corequisite: MA 512. 3(3-0) F,S.

PY 416 Physical Optics. Prerequisite: PY 415. 3(2-2) F.

PY 443 Astrophysics. Prerequisites: PY 203 or PY 407; PY 411. 3(3-0) S.

PY 451, 452 Intermediate Experiments in Physics I, II. Corequisites: PY 411, PY 414. 2(1-3) F,S.

PY 499 Special Problems in Physics. Prerequisite: Consent of department. 1-3 F, S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PY 501, 502 Introduction to Quantum Mechanics I, II. Prerequisites: MA 512; PY 411 or PY 414. 3(3-0) F,S. An introduction to the fundamental concepts and formulations of non-relativistic quantum mechanics, including its interpretation and techniques, and the application of the Schrödinger equation to bounded systems and to scattering systems. Other topics include approximation methods, angular momentum theory, identical particles and spin, transformation theory, symmetry and invariance, radiation theory, S-matrix and T-matrix theory. Chung

PY 503, 504 Introduction to Theoretical Physics I, II. Prerequisites: MA 512, PY 412, PY 414. 3(3-0) F,S. An introductory course in theoretical physics which offers preparation for advanced graduate study. Emphasis is on classical mechanics and special relativity. Topics covered include variational principles, Lagrangian and Hamiltonian mechanics, canonical transformation theory, invariances and conservation laws, structure of the Lorentz group, and elementary dynamics of unquantized fields. Katzin

PY 507 Advanced Atomic Physics. Prerequisites: MA 512, PY 412, PY 415. 3(3-0) F. An introduction to the quantum mechanical treatment of atomic structure and spectra. Topics covered include the relativistic hydrogen atom, the helium atom, multielectron atoms, selection rules, etc. Memory

PY 509 Plasma Physics. Prerequisite: PY 414. 3(3-0) F. A study of the individual and collective motion of charged particles in electric and magnetic fields and through ionized gases, including the pinch effect and induced processes in relativistic streams; transport equations; and properties of plasmas, including wave production and propagation, instabilities, shocks, and radiation losses, with applications. Doggett

PY 510 Nuclear Physics II. Prerequisite: PY 410. 4(3-2) F. A study of the properties of the atomic nucleus as revealed by radioactivity, nuclear reactions and scattering experiments, with emphasis on the experimental approach. The laboratory is designed to stimulate independent research and offers project work in nuclear spectroscopy and in neutron physics. Waltner

PY 511 (NE 511) Nuclear Physics for Engineers. Prerequisite: PY 410. 3(3-0) F. A study of the properties of atomic nuclei, of nuclear radiations and of the interaction of nuclear radiation with matter. Emphasis is placed on the principles underlying the use of modern equipment and on techniques of nuclear measurement and their application to practical problems. Waltner

PY 514, 515 Advanced Electricity and Magnetism I, II. Prerequisite: PY 415. 3 (3-0) F,S. An advanced treatment of electromagnetic theory. Topics include: techniques for the solution of electrostatic and magnetostatic problems, special functions, the Fourier theorem for separable Hilbert spaces, Maxwell's equations, gauge transformations, four-dimensional Fourier transforms, dispersion relations, Green's functions, relativity, and radiation from accelerated charges. Hall

PY 517 Molecular Spectra. Prerequisites: PY 407, PY 412; PY 507 recommended. 3(3-0) S. Topics include the interpretation of infrared and Raman spectra for diatomic and simple polyatomic molecules; the effects due to vibration-rotation interaction, electronic motion and nuclear spin; nuclear magnetic resonance spectroscopy; infrared absorption in the earth's atmosphere. Memory

PY 520 Measurements in Nuclear Physics. Prerequisite: PY 410. 3(2-2) S. A study of the fundamental measurements in nuclear physics with emphasis on the statistical treatment of data. Waltner

PY 521 Kinetic Theory of Gases. Prerequisite: PY 413. 3(3-0) F. A study of kinetic equations, with emphasis on the transport properties of a dilute gas, including mean free path techniques and the Boltzmann equation and its consequences. Wide-ranging further applications include topics such as Brownian motion, population dynamics, etc. Lado

PY 552 Introduction to the Structure of Solids. Prerequisite: PY 401. 3(3-0) S. Basic considerations of crystalline solids, metals, conductors and semiconductors. Schetzina

PY 555 (MA 555) Mathematical Introduction to Celestial Mechanics. 3(3-0) F. (See mathematics, page 188.)

PY 556 (MA 556) Orbital Mechanics. 3(3-0) S. (See mathematics, page 188.)

PY 599 Senior Research. Prerequisite: Senior honors program standing, except with special permission. 3 F,S. Investigations in physics under the guidance of staff members that may consist of literature reviews, experimental measurements or theoretical studies. Graduate Staff

FOR GRADUATES ONLY

PY 600 Planetary Atmospheres. Prerequisite: PY 507. 3(3-0) S. Gas dynamics of atmospheres with emphasis on recent results of rocket, satellite and interplanetary probes. Theories of the airglow, aurora and ionosphere are developed. Manring

PY 601, 602 Theoretical Physics I, II. Prerequisites: PY 503, PY 514; Corequisite: MA 661. 3(3-0) F,S. The mathematical and theoretical approach to the relationships between various branches of physics is treated. The restricted theory of relativity, electrodynamics, classical field theory and the general theory of relativity and geometrodynamics are considered. Davis

PY 609 High Energy Physics. Prerequisite: PY 510. 3(3-0) S. The experimental and theoretical aspects of nuclear processes at high energy are treated. Graduate Staff

PY 610 Advanced Nuclear Physics. Prerequisite: PY 410; Corequisite: PY 501. 3 (3-0) F. A theoretical study of nuclear structure and reactions. Topics include the deuteron, low energy nucleon scattering, nuclear forces, nuclear moments, nuclear shell theory, collective model, compound nucleus, optical model and direct reaction theories. Park

PY 611 Quantum Mechanics. Prerequisites: MA 512, PY 502. 3(3-0) F. A treatment of nonrelativistic quantum mechanics at the advanced level, including an introduction to the relativistic quantum theory of Dirac particles and the methods of Feynman that are employed in his formulation of positron theory. Applications are made to scattering problems and to general problems of atomic and molecular structure. Park

PY 612 Advanced Quantum Mechanics. Prerequisites: PY 601, PY 611. 3(3-0) S. A general propagator treatment of Dirac particles, photons, and scalar and vector mesons, with an introduction to quantum electrodynamics and S-matrix theory. Applications of Feynman graphs and rules will be given illustrating basic techniques employed in the treatment of electromagnetic, weak and strong interactions. Renormalization theory, the effects of radiative corrections and aspects of the general Lorentz covariant theory of quantized fields will also be considered. Park

PY 622 Statistical Mechanics. Prerequisites: PY 413, PY 501, PY 503. 3(3-0) S. An introduction to the structure and techniques of equilibrium statistical mechanics (both classical and quantum) as a basis for the study of the equilibrium properties of bulk matter, including the derivation of the laws of thermodynamics and applications to simple physical systems. Lado

PY 630, 631 Nuclear Structure Physics I, II. Prerequisites: PY 502, PY 510. 3 (3-0) F,S. Advanced description of nuclear models and nuclear reactions. Topics include: internucleon forces, compound nucleus processes, shell model, optical model, R-matrix theory, direct reactions, collective model, electromagnetic transitions, isobaric analog states. Mitchell

PY 641 Non-Inertial Space Mechanics. Prerequisites: MA 661, PY 601; Corequisite: PY 602. 3(3-0) S. This course treats the theoretical description of the phenomena of mechanics relating to noninertial frames of reference, with applications to space travel and the instrumentation problems of rocketry. Applications to inertial guidance and electromagnetic-inertial coupling effects are also considered. Davis

PY 651 Mathematics of Solid-State and Many-Body Theory. Prerequisites: MA 513, PY 502, PY 552. 3(3-0) F. Fourier techniques from solid-state theory are generalized and adapted to many areas of physics. Topics include: Fourier series on n-dimensional Bravais lattices, Fourier integrals, Schwartz distributions, Brillouin zones, Green's functions, Patterson functions, convolutions, and correlation coefficients. The Poisson sum formula and the theta function summation method are extensively developed for Bravais and non-Bravais lattices in n-dimensions. Hall

PY 652 Cooperative Phenomena in Solids. Prerequisite: PY 651. 3(3-0) S. Classical and quantum theories of equilibrium and transport properties of ferromagnetism, antiferromagnetism, and order-disorder in alloys. Statistical mechanics of, and phase transitions in, these and other systems are treated. Hall

PY 655 (MA 655) Qualitative Methods in Celestial Mechanics. 3(3-0) F. (See mathematics, page 191.)

PY 656 (MA 656) Perturbation Theory in Celestial Mechanics. 3(3-0) S. (See mathematics, page 191.)

The following five courses offer opportunities for advanced study in special areas of physics under staff members working in these areas.

PY 690 Special Topics in Molecular Physics. Prerequisite: Consent of instructor. 1-6 F,S.

PY 691 Special Topics in Nuclear Physics. Prerequisite: Consent of instructor. 1-6 F,S.

PY 692 Special Topics in Plasma Physics. Prerequisite: Consent of instructor. 1-6 F,S.

PY 693 Special Topics in Solid State Physics. Prerequisite: Consent of instructor. 1-6 F,S.

PY 694 Special Topics in Theoretical Physics. Prerequisite: Consent of instructor. 1-6 F,S.

PY 695 Seminar. 1(1-0) F,S. Reports on topics of current interest in physics. Several sections are offered so that students with common research interests may be grouped together. Graduate Staff

PY 699 Research. Credits Arranged. Graduate students sufficiently prepared may undertake research in some selected field of physics. Graduate Staff

Physiology

GRADUATE FACULTY

Professors: L. Goode, C. H. Hill, E. Hodgson, I. S. Longmuir, H. L. Lucas Jr., D. E. Smith, L. C. Ulberg; *Adjunct Professor:* D. H. K. Lee; *Associate Professors:* E. V. Caruolo, T. E. LeVere, J. F. Roberts J. P. Thaxton, R. T. Yamamoto; *Assistant Professors:* B. H. Johnson, W. P. Marley

Graduate study under the direction of the physiology faculty may lead to the Master of Science and the Doctor of Philosophy degrees. The physiology faculty is an interdepartmental group drawn from the departments participating in the program. They are: animal science, biochemistry, entomology, physical education, poultry science, psychology, statistics and zoology. The program emphasizes the comparative approach implicit in this type of organization.

Experimental facilities of the above departments are available for physiological research, as are such special facilities as the Reproductive Physiology Laboratory and the Wrightsville Marine Biomedical Laboratory. Experimental animals available cover a wide range, from insects and other invertebrates to large mammals.

In addition to courses in physiology, majors in the program are expected to take selected courses in biochemistry and cell biology. Minors are usually chosen from such fields as biochemistry, cell biology, entomology, genetics, statistics and zoology. A strong basic knowledge in one of these areas is essential.

Financial assistance for qualified students in the form of research assistantships, fellowships and traineeships is available through participating departments. Prospective students may obtain further information by writing to any one of the graduate faculty listed above or to the Chairman, Physiology Program P. O. Box 5306, N. C. State University, Raleigh, North Carolina 27607.

Graduate students enrolled as physiology majors are located in the department of their major professor and may participate in the activities of that department.

PHY 502 (ANS 502) Reproductive Physiology of Vertebrates. 3(3-0) S. (See animal science, page 69.)

PHY 503 General Physiology I. Prerequisite: Senior or graduate standing. 3(3-0) F. The general principles of homeostatis will be discussed, emphasizing the importance of integrative action. The following systems will be studied: respiratory, cardiovascular, renal, reproductive, and myological. Longmuir, Staff

PHY 504 General Physiology II. Prerequisite: Senior or graduate standing. 3(3-0) S. The general principles of homeostatis will be discussed, emphasizing the importance of integrative action. The following will be studied: alimentary, reticuloendothelial, central nervous, autonomic nervous, and endocrine systems; detoxication mechanisms; special senses; and the response of man to the environment. Longmuir, Staff

PHY 513 (ZO 513) Comparative Physiology. 4(3-3) S. (See zoology, page 277.)

PHY 553 (BCH 553) Physiological Biochemistry. 3(3-0) S. (See biochemistry, page 74.)

PHY 575 (ZO 575, ENT 575) Physiology of Invertebrates. Prerequisite: Consent of instructor. 3(3-0) F. The course deals with the physiology of the invertebrates, including the Insecta but excluding the Protozoa. The unity of the physiology of the various groups is stressed, and the relationship of physiology to contemporary biology and to other related biological fields will be illustrated. Graduate Staff

PHY 580 (ANS 580) Mammalian Endocrine Physiology. 3(3-0) F. (See animal science, page 69.)

PHY 590 Special Problems in Physiology. Prerequisites: Graduate standing, consent of instructor. Credits Arranged. Graduate Staff

PHY 604 (ANS 604) Experimental Animal Physiology. 4(2-4) F. (See animal science, page 70.)

PHY 690 Physiology Seminar. Prerequisite: Graduate standing. 1(1-0) S. Graduate Staff

PHY 695 Selected Topics in Physiology. Prerequisite: Graduate standing. 1-4.
Graduate Staff

PHY 699 Physiological Research. Prerequisites: Graduate standing, consent of instructor. Credits Arranged F,S.
Graduate Staff

COURSES FROM ASSOCIATED DEPARTMENTS

PO 524 (ZO 524) Comparative Endocrinology.
BCH 551 General Biochemistry.
ZO 614 Advanced Cell Biology.

OTHER SUPPORTING COURSES AVAILABLE

ENT 611 Biochemistry of Insects.
GN 532 (ZO 532) Biological Effects of Radiations.
PSY 502 Physiological Psychology.
ZO 510 Adaptive Behavior of Animals.

Certain courses on the interface between physiology and engineering may be taken after consultation with adviser and the instructors concerned.

Plant Pathology

GRADUATE FACULTY

Professor R. AYCOCK, *Head*

Professors: J. L. APPLE, K. R. BARKER, C. N. CLAYTON, E. B. COWLING, E. ECHANDI, G. V. GOODING JR., T. T. HEBERT, G. B. LUCAS, L. W. NIELSEN, N. T. POWELL, J. N. SASSER, D. L. STRIDER, HEDWIG H. TRIANTAPHYLLOU, N. N. WINSTEAD; *Professors USDA:* C. S. HODGES JR., J. P. ROSS; *Adjunct Professor:* G. H. HEPTING; *Extension Professor:* J. C. WELLS; *Professor Emeriti:* D. E. ELLIS, C. J. NUSBAUM, F. L. WELLMAN; *Associate Professors:* M. K. BEUTE, L. F. GRAND, D. HUISINGH, S. F. JENKINS JR., M. P. LEVI, L. T. LUCAS, C. E. MAIN, R. D. MILHOLLAND; *Associate Professors USDA:* K. J. LEONARD, R. A. REINERT, H. W. SPURR JR., R. E. WELTY; *Adjunct Associate Professors:* J. W. KOENIGS, E. G. KUHLMAN; *Extension Associate Professors:* H. E. DUNCAN—*In Charge*, C. W. AVERRE; *Assistant Professor:* C. G. VAN DYKE; *Adjunct Assistant Professor:* R. W. PERO; *Assistant Professor USDA:* A. S. HEAGLE

The Plant Pathology faculty exhibits strength in forest pathology, nematology, virology and general plant pathology. Programs leading to both the Master of Science and Doctor of Philosophy degrees are offered.

Strong foundation courses in biology, chemistry, mathematics, physics and soil science are usually prerequisite for admission to candidacy for the Ph.D. degree. For students who wish more general training without the thesis requirement, the Master of Agriculture and Master of Life Sciences degrees are offered, with major emphasis in plant pathology.

Opportunities for employment include research, extension and teaching appointments at land grant colleges and with the United States Department of Agriculture. The agricultural chemicals industry also utilizes plant pathologists in research, promotion and service. Plant pathologists often participate in foreign service through international and federal organizations, as well as in commercial enterprises.

Separate laboratories fully equipped and staffed for research in nematology, virology, physiology of pathogenesis and special biochemical problems are available; excellent facilities also exist for training in general phytopathology. In-depth training in all of these areas is possible.

The Department has greenhouse facilities and controlled environmental studies in a new Phytotron. Student participation in the Plant Disease Clinic provides experience in the diagnosis of all types of plant diseases.

North Carolina exhibits a wide range of soil types and climatic areas. Large acreages are planted to a variety of field, vegetable and ornamental crops, as well as forest trees. Special facilities for experimental work on diseases of these crops are found at some 16 permanent research stations located throughout the state.

The Department has a number of graduate fellowships and assistantships funded by the Agricultural Experiment Station, the Agricultural Foundation and other agencies. Stipends are adjusted to the previous training and experience of the recipients. The E. G. Moss and W. E. Cooper Memorial Fellowship funds supplement stipends of exceptional students. Students applying directly for aid from the National Science Foundation, the National Institutes of Health and other granting agencies are invited to specify the department as host institution.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PP 500 Plant Disease Control. Prerequisite: PP 315. 3(2-3) S. Disease control strategies and tactics are developed in a practical manner. Control economics and practices are considered in relation to principles and current research on biological, cultural, physical and chemical methods. Disease resistance and regulatory methods are also discussed. Jenkins, Spurr

PP 501 Phytopathology I. Prerequisites: PP 315 or equivalent. 5(3-6) F. A study of the classification, terminology, etiology and basic concepts of plant diseases caused by fungi and bacteria. In-depth studies of carefully selected examples will be used to illustrate and integrate general principles. Laboratory sessions will consider research and diagnostic techniques including preparation of media, isolation and study of pathogens in pure culture, inoculation, symptom development and disease measurement. Echandi, Strider

PP 502 Phytopathology II. Prerequisites: PP 315 or equivalent. 5(3-6) S. A study of virus, nematode, and abiotic diseases of plants with an overall consideration of such major topics as epidemiology, and control. Laboratory sessions will consider useful research and diagnostic techniques. Powell, Barker, Main, Gooding

PP 503 Identification of Plant Pathogenic Fungi. Prerequisites: Mycology or one advanced course in plant pathology. 3(4-12) Sum. A study of the recognition and identification of fungi which cause plant diseases and the differentiation of fungal diseases from those caused by other agents. Special consideration will be given to

use of keys in the identification of fungi and the major sources of descriptive information on plant pathogens. (Offered first summer session 1974 and alternate years.) Grand

PP 507 (MB 507) Pathogenic Microbiology. 4(3-2) F. (See microbiology, page 203.)

PP 575 (MB 575, BO 575) The Fungi. 3(3-0) F. (See botany, page 83.)

PP 576 (BO 576, MB 576) The Fungi—Lab. 1(0-3) F. (See botany, page 83.)

PP 595 Special Problems in Plant Pathology. Prerequisites: Consent of instructor. Credits Arranged, Maximum 6. Investigation of special problems in plant pathology not related to a thesis problem. The investigations may consist of original research and/or literature survey. Staff

FOR GRADUATE ONLY

PP 604 Morphology and Taxonomy of Nematodes. Prerequisites: PP 550, consent of instructor. 3(1-6) S. A study of the morphology, anatomy and taxonomy of nematodes with emphasis on the identification of important plant-parasitic genera. Exercises include preparation of semipermanent and permanent nematode mounts. H. H. Triantaphyllou

PP 605 Plant Virology. Prerequisites: PP 315, GN 411, and a course in organic chemistry. 3(1-6) F. A study of plant viruses including effects on host plants, transmission, classification, methods of purification, determination of properties, chemical nature, structure and multiplication. (Offered in 1975 and alternate years.) Hebert

PP 608 History of Phytopathology. Prerequisites: PP 315, consent of instructor. 1(1-0) F. Development of the science of phytopathology from its early beginnings to the early part of the 20th century. (Offered 1975 and alternate years.) Staff

PP 609 Current Phytopathological Research Under Field Conditions. Prerequisites: Graduate standing. 2(1-3) S. Study of concepts involved, procedures used, and evaluation made in current phytopathological research by plant pathology staff. Visits to various research stations will be made by the class. Clayton

PP 611 Advanced Plant Nematology. Prerequisite: PP 604. 3(2-3) S. A study of the biology, physiology and ecology of plant parasitic nematodes with emphasis on mechanisms of pathogenesis, host responses to infection and population dynamics. Laboratory exercises will include methods of cultivating nematodes and means of determining nutritional requirements, special physiological techniques and approaches used in ecological investigation. (Offered in 1974 and alternate years.) Barker

PP 612 Plant Pathogenesis. Prerequisite: PP 500, consent of instructor. 3(2-3) F. The following major topics will be considered: Infection processes, alterations in photosynthesis, respiration, nitrogen metabolism, vascular function and growth regulator function. The biochemical nature of the weapons utilized by pathogens in pathogenic attack and the defensive mechanisms employed by the hosts in resisting attack and the resultant dynamic interactions will be the central theme of the course. (Offered in 1974 and alternate years.) Huisingh

PP 614 Nematode Development, Cytology and Genetics. Prerequisites: PP 604 or consent of instructor. 2(1-3) F. A study of embryogenesis, post-embryonic develop-

ment, gametogenesis, cytology, reproduction, sexuality, genetics and evolution of nematodes with emphasis on plant-parasitic forms. Laboratory exercises include small research projects in each area of study and demonstrations of techniques and materials. (Offered in 1974 and alternate years.) A. C. Triantaphyllou

PP 625 (BO 625) Advanced Mycology. Prerequisites: PP 575 or consent of instructor. 4(2-6) F. An in-depth treatment of major groups of fungi. Aspects of taxonomy, nomenclature, developmental morphology, genetics, host-parasite relations, physiology, and ecology will be presented. Laboratories will provide opportunities to study cardinal characteristics of selected fungi representing the major groups; field observations and collecting will be included. (Offered in 1974 and alternate years.) Grand

PP 650 Colloquium in Plant Pathology. Prerequisites: PP 502 or consent of instructor. 3(3-0) F. Group discussion of prepared topics assigned by the instructor with the view of developing a thorough understanding of basic concepts and their significance in the etiology, pathogenesis, epidemiology and control of plant diseases. Attention will be given to the genesis and evolution of fundamental ideas and values and how the development of new techniques and the acquisition of new knowledge influences the advancement of plant pathology and its various specialized fields. (Offered 1975 and alternate years.) Cowling

PP 690 Seminar in Plant Pathology. Prerequisite: Consent of seminar chairman. 1(1-0) F,S. Discussion of phytopathological topics selected and assigned by seminar chairman. Graduate Staff

PP 699 Research in Plant Pathology. Prerequisites: Graduate standing, consent of instructor. Credits Arranged. Original research in plant pathology.
Graduate Staff

Politics

GRADUATE FACULTY

Professor W. J. Block, *Head*

Professors: F. V. Cahill Jr., J. T. Caldwell—*Chancellor*, A. Holtzman, R. O. Tilman—*Dean, School of Liberal Arts; Associate Professors:* H. G. Kebschull, J. M. McClain, K. S. Petersen, J. O. Williams; *Assistant Professor:* W. G. Ellis

The Department of Politics offers a program of graduate studies leading to a Master of Arts degree and a Master of Public Affairs degree.

A candidate for admission to either program must have demonstrated an aptitude for graduate study in politics; the student may also be required to take certain further undergraduate courses to make up any deficiencies that may exist in his record.

The Master of Public Affairs degree requires completion of a 36-semester hour professional program for persons who are now or hope to be employed by government or by a government related private enterprise or association.

The program requires 27 hours to be selected from courses offered by the Department of Politics. Students may concentrate either in administration, comparative political development, or American political institutions and processes. The remaining hours may be taken in another discipline, such as economics, English, history, operations research, psychology, sociology or statistics. As an alternative the student may take the remaining hours in some area of technology, such as adult education and water resources, civil engineering, forestry.

Students who enroll in the program should have completed nine hours in the social sciences (including three in government) as undergraduates and have achieved a B average in the undergraduate major.

The Master of Arts degree requires each candidate to complete 30 hours of graduate work. The candidate must concentrate (18-21 hours, including thesis) in two major fields in the Department of Politics. Major fields are to be selected from the following: political theory, American politics, comparative politics, international relations and public administration. A disciplinary minor of 9 to 12 hours outside the Department of Politics is required. In either case a student's work in a minor field must constitute a unified pattern and must contribute to one or both of the student's major fields.

In either program each student will be assigned to a graduate committee chairman for the preparation of a study which shall be subject to the approval of two other committee members, including one from outside the Department of Politics.

Scope and Method of Politics (PS 509) is required of every candidate for both degrees as are comprehensive written and oral examinations. In addition, a candidate for the Master of Arts degree must demonstrate reading proficiency in one modern language (normally German, French, Spanish or Russian) and write a thesis in one of his major areas.

FOR ADVANCED UNDERGRADUATES

PS 401 American Parties and Pressure Groups. 3(3-0) F.

PS 403 Black Americans in American Politics. Prerequisite: Six hours of social science. 3(3-0) F,S.

PS 404 Black Political Ideology. Prerequisite: Six hours of social science. 3(3-0) F,S.

PS 405 National Security Policy. Prerequisite: PS 321. 3(3-0) S,Sum.

PS 406 Politics and Policies of American State Governments. 3(3-0) F,S,Sum.

PS 421 Soviet and Soviet Bloc Foreign Policy. Prerequisite: Junior standing. 3(3-0) F,S.

PS 431 International Organization. 3(3-0) S.

PS 461 Public Opinion in Democracies. Prerequisite: Three hours of politics. 3(3-0) F,S.

PS 472 Soviet Politics. 3(3-0) F,S.

PS 473 Political Systems of New States. 3(3-0) F.

PS 475 Governments and Politics in the Middle East. Prerequisite: Junior standing in any curriculum. 3(3-0) F.

PS 493 Seminar on Theories of Political Violence and Nonviolence. Prerequisite: Junior standing. 3(3-0) S,Sum.

PS 494, 495 (SOC 494, 495) Urban Seminar. Prerequisite: Junior standing. 3 (3-0) F,S.

PS 496 Governmental Internship and Seminar. Prerequisite: Junior standing; approval of the committee of election. Credits Arranged. 3-6 S.

PS 498 Special Topics in Politics. Prerequisite: Six hours of politics. 3-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PS 500 Political Thought: Plato to the Reformation. Prerequisite: Consent of instructor. 3(3-0) F. The emergence and development of the theories underlying or explaining the political aspects of behavior, approached through the study of the writings of the principal political philosophers from the days of the Greek city-state to the Reformation. Marshall

PS 501 Modern Political Theory. Prerequisite: Consent of instructor. 3(3-0) S. A study of the state and its relationship to individuals and groups, approached through reading of selected passages from the works of outstanding philosophers from the 16th century to the present. Marshall

PS 502 (ED 502) Public Administration. Prerequisite: Consent of instructor. 3 (3-0) F,S,Sum. A study of the factors which contribute to goal displacement in public agencies and the institutions, concepts and techniques which may be used in such agencies to reduce the effects of these factors. Block, McClain, Ellis

PS 503 Comparative Administration. Prerequisite: PS 502 or PS 473 or consent of instructor. 3(3-0) F,S. Concentration will be on administrative systems of developing nations with limited attention to developed systems. The major emphasis will be on administrative aspects of governmental change and modernization in developing nations; colonial influence on administration; problems of establishing new nations and adapting to change in established states; bureaucratic development and behavior; theories of development administration. Ellis

PS 505 Contemporary Political Theory. Prerequisite: Consent of instructor. 3(3-0) S. The course will focus upon major topics in contemporary political theory, including the relationship between political science theory and political philosophy; the foundations, conditions, and prospects of democratic forms of government; bureaucratization and democratic values; theories of mass society; violence and revolution as possible instruments of democratic change; human nature and politics; and dilemmas of modern citizenship. Attention will be given to the actual and potential contributions of empirical studies to the analysis of the various topics. The range of writers studied will extend from social scientists, such as Robert Dahl and Seymour Lipset, to political philosophers, such as Leo Strauss, Herbert Marcuse, and Albert Camus. Marshall

PS 506 Public Personnel Administration. Prerequisite: PS 502 or consent of instructor. 3(3-0) Sum. A study in depth of the institutions and the sequence of processes in public personnel administration. It examines existing practices but is primarily concerned with emerging theories and trends. Ellis

PS 507 Collective Negotiations in the Public Service. Prerequisite: PS 201 or consent of instructor. 3(3-0) Sum. This course includes intensive consideration of the background of collective negotiations movement; analysis of key policy issues, such as bargaining rights and use of strike weapons; framework for collective negotiations; scope and conduct of negotiations; impasse resolution; grievance procedure. Ellis

PS 509 Scope and Method of Politics. Prerequisite: Consent of instructor. 3(3-0) F,S,Sum. This course reviews contemporary theories, concepts and methods fundamental to the study of politics. It emphasizes current empirical research and the collateral involvement in research activities aimed at the development of basic skills in this area. Williams, Rassel

PS 510 Public Finance. Prerequisite: EC 205. 3(3-0) F. A survey of the theories and practices of governmental taxing, spending, and borrowing, including intergovernmental relationships and administrative practices and problems. McClain

PS 511 The Budgetary Process. Prerequisite: Consent of instructor and at least nine hours in the social sciences including a course in American government. 3(3-0) S,Sum. A study of the generalized budgetary process used at all levels of government in the United States. Understanding of the process is based upon comprehension of the institutions involved, the roles of politicians and professionals, and the objectives of budgetary systems. The course will also focus upon budgetary reforms and the expanding Planning-Programming-Budgeting System as a management tool. McClain

PS 512 American Constitutional Theory. Prerequisite: PS 200 or an acceptable substitute. 3(3-0) F. Basic constitutional doctrines, including fundamental law, judicial review, individual rights and political privileges, and national and state power. Special attention is given to the application of these doctrines to the regulation of business, agriculture and labor and to the rights safeguarded by the First, Fifth and Fourteenth Amendments to the Constitution. Cahill

PS 513 Constitutional Theory II. Prerequisite: Advanced undergraduate or graduate standing. 3(3-0) F,S. A continuation of PS 512 but may be elected separately. An examination of leading constitutional cases, especially in the fields of civil liberties and individual rights, and the writings of leading commentators. Cahill

PS 515 American Political Thought. Prerequisite: Senior or graduate standing. 3 (3-0) F,S,Sum. The course will examine and evaluate major American writings on the nature and purpose of politics. Readings will be grouped under the following topics: (1) various interpretations of the American Constitution and the principles embodied therein; (2) writings on civil and natural rights; (3) the character of American liberalism; (4) Black American political thought and (5) the contemporary crisis in liberal thought. The purpose is to develop the independent capacity to read and reflect with care on the grounds of different views about American politics. Marshall

PS 516 Public Policy Analysis. Prerequisite: Graduate standing; advanced undergraduate standing and consent of instructor. 3(3-0) F,S,Sum. Course will focus on the theories and methodology of analyzing and explaining public policy and the sub-

stance of recent domestic policies in the human and physical resources area, including welfare, poverty, education, housing, urban renewal, transportation, recreation-conservation, and agriculture. Williams

PS 517 (SOC 517) The Police Bureaucracy in Democratic Society. Prerequisite: Senior or graduate standing. 3(3-0) S. This is a political science seminar which focuses on the proposition that police departments are bureaucratic organizations which can be studied as such. Emphasis is placed on understanding the process by which police policy is made. Internal and external, psychological and structural variables are identified in tracing decisions on specific issues. Thus, attitudes of policemen, the nature of their work, and the resources and power of various constituencies are factors seen as determining police behavior. Wentworth

PS 520 Urban Politics. Prerequisite: PS 206. 3(3-0) F,S. A comparative study of political conditions in cities and localities. Topics will include the formal structures and rules of city and metropolitan governments, and the relationships to the informal norms and distribution of power; patterns of local decision-making: elite recruitment and citizen participation; variations of local autonomy and the scope of local politics; and approaches to urban policy issues. Clary

PS 521 Problems in Urban and Metropolitan Area Government. Prerequisite: PS 206 or consent of instructor. 3(3-0) S. This course examines theory and research on problems affecting governments in metropolitan areas. Principal attention is given to those problems which affect (or result from) governmental structure, institutions, and politics and to the alternative approaches to their solution. Clary

PS 522 Seminar on War and Peace in the International System. Prerequisite: Senior standing. 3(3-0) F. This seminar will focus upon war and peace in the international system; in particular, the circumstances under which violent international conflict is likely and the factors that enhance the probability that the conflicts will be resolved by peaceful means. Consideration will not only be given to the wars and problems of the past but also to alternative future worlds in which war or peace might be prevalent. The course will focus on empirical theory and research including the work of peace theorists and futures researchers. Soroos

PS 531 The Legislative Process. Prerequisite: PS 206 or consent of instructor. 3 (3-0) S. A study of the formulation of public policy from the institutional and behavioral viewpoints. Important current legislative problems at the congressional and state legislative levels will be selected and will serve as a basis for analyzing the legislative process. Holtzman

PS 532 The Chief Executive. Prerequisite: PS 200 or 201. 3(3-0) F,Sum. This course will focus upon three major concepts of the office of the chief executive, as developed under several incumbents. First are the institutions which surround that office and which facilitate the expansion of its power and operations. Next are the various roles, which are played by different chief executives. Last are the processes of leadership by which the chief executive can attempt to direct the machinery of government to achieve predetermined objectives. Holtzman

PS 542 Governmental Planning. Prerequisite: PS 502. 3(3-0) F,Sum. A study of the planning function at all levels of government in the United States, with particular attention to the problems posed for planning by the rapid growth of metropolitan areas. McClain

PS 552 Seminar in Management Systems. Prerequisite: Six hours of graduate public administration including either PS 509 or PS 516. 3(3-0) S. A special graduate-level seminar that is to be an integral part of the Master of Public Affairs Pro-

gram in the Department of Politics. The students in this seminar will study in detail the various management systems in use in the public administration field. Through case studies and applied methodology, students in the course apply management systems theory to practical problems in the public sector. Graduate Staff

PS 572 Seminar in Comparative Politics. Prerequisite: One course in comparative politics. 3(3-0) F,S. This seminar will open with a survey of the problems and methods of comparative political analysis, after which students will be assigned a specific, limited subject to be examined within the framework of a systematic, analytical scheme appropriate to the topic. Specific topics will be drawn from the subjects of political ideologies, political groups, political elites, and decision-making institutions and processes. Kebschull

PS 573 Problems of National Integration and Institution Building in Black Africa. Prerequisite: Comparative government course or consent of instructor. 3 (3-0) S. A central problem in the political development of African nations is the building of institutions capable of creating and managing change in the face of cultural pluralism. This course will look at theories of cultural pluralism, the background and consequences of cultural pluralism in Africa, and the attempts by various political actors and institutions (e.g., "charismatic" leaders, political parties, armies, governments) to cope with the fact of cultural pluralism. Hurwitz

PS 574 Political Systems and Constraints on Development in Latin America. Prerequisite: Senior or graduate standing. 3(3-0) S. The course focuses on the adequacy of Latin America's contemporary political systems for meeting the challenges of economic development. Several different approaches to developmental problems will be studied, as well as political factors which have retarded their implementation. The political systems of Latin America will be examined, along with the value systems and power capabilities of important groups. The leftist critique of the established political systems and its relationship to contemporary guerrilla movements concludes the course. Graduate Staff

PS 575 Political Development. Prerequisite: Nine hours of political science. 3 (3-0) F. This course examines the concept, theories, characteristics and problems of political development. Within a broad historical framework, particular subjects are analyzed in relationship to political development. These subjects include, among others, political culture, political integration, political institutions, military forces, and economic development. Data derived from comparative cultural and political studies are employed in an attempt to discover patterns of change related to political development. Kebschull, Hurwitz

PS 578 Comparative Communist Systems. Prerequisite: Comparative government course or consent of instructor. 3(3-0) F,S. A study of the international Communist movement and the evolution of the international sub-system of Communist states. Focuses on the Soviet and Chinese systems as alternative models for development in Communist and non-Communist states. Additional emphasis is placed on the institutional, political and ideological similarities and differences within the Communist world and major Communist parties outside the Communist state system.
Mastro

PS 590 Topics in Political Theory. Prerequisite: Senior or graduate standing. 3 (3-0) F,S. A close examination of particular topics or theorists that are not included in the basic courses in political theory. Course content changes in different years, and, with permission of instructor, the course may be repeated for credit. Examples of course topics are: "Foundations of Modern Radicalism," "Twentieth Century Political Philosophy and Political Science," "Political Philosophy and the Problem of Law," and "Origins of Political Science." Marshall

FOR GRADUATES ONLY

PS 601 Seminar in Party and Group Politics. Prerequisite: PS 401 and consent of instructor. 3(3-0) S. This course examines in depth such problems as mobilization of consent, recruitment of leaders, financing and conduct of campaigns, nomination processes, interparty and intraparty politics, party-interest group relations and ideology, and party-interest group relations with government and public policy. Short research papers will be required, some of which will be presented and evaluated in class. Holtzman

PS 602 Seminar in Legislative Problems. Prerequisite: Graduate standing and consent of instructor. 3(3-0) S. This seminar considers basic problems characteristic of American legislative systems: development and maintenance for formal and informal rules of the game; relationships between outside inputs (by parties, interest groups, constituents, executives, courts) and legislators; strategies and tactics of leadership; committee decision-making, roles and role behavior of legislators; bicameral and apportionment problems. Each student is required to do extensive reading, to interview legislators and those who seek to influence them and to prepare reports. Holtzman

PS 603 Seminar in Administrative Problems. Prerequisite: PS 502 or equivalent. 2-4. S,Sum. An advanced course in administrative principles and methods. Students will perform individual or group research, under supervision in specific administrative topics within the context of those public agencies which function in their respective fields of technology. Block

PS 604 Seminar in Judicial Problems. Prerequisite: Graduate standing; PS 533 or equivalent. 3(3-0) F. Building on previously acquired familiarity with the judicial process, this course requires the students to work in depth on one or more contemporary judicial problems and to use various research techniques in his study. Cahill

PS 605 Seminar in Organizational Theory. Prerequisite: PS 502. 3(3-0) F,S. A seminar in which the students read, analyze and discuss the original writings of some of the major theories of organizational structures and behavior. It will focus upon classical management theory, the human relations theories, and recent empirical and integrative organizational theories. Among the writers upon whose works the seminar will focus are Max Weber, Mary Parker Follett, Luther Gulick, Frederick Taylor, Elton Mayo, F. J. Roethlisberger, Chester Barnard, Herbert Simon, Amiti Etzioni, Robert Presthus, Victor Thompson, and Robert Golembiewski. Organization theories are based upon studies of both private and public organizations, so the literature of both areas is relevant. However, most of the emphasis upon current theories will focus on the public or governmental sector. Ellis, Block

PS 606 Seminar in Policy and Administration. Prerequisite: PS 505 and three additional hours in administration. 3(3-0) F. A seminar in theories and techniques of administration in applied situations, using case study techniques. McClain

PS 621 Seminar in International Politics. Prerequisite: Graduate standing and consent of instructor. 3(3-0) F. Examination in depth of selected theories, practices and problems of international politics. Petersen

PS 696 Seminar in Politics. Prerequisite: Advanced graduate standing. 2-4 F. An independent advanced research course in selected problems of government and politics. The problems will be chosen in accordance with the needs and desires of the students registered for the course. Graduate Staff

PS 699 Research in Politics. Prerequisite: Graduate standing and approval of adviser. Credits Arranged F,S. Research for writing of master's thesis.
Graduate Staff

Poultry Science

GRADUATE FACULTY

Professor R. E. Cook, *Head*

Professors: H. L. Bumgardner, W. E. Donaldson, E. W. Glazener, P. B. Hamilton, C. H. Hill Jr.; *Extension Professor:* J. R. Harris; *Associate Professors:* W. M. Colwell, J. P. Thaxton Jr.; *Assistant Professors:* D. M. Briggs, J. D. Garlich, W. R. Prince, D. G. Simmons; *Extension Assistant Professor:* M. H. Gehle

The Department of Poultry Science offers the Master of Science degree in poultry science. Doctoral programs are offered in the disciplines of microbiology, physiology, genetics and nutrition.

The Department of Poultry Science occupies Scott Hall, a building containing well-equipped laboratories, animal rooms and offices. Additional research facilities are located on the University farms and the Piedmont Research Station.

The Dearstyne Avian Health Center, a three-building complex, is used in connection with special research projects related to disease resistance and treatment of various pathological conditions. The complex is made up of animal isolation rooms, biochemical laboratories and related facilities.

The research program is comprehensive and includes fundamental studies in nutrition, physiology, genetics, pathology and microbiology. In addition, investigation of problems of more practical urgency is undertaken when appropriate.

The demand for men and women with advanced training in poultry science is far greater than the supply. Opportunities exist for graduates in research in universities, in government and in private industry. The extension service is anxious to hire properly trained persons in this field. The industry is seeking properly trained people to fill management positions.

FOR ADVANCED UNDERGRADUATES

PO 401 Poultry Diseases. 4(3-3) S.

PO 402 Commercial Poultry Enterprises. 4(3-3) S. Required of technology and business majors in poultry science; elective for others with consent of instructor.

PO 404 (FS 404) Poultry Products. 3(2-3) F. (See food science, page 152.)

PO 405 Avian Physiology. Prerequisite: CH 220. 4(3-3) S.

PO 415 (ANS 415, NTR 415) Comparative Nutrition. Prerequisite: CH 220 or CH 221. 3(3-0) F.

PO 490 Poultry Seminar. 1(1-0) F,S. Required of seniors in poultry science.

PO 495 Special Problems in Poultry Science. Prerequisite: Junior standing and consent of instructor. 1-6 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PO 520 (GN 520) Poultry Breeding. Prerequisite: GN 411. 3(2-2) F. Application of genetic principles to poultry breeding, considering physical traits and physiological characteristics—feather patterns, egg production, hatchability, growth, body conformation and utility. Briggs

PO 524 (ZO 524) Comparative Endocrinology. Prerequisite: ZO 414 (BO 414) or ZO 421. 4(3-3) S. Study of the endocrine system with respect to its physiological importance to metabolism, growth and reproduction. Prince

FOR GRADUATES ONLY

PO 698 Special Problems in Poultry Science. Prerequisite: Graduate standing. Maximum 6 F,S. Specific problems of study are assigned in various phases of poultry science. Graduate Staff

PO 699 Poultry Research. Prerequisite: Graduate standing. Credits Arranged F,S. A maximum of six credits is allowed towards a master's degree. Appraisal of present research; critical study of some particular problem involving original investigation. Problems in poultry breeding, nutrition, disease, endocrinology, hematology or microbiology. Graduate Staff

Product Design

GRADUATE FACULTY

Associate Professor V. M. Foote, *Acting Head*

Professors: J. H. Cox, C. E. McKinney, D. R. Stuart; *Associate Professors:* G. L. Bireline, D. A. Masterton; *Assistant Professor:* A. V. Cooke

The Department of Product Design offers programs of study in product and visual design leading to the Master of Product Design.

All students with a four-year undergraduate degree shall be required to complete a minimum of 48 hours of course work of which approximately 70 percent will be in the major field and the remainder elected from various specialized areas. All students with a five-year undergraduate degree shall be required to complete a minimum of 30 hours of course work of which approximately 70 percent will be in the major field and the remainder elected from various specialized areas.

The program of course work to be followed by the student and the terminal project is under the direction of the student's graduate committee. The terminal pro-

ject shall continue the final test of the candidate's mastery of his design studies. The project shall be developed in the design studio or special projects framework in the sixth year and shall consist of an in-depth investigation of an approved problem which relates product or visual design studies to the student's minor field. Group projects, with a maximum of three students collaborating, may be permitted by special arrangement, if the problem to be explored is sufficiently broad or its nature requires a wide range of investigation.

Admission—Applicants for this program may come from the following sources:

1) Graduates of approved schools of product design.
2) Graduates of approved programs of industrial design.
3) Graduates of accredited schools of engineering.
4) Graduates of accredited schools of architecture.
5) Graduates of approved schools of visual design.
6) Under special circumstances, students with degrees in fields other than design. In these latter instances an advisory committee will evaluate the applicant's preparation with regard to design capabilities and professional competence.

In addition, course offerings are available to any graduate student who can demonstrate reasonable competence or equivalent qualifications for prerequisites in the requested courses.

All applicants, in addition to meeting the requirements of the Graduate School, must meet the special requirements of the Department of Product Design with regard to design capabilities and professional competence.

FOR ADVANCED UNDERGRADUATES

PD 400 Intermediate Product Design (Series). Prerequisite: DN 202 or equivalent or consent of department. 4(6-3) F,S.

PD 411, 412 Applied Physical Principles. Prerequisite: Intermediate design standing. 3(2-2) F,S.

PD 421, 422 Colloquium III, IV. 1(1-0) F,S.

PD 431, 432 Office and Industrial Practice I, II. 1(1-0) F,S.

PD 440 Intermediate Visual Design (Series). Prerequisite: DN 202 or equivalent or departmental approval. 4(6-3) F,S.

PD 490 Intermediate Special Projects (Series). 2-4 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PD 501, 502 Product Design V, VI. Prerequisite: PD 400 or graduate standing. 6 (3-12) F,S. PD 501—Unlimited production systems designed with object(s) possibilities produced additively of new synthetic materials utilizing new molecular joining for national class and age groups. PD 502—Unlimited production systems design with object(s) possibilities produced additively of new synthetic materials utilizing new molecular joining for international class and age groups. (Individually selected problems within interdisciplinary team organizations.) NOTE: It shall be assumed that the program is cumulative and that these statements are problem parameters, exclusive of communication requirements.

PD 511, 512 Materials and Processes V, VI. Prerequisite: Graduate standing. 2 (1-3) F,S. Advanced studies in mass production processes and their influence on design. Emphasis is placed on material search and process selection in relation to cost, function, human factors, form, finishes and joining methods, as indicated by the current design projects in which the students are involved.

PD 532 Office and Industrial Practice. Prerequisite: PD 432 or graduate standing. 1(1-0) F,S. Advanced studies and procedures of professional product design practice, product and industrial planning and patent law.

PD 541, 542 Advanced Visual Design I, II. Prerequisites: ARC 400, LAR 400, PD 400 and PD 440; waiver of prerequisite is at the discretion of the instructor. 6(3-9) F,S. Application of previous studies in design and visual communications to a wide variety of visual problems presented by our physical environment.

PD 590, 591 Special Projects. 2-4 F,S. Special projects of an interdisciplinary nature, guided by various faculty specialists involved in areas supplementary to product design. Emphasis placed on latest technological development of new materials. Also emphasis on concept of new useful designs for the mass market. The production aspects of products such as materials, processes, functions, human factors, form, sales appeal, finishing and assembly methods and packaging will be stressed in special project designs.

FOR GRADUATES ONLY

PD 601, 602 Advanced Product Design VII, VIII. Prerequisites: PD 501, 502 or graduate standing. 6(0-18) F,S. Continuation of PD 501, 502 at an advanced level. Unlimited production systems designed with object(s) possibilities produced additively of new synthetic materials utilizing new molecular joining for international class and age groups.

PD 631, 632 Advanced Concepts in Product Engineering. Prerequisites: PD 502, graduate standing. 3(3-0) F,S. Group investigation of advanced concepts in product design with emphasis on engineering. Engineering principles play an important role in the design of useful products. The scope of this course will include mass movement of persons as well as the designs of consumer products. The field of transportation and consumer products are fast changing to satisfy the needs of the present and future generations. The product designer is to be made aware of these needs by special investigations into future technologies and future material developments.

Psychology

GRADUATE FACULTY

Professor H. G. MILLER, *Head*

Professors: H. M. CORTER, D. W. DREWES, J. C. JOHNSON, S. E. NEWMAN, R. G. PEARSON; *Professor Emeritus:* K. L. BARKLEY; *Visiting Professor:* R. G. HAYDEN; *Associate Professors:* J. L. COLE, J. W. CUNNINGHAM, T. E. LEVERE, J. MAGILL, B. A. NORTON, J. L. WASIK, B. W. WESTBROOK; *Adjunct Associate Professors:* MARGARET N. WIEBE, R. W. OPPENHEIM; *Assistant Professors:* J. E. R. LUGINBUHL, D. H. MERSHON, RACHEL F. RAWLS, F. J. SMITH; *Adjunct Assistant Professor:* BRENDA C. BALL

The Department of Psychology offers courses of study leading to the Master of Science and Doctor of Philosophy degrees. Specialization in community clinical psychology, experimental psychology, human factors engineering, social psychology, school psychology and human resource development is available.

A minimum of 30 semester hours of graduate credit is required for the master's degree. Though no minimum number of additional hours is required for the doctoral degree, the student may expect to take 30 or more additional semester hours of graduate credit. In any case, both for master's and doctoral candidates, the actual graduate program for each student is determined on the basis of individual needs, interests and accomplishments. Admission requirements for the beginning graduate student in the Department of Psychology are: satisfactory grades in all undergraduate work and at least a "B" average in undergraduate psychology courses and in the undergraduate major; satisfactory scores on the Graduate Record Examination (including the advanced test in psychology for undergraduate psychology majors, or, for non-psychology majors, the advanced test in the undergraduate major) and the Miller Analogies Test; and three satisfactory letters of recommendation in regard to quality of work and character. It is possible to enter the program without undergraduate coursework in psychology but, as a general rule, some preparation in experimental psychology, statistics and mathematics is desirable.

Admission requirements for students already possessing the master's degree who wish to obtain the doctorate in psychology are: a minimum of a "B" average in their graduate work and a substantial background in psychology or related fields; satisfactory grades in undergraduate studies; satisfactory scores on the Graduate Record Examination including the advanced test in psychology (if the applicant's master's degree is in a field other than psychology, he should also submit the advanced score in that field and the Miller Analogies Test; and three satisfactory letters of recommendation in regard to quality of work and character.

Research and teaching assistantships and fellowships are available to qualified graduate students. The assistantships are usually based on one-third time assignments but are occasionally for one-half time.

FOR ADVANCED UNDERGRADUATES

PSY 411 Social Psychology. Prerequisite: PSY 200. 3(3-0) S.

PSY 475 Child Psychology. Prerequisite: PSY 200 or PSY 304. 3(3-0) S.

PSY 476 Adolescent Psychology. Prerequisite: PSY 200 or PSY 304. 2(2-0) F,S.

PSY 491, 492 Seminar in Psychology. Prerequisites: Senior standing, consent of department. 3(3-0) F,S.

PSY 493 Special Topics in Psychology. Prerequisite: Consent of instructor. 1-6 F,S.

PSY 495 Human Resource Development Practicum. Prerequisites: Junior standing, PSY HRD option; PSY 350, PSY 351, PSY 352, SP 231. 8(0-8) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

PSY 500 Perception. Prerequisite: Graduate standing. 3(2-2) S. The first half of the course will be a summary and analysis of the major classes of variables affecting perception. The data will be examined in the context of the development of theories of perception with emphasis on the general problem of scientific method and theory construction as well as the specific content of perceptual theory. The second half of the course will summarize and analyze the major modes of thinking and the variables affecting the thinking process. Special emphasis will be placed on the relationship between perception and thinking, and number of the theories of thinking will be evaluated. Mershon, Newman

PSY 502 Physiological Psychology. Prerequisite: Twelve hours of psychology, including PSY 200, PSY 300, PSY 310. 3(3-0) F. A survey of the physiological bases of behavior including the study of coordination, sensory processes, brain function, emotions and motivation. LeVere

PSY 503 (ZO 503) Comparative Psychology. Prerequisites: PSY 310 and BS 100 or consent of instructor. 3(3-0) S. Covers the history of the study of the comparative behavior of organisms; methodological and theoretical problems peculiar to comparative psychology, with emphasis on the ontogeny and evolution of behavior in vertebrate animals.

PSY 504 Advanced Educational Psychology. Prerequisite: Six hours of psychology. 3(3-0) F,S. A critical appraisal of current psychological findings that are relevant to educational practice and theory. Johnson

PSY 510 Learning and Motivation. Prerequisite: Graduate standing. 3(3-0) F,. A systematic analysis of some of the major classes of variables determining behavioral change. Learning variables are analyzed within their primary experimental setting, and emphasis is upon the diversity of the functions governing behavior change rather than upon the development of some comprehensive theory. Both learning and motivational variables are examined as they contribute to changes in performance within the experimental setting. Cole, Newman, Pearson

PSY 511 Advanced Social Psychology. Prerequisite: Graduate standing or consent of instructor. 3(3-0) S. A survey of theory and research in social psychology through reading and discussion of primary source materials. In addition, the course will deal with issues of methodology, ethical questions in social psychological research and application of research findings to the world at large. Luginbuhl

PSY 514 Logical Foundations of Behavioral Analysis. Prerequisite: Graduate standing in psychology. 3(3-0) F. An analysis of fundamental considerations involved in the formulation and verification of theories of behavior. Such topics as operationalism, formalism, reductionism, logical analysis and the nature of truth in empirical sciences will be introduced and related to research in various areas of psychological interest. The objectives are to provide insight into the nature of scientific research, to foster the ability to derive empirical, hypotheses, to develop facility in designing experimental tests of hypotheses, and to promote effective writing and speaking about psychological theory and experimentation. Drewes

PSY 520 Cognitive Processes. Prerequisite: Graduate standing. 3(2-2) F. This course will emphasize the results from research on a number of complex processes (e.g., remembering, concept learning, acquisition and use of language) and the theories that have been proposed to explain these results. Newman

PSY 530 Abnormal Psychology. Prerequisites: PSY 200, PSY 302. 3(3-0) S. A study of the causes, symptomatic behavior and treatment of the major personality

disturbances. Emphasis will be placed on theory, experimental psychopathology and preventive measures. Corter, Wiebe

PSY 531 (ED 531) Mental Deficiency. 3(3-0) S,Sum. (See education, page 126.)

PSY 532 Psychological Aspects of Exceptionality. Prerequisite: Consent of instructor. 3(3-0) S,Sum. The course is designed to give consideration to effects of severe deficiency (sensory, physical, mental, etc.) arising from any causes at any stage of life; the personal and social ramifications of these; and possible courses of intervention; as well as utilization of psychological theory and clinical information in interpreting probable implications. Research findings related to sensory deprivation, research needs and possible research projects will be discussed. Rawls

PSY 535 Tests and Measurements. Prerequisite: Six hours of psychology. 3(3-0) F,S. A study of the principles of psychological testing including norms and units of measurement, elementary statistical concepts, reliability and validity. In addition, some attention is devoted to the major types of available tests such as general intellectual development, tests of separate abilities, achievement tests, measures of personality and interest inventories. Westbrook

PSY 540 (IE 540) Human Factors in Systems Design. 3(3-0) S. (See industrial engineering, page 172.)

PSY 545 Fundamentals of Skill. Prerequisite: Graduate standing. 3(3-0) Alternate F. Fundamentals of human perceptual, cognitive, and sensory-motor abilities that are basic to skilled performance. Treatment of such topics as channel capacity, short-term memory, stress, fatigue, arousal theory, task taxonomy, skill acquisition, proficiency decrement, information feedback, and performance analysis. Problems of attention, search, monitoring, tracking, complex tasks, and skill maintenance.

PSY 565 Organizational Psychology. Prerequisite: Nine hours of psychology. 3 (3-0) S. A study of the application of behavioral science, particularly psychology and social psychology, to organizational and management problems. Miller

PSY 570 Theories of Personality. Prerequisite: Graduate standing. 3(3-0) F. A review of theories of personality, with emphasis on research, application in psychotherapy and measurement, and principles involved in similarities and differences among them. Corter

PSY 571 Individual Intelligence Measurement. Prerequisite: PSY 570. 3(3-0) S. A practicum in individual intelligence testing with emphasis on the Wechsler Bellevue, Stanford-Binet, report writing and case studies.

PSY 576 Developmental Psychology. Prerequisite: Nine hours of psychology, including PSY 475 or PSY 476. 3(3-0) F. A survey of the role of growth and development in human behavior, particularly during the child and adolescent periods. This course will pay particular attention to basic principles and theories in the area of developmental psychology. Johnson

PSY 578 Individual Differences. Prerequisite: Six hours of psychology. 3(3-0) F,S. Nature, extent and practical implications of individual differences and individual variation. Graduate Staff

PSY 591 Area Seminar in Clinical-Community Psychology. Prerequisite: Consent of instructor. 1-3, Maximum 6. F,S. The following topics will be dealt with: (1) the development of clinical-community psychology as an area of study, (2) methods of inquiry, (3) contemporary issues, (4) ethical questions, (5) relationship to other areas within psychology. Graduate Staff

PSY 592 Area Seminar in Experimental Psychology. Prerequisite: Graduate standing in psychology. 1-3, Maximum 6. F,S. The following topics will be dealt with: (1) the development of experimental psychology as an area of inquiry, (2) methods of inquiry, (3) contemporary issues, (4) ethical questions, (5) relationship to other areas within psychology. Graduate Staff

PSY 593 Area Seminar in Human Factors Engineering. Prerequisite: Graduate standing. 1-2, Maximum 3. F,S. Introduction to human factors engineering as an area of study; historical aspects; contemporary issues; ethical questions; overview of campus research, facilities and courses in the area; consideration of information sources, financial support for research proposals and employment opportunities. Pearson

PSY 594 Area Seminar in Human Resources Development. Prerequisite: Consent of instructor. 1-3, Maximum 6. F,S. The following topics will be dealt with: (1) human resources development as an area of inquiry, (2) methods of inquiry, (3) contemporary issues, (4) ethical questions, (5) relationship to other areas within psychology. Graduate Staff

PSY 595 Area Seminar in School Psychology. Prerequisite: Graduate standing. 1-3, Maximum 6. F,S. The following topics will be dealt with: (1) the development of school psychology as a professional area, (2) methods of inquiry, (3) scientific and theoretical bases, (4) contemporary issues, (5) ethical questions, (6) relationship to other areas within psychology. Graduate Staff

PSY 596 Area Seminar in Social Psychology. Prerequisite: Graduate standing. 1-3, Maximum 6. F,S. This course will deal with the following topics: (1) a survey of areas within social psychology, (2) methods of inquiry, (3) contemporary issues, (4) ethical questions, (5) the relation of social psychology to other branches of psychology, to other disciplines, and to society and its problems. Graduate Staff

PSY 599 Research Problems in Psychology. Prerequisite: Consent of instructor. Credits Arranged. F,S. Research project for graduate students supervised by members of the graduate faculty. Research to be elected on basis of interest of student, and is not to be part of thesis or dissertation research. Graduate Staff

FOR GRADUATES ONLY

PSY 602 Physiological Psychology. Prerequisites: PSY 502 and/or consent of instructor. 3(3-0) S. Psychology 602 is the sequel to Psychology 502 and will concentrate on relating the neuroanatomy and neurophysiology studied in PSY 502 to overt observable behaviors such as sleep-waking, motivation-emotion, and reflexive and learned behaviors. LeVere

PSY 603 Verbal Learning and Verbal Behavior. Prerequisites: PSY 510, PSY 514. 3(3-0) S. This course will provide opportunity for exploration in depth of verbal-learning research studying acquisition, transfer and retention and the theories that have been proposed to explain the results of this research. Implications of findings from verbal-learning research for understanding concept learning, problem-solving and the acquisition and use of language will also be explored. Newman

PSY 604 Classical Conditioning. Prerequisites: PSY 510, PSY 514. 3(3-0) F. The origins of classical conditioning theory and methodology will be traced from Sechenov, Bechterev and Pavlov through the recent Russian and American work. The influence of the classical conditioning paradigm on American psychology as expressed in learning theory and the conditioning therapies will be examined.

PSY 605 Instrumental Learning. Prerequisites: PSY 510, PSY 514. 3(3-0) S. A systematic analysis of various experimental techniques and alternative data languages for the study of instrumental learning. Primary orientation will be upon what is happening in the experimental situation rather than upon theoretical explanations of the data. Special problems, for example, discrimination, avoidance chaining and reinforcement schedules, will be studied in depth. Various models for description of the data will be compared with special emphasis upon mathematical learning models. Cole

PSY 607 Advanced Industrial Psychology I. Prerequisite: Nine hours of psychology and statistics or concurrent with statistics. 3(3-0) S. Application of scientific methods to the measurement and understanding of industrial behavior.
Drewes, Miller

PSY 608 Advanced Industrial Psychology II. Prerequisite: PSY 607. 3(3-0) F. Application of scientific methods to the measurement and understanding of industrial behavior. Drewes, Miller

PSY 610 Theories of Learning. Prerequisites: PSY 510, PSY 514. 3(3-0) F or S. The objectives of this course are to promote learning of the theories currently used to explain how learning and forgetting occur so that testable consequences of these theories can be derived and so that the theories and their testable consequences are capably written and spoken about. Cole, Newman

PSY 611 Social Psychology: Small Groups Research. Prerequisite: PSY 511. 3 (3-0) S. Factors that determine the pattern of interaction within small groups will be examined. Some factors to be considered are social norms, roles, communication networks, power and status hierarchies and types of leadership. Conformity behavior, affiliative behavior and techniques of interpersonal influence will also be analyzed. The role of interpersonal perception and individual differences in social behavior will be examined. Luginbuhl

PSY 635 Psychological Measurement. Prerequisites: ST 507, 511 or equivalent, 12 hours of psychology. 3(3-0) F. Theory of psychological measurement. Statistical problems and techniques in test construction. Cunningham, Drewes

PSY 640 (IE 640) Skilled Operator Performance. 3(3-0) S. (See industrial engineering, page 173.)

PSY 672 Personality Measurement. Prerequisite: PSY 570, PSY 571. 3(2-3) S. Theory and practicum in individual personality testing of children and adults with emphasis on projective techniques, other personality measures, report writing and case studies. Corter

PSY 674 Psychological Intervention I. Prerequisite: PSY 672, PSY 530 and approval of instructor. 3(2-2) F. This course is designed to examine theories, research, techniques, ethics and professional responsibilities related to approaches to psychological intervention. Types of psychological intervention to be studied will include behavior modification, milieu approaches, crisis intervention techniques and group process methods, in addition to more intensive relationship approaches. A close integration of experiences, content and supervision will be emphasized in a variety of professional settings with a wide range of personal problems and age groups.
Norton

PSY 675 Psychological Intervention II. Prerequisite: PSY 674. 3(2-2) S. The primary purpose of this course is to provide students opportunities to acquire information, conceptual frameworks, interpersonal skills and a sense of ethical responsibi-

lity, all of which are basic to their further development as practicing psychologists. A major effort in the course is made to help the student increase his interpersonal skills as a means of promoting the psychological growth and effectiveness of others. Norton

PSY 690 Seminar in Industrial Psychology. 3(3-0) F,S. Scientific articles, analysis of experimental designs in industrial psychology and study of special problems of interest to graduate students in industrial psychology. Drewes, Miller

PSY 691 Special Topics in Psychology. Prerequisite: Graduate standing, consent of instructor. 1-3 F,S. Course will provide opportunity for exploration in depth of advanced topical areas which, because of their degree of specialization, are not generally involved in other courses, for example, multivariate methodology in psychology, computer simulation, mathematical model building. Some new 600-level courses will first be offered under this title during the developmental phase and as such may involve lectures and/or laboratories. Graduate Staff

PSY 693 Psychological Clinic Practicum. Prerequisite: Nine hours in psychology. Maximum 12 F,S. Clinical participation in interviewing, counseling, psychotherapy and administration of psychological tests. Practicum to be concerned with adults and children. Corter

PSY 696 Advanced Problems in Perception. Prerequisites: PSY 500, PSY 514. 3 (2-2) F. Advanced topics in perception will be the subject matter of this course. Topics will include a survey and analysis of contemporary trends in perceptual research and theory. Mershon

PSY 697 (ED 697) Advanced Seminar in Research Design. 3(3-0) S. (See education, page 133.)

PSY 699 Thesis and Dissertation Research. Prerequisites: Graduate standing, consent of instructor. Credits Arranged F,S. Individual or group research problems; a maximum of six credits is allowed toward the master's degree, but any number toward the Ph.D. degree. Graduate Staff

Recreation Resources Administration

GRADUATE FACULTY

Professor T. I. HINES, *Head*

Professor: W. E. SMITH; *Associate Professors:* G. A. HAMMON, L. L. MILLER, R. E. STERNLOFF; M. R. WARREN JR.

The Department of Recreation Resources Administration offers programs of study leading to the Master of Science and Master of Recreation Resources degrees. The programs are based on an interdisciplinary approach and are designed to meet the problems and opportunities posed by changing social forces which affect the recreation profession. Students pursuing these degrees will have an opportunity to develop an understanding of the relationship between recreation and disciplines such as forestry, wildlife management, horticulture, landscape design, conservation, economics, politics, sociology and anthropology.

The Master of Science degree is designed to enhance in advanced students scholarly development and a more adequate comprehension of the requirements and responsibilities essential for independent research. A student will be required to complete a minimum of 30 hours of graduate work. The program will consist of a major and minor field of study. The minor may be concentrated wholly in a different discipline or may consist of courses selected from the offering of two departments. In either case, the minor field must constitute a unified pattern and must contribute to the student's education in the major field. A high degree of flexibility is maintained to permit each student's program to be structured to meet individual needs.

Each candidate for the Master of Science degree will be required to complete a thesis representing an original investigation as a part of the minimum requirements for the degree.

The Master of Recreation Resources degree is designed for students who are interested in the more advanced applications of administrative principles in specialized areas of the recreation field. Students for this degree will usually terminate their graduate program upon completion of the master's degree. Requirements for the Master of Recreation Resources degree include a minimum of 36 hours of course work, and in lieu of a thesis, the student will be required to complete a departmental course in research and a problem report.

FOR ADVANCED UNDERGRADUATES

RRA 440 Recreation Resource Inventory and Planning. Prerequisite: RRA 241. 3 (2-2) F,S.

RRA 441 Recreation Resource Development. Prerequisite: RRA 241. 3(3-0) F,S.

RRA 442 Wildland Recreation Environments. Prerequisite: Junior standing. 3 (2-3) F,S.

RRA 451 Facility and Site Planning. Prerequisites: RRA 215 and RRA 216. 3(0-6) F,S.

RRA 453 Administrative Policies and Procedures. Prerequisite: RRA 359. 3(3-0) F,S.

RRA 454 Recreation and Park Finance. Prerequisites: Six hours recreation resources administration courses, senior standing. 3(3-0) F,S.

RRA 491 Special Problems in Recreation. Prerequisite: Consent of department. 3 (2-2) F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

RRA 500 Theories of Leisure and Recreation. Prerequisite: Nine hours of RRA courses. 3(3-0). Analysis of leisure and recreation and a study of their origin and development as revealed by man's behavioral patterns. Interpretation of the influence and social significance of leisure and recreation concepts on contemporary American culture and their implications on future recreation thought and action. Warren

RRA 501 Theory Development in Recreation Research. Prerequisites: ST 311 and SOC 416. 4(3-2). Review of the historical emphasis of recreation research with analyses of various approaches to research design and model building. Examination of the philosophy of social scientific investigation, and possible application of existing behavioral theory to recreation research with a special emphasis on efforts to develop theory useful in explaining use of leisure time. Graduate Staff

RRA 538 Recreation for Special Populations. 3(3-0). Emphasis on the leisure concerns of deprived groups with exposure to the status, problems, and community service needs of special populations found in most American communities. Special populations include the physically disabled, the mentally retarded, the aging, and the economically deprived. Sternloff

RRA 591 Recreation Resources Problems. Prerequisite: Advanced undergraduate or graduate status. 1-4. Assigned or selected problems in the field of recreation administration, planning, supervision, maintenance, operations, financing, or program. Special research problems selected on basis of interest of students and supervised by members of the graduate faculty. Graduate Staff

FOR GRADUATES ONLY

RRA 691 Seminar in Recreation Administrative Policies. Prerequisite: RRA 501 or equivalent. 2(0-4). Advanced course in administrative principles; students do individual and group research, under supervision, in specific administrative categories of study in the field of recreation. Independent study and research required of students who must develop written and oral presentations for critical analyses by graduate students and faculty. Hines

RRA 692 Advanced Problems in Recreation. Prerequisite: Twelve hours of RRA courses. Credits Arranged. Directed research in a specialized phase of recreation other than a thesis problem. Graduate Staff

RRA 699 Research in Recreation. Prerequisite: Twelve hours of RRA courses. Credits Arranged. Original research preliminary to writing a master's thesis. Graduate Staff

Sociology and Anthropology

GRADUATE FACULTY

Professor S. C. MAYO, *Head*

Professors: L. W. DRABICK, G. C. MCCANN—*Graduate Administrator*, C. P. MARSH, J. N. YOUNG; *Extension Professor:* J. D. GEORGE; *Professor Emeritus:* C. H. HAMILTON; *Associate Professors:* W. B. CLIFFORD II, A. C. DAVIS, C. V. MERCER, R. D. MUSTIAN, H. D. RAWLS, M. M. SAWHNEY, ELIZABETH M. SUVAL, O. UZZELL; *Extension Associate Professor:* M. E. VOLAND; *Visiting Associate Professor:* H. D. HOLDER; *Assistant Professors:* R. C. BRISSON, C. G. DAWSON, G. L. FAULKNER, R. L. MOXLEY, G. S. NICKERSON, D. J. STEFFENSMEIER, R. C. WIMBERLEY; *Adjunct Assistant Professor:* J. L. FRANKLIN; *Extension Assistant Professor:* C. E. LEWIS

The Department of Sociology and Anthropology offers a program of study leading to the Doctor of Philosophy degree with a major in sociology. The department also has programs leading to the Master of Sociology degree (nonthesis) with a major in sociology and the Master of Science degree with a major in rural sociology. The curriculum includes several major areas of interest: community and area development; demography; planned change; social change and development; and deviancy and rehabilitation. The core program includes sociological theory, research methods and quantitative analysis. Special attention is given in the curriculum to the development of sociological skills involved in an understanding of social factors and public policies as they affect regional, national and international development.

Graduate students on assistantships and fellowships are usually provided with office space and equipment. Computational facilities are available for students whose research problems involve extensive analyses of data as well as for those students who want to learn to do their own programming. Computing facilities available to students and faculty in the department are described on page 22.

The department has the responsibility for a state-wide program in community and area development. This provides an excellent laboratory for both personal observation and research, and graduate students are encouraged to use the facilities and other resources of this program in extended education.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ANT 511 Anthropological Theory. Prerequisites: Six hours sociology, ANT 252 and ANT 305 or equivalent. 3(3-0) F. This course approaches anthropological theory from both an historical and contemporary point of view. The central concern is with the key anthropological concept of culture and its significance for understanding man and his works. Graduate Staff

ANT 512 Applied Anthropology. Prerequisite: ANT 252 or consent of instructor. 3 (3-0) F,S. The course includes a review of the historical development of applied anthropology and a study of anthropology as applied in government, industry, community development, education and medicine. The processes of culture change are analyzed in terms of the application of anthropological techniques to programs of developmental change. Graduate Staff

SOC 501 (ED 501) Leadership. Prerequisite: SOC 202 or equivalent. 3(3-0) F,S.A study of leadership in various fields of American life; analysis of the various factors associated with leadership; techniques of leadership. Particular attention is given to recreational, scientific and executive leadership procedures. Young

SOC 502 Society, Culture and Personality. Prerequisite: SOC 202 or equivalent. 3 (3-0) F,S. Human personality is studied from its origins in primary groups through its development in secondary contacts and its ultimate integration with social norms. While comparative anthropological materials will be drawn upon, emphasis is placed upon the normal personality and the adjustment of the individual to our society and to our culture. Dynamics of personality and character structure are analyzed in terms of the general culture patterns and social institutions of society.
Uzzell

SOC 503 Contemporary Sociology. Prerequisite: Graduate standing. 3(3-0) F,S. The basic purpose of this course is to provide the student with an overview of the

current status of sociological theory and research. It will introduce the student to contemporary sociological thinking and research and provide a base for further graduate training in the discipline. Marsh

SOC 504 Education in Modern Society. Prerequisites: SOC 202, SOC 301, or equivalent. 3(3-0) F,S. An analysis of education using basic sociological concepts. Varying emphases will be placed upon the historical development of education in the United States, cross-cultural comparisons of educational structure and function, professionalization of educators, investigation of the ecological factors affecting education, effects of group processes upon learning, and the effects of social processes and changes upon the educational institution. Drabick

SOC 505 The Sociology of Rehabilitation I. Prerequisite: Graduate standing and/or consent of instructor. 3(3-0) F. The area of disability of handicap is introduced from a conceptual and theoretical standpoint. Sociological and social-psychological aspects of handicaps, the rehabilitation processes, and rehabilitative organizations are stressed throughout. Particular attention is given to rehabilitation of the sociology of work in the rehabilitation processes. Socio-cultural factors in disability and handicap (residence, social class, family relationships, etc.) are analyzed in depth. Rawls

SOC 506 The Sociology of Rehabilitation II. Prerequisite: Graduate standing and/or consent of instructor. 3(3-0) S. Students will be expected to engage in individual research projects on a specific handicap, a rehabilitation process or a rehabilitative agency or subagency. An attempt will be made through lectures and discussions to give the student perspective concerning the actual work of rehabilitation in process while he is pursuing his specialized interest. Emphasis will be placed on sociological methods and techniques applicable to the study of the above aspects of social behavior. Graduate Staff

SOC 509 Population Problems. Prerequisite: SOC 202 or equivalent. 3(3-0) F. A study of population growth, rates of change and distribution. Considerable attention is given to the functional roles of population, i.e., age, sex, race, residence, occupation, marital status and education. The dynamic aspects of population are stressed: fertility, mortality and migration. Population policy is analyzed in relation to national and international goals. A world view is stressed throughout. Clifford

SOC 510 Industrial Sociology. Prerequisite: SOC 202 or equivalent. 3(3-0) F,S. Industrial relations are analyzed as group behavior with a complex and dynamic network of rights, obligations, sentiments and rules. This social system is viewed as an interdependent part of total community life. The background and functioning of industrialism are studied as social and cultural phenomena. Specific social problems of industry are analyzed. Mercer

SOC 511 Sociological Theory. Prerequisites: Six hours in sociology and graduate standing or consent of instructor. 3(3-0) F,S. Study of the interdependence of theory and method; the major theoretical and methodological systems; and examination of selected cases of research in which theory and method are classically combined. Sawhney

SOC 512 Family Analysis. Prerequisite: SOC 202 or equivalent. 3(3-0) F. This course examines the basic theoretical and methodological framework in sociology within which contemporary family research is conducted. Mercer

SOC 513 (ED 513) Community Organization. Prerequisite: SOC 202 or equivalent. 3(3-0) F. Community organization is viewed as a process of bringing about desirable changes in community life. Community needs and resources available to

meet these needs are studied. Democratic processes in community action and principles of community organization are stressed, along with techniques and procedures. The roles of leaders, both lay and professional, in community development are analyzed. Moxley

SOC 514 Developing Societies. Prerequisites: Six hours of sociology or anthropology or graduate standing. 3(3-0) S. The purpose of this course is to define the major problems posed for development sociology and to explore the sociological barriers and theoretical solutions for development set forth with special regard to the newly-developing countries. Significant past strategies will be reviewed as well as main themes in current development schemes. Finally, some untested strategies for the future will be proposed for discussion. These problems will be examined in their national and international contexts. Moxley

SOC 515 Deviant Behavior. Prerequisites: Six hours of sociology or anthropology or graduate standing. 3(3-0) S. Many topics include: the inevitability of deviance and its social utility; cross-cultural variations in appearance and behavioral cues for labeling the deviate; descriptive and explanatory approaches to kinds and amounts of deviance in contemporary American society; social change, anomie and social disorganization theories; the process of stigmatization; formal and informal societal responses to deviance and the deviate; social action implications. Suval

SOC 517 (PS 517) The Police Bureaucracy in Democratic Society. 3(3-0) S. (See political science, page 228.)

SOC 523 Sociological Analysis of Agricultural Land Tenure Systems. Prerequisite: Three hours of sociology. 3(3-0) F. A systematic sociological analysis of the major agricultural and land-tenure systems of the world with major emphasis on the problems of family farm ownership and tenance in the United States.
Graduate Staff

SOC 533 Theory of Human Communication Behavior. Prerequisites: Six hours sociology or social psychology and graduate standing. 3(3-0) F,S. This course is organized to introduce students to the behavioral science approach to an understanding of human communication. Communication is treated as a basic social psychological process in which communication events are analyzed in terms of their effects on individual, interpersonal and group behavior. Students will survey the theory, research methods and empirical findings developed in the emerging field of communication. Communication behavior is treated as a mediating mechanism in social interaction. Graduate Staff

SOC 534 Agricultural Organizations and Movements. Prerequisites: Three hours of sociology, American history, American government or a related social science or consent of department. 3(3-0) S. A history of agricultural organizations and movements in the United States and Canada principally since 1865, emphasizing the Grange, the Farmers' Alliance, the Populist revolt, the Farmers' Union, the Farm Bureau, the Equity societies, the Nonpartisan League, cooperative marketing, government programs and present problems. Graduate Staff

SOC 541 Social Systems and Planned Change. Prerequisite: Three hours of sociology. 3(3-0) F,S. An examination of social systems within the framework of both functional theory and conflict theory with particular emphasis upon system change and the planning of social change. Marsh

SOC 555 Social Stratification. Prerequisite: Six hours sociology. 3(3-0) F,S. In this course the student would be introduced to the theoretical background, the methodological approaches, and the analysis of the consequences of systems of stratifica-

tion. Emphasis would be on the static and dynamic qualities of stratification systems in rural and urban-industrial societies as well as the effects of these systems on relations within and between societies. Particular attention will be paid to the integrative and divisive quality of stratification as it is expressed in life styles, world views, etc. Davis

SOC 560 Racial and Cultural Contacts. Prerequisite: Six hours of sociology or consent of instructor. 3(3-0) S. The course is organized in three sequential sections, the first of which deals with intergroup relation as a legitimate concern of the social sciences. The second consists of an appraisal of cross-cultural data that have been drawn from a variety of situations within race and ethnicity figure in a significant manner. Finally, an effort is made to interpret data by delineating observable patterns, trends, and relationships. Graduate Staff

SOC 565 Sociology and General Systems Theory. Prerequisites: Six hours of sociology, one course in statistics. 3(3-0) F. In this course the student will study the basis of general systems theory and review its application in the field of sociology. Emphasis is placed on the philosophical nature of systems theory and its potential as an alternative conceptualization to mechanistic and organisimic models. Attention is given to the underlying basis of systems theory; to cybernetics as models of change and control; learning and equilibrium; to information theory as models of choice and selection; to decision theory; and to game theory. Holder

SOC 570 Commitment. Prerequisite: Six hours of sociology. 3(3-0) F. The process of commitment and its strength are covered from several theoretical views as applicable to collective behavior, social movements, the sociology of religion, political sociology, deviance, attitudes, decision making, dissonance, structural effects and other topics. An aim is to construct propositions and testable models of the commitment process. Wimberley

SOC 574 (EC 574) The Economics of Population. 3(3-0) S. (See economics, page 111.)

SOC 590 Applied Research. Prerequisite: SOC 202 or equivalent. 3(3-0) F,S. A study of the research process with particular emphasis upon its application of action problems. The development of research design to meet action research needs receives special attention. Graduate Staff

SOC 591 Special Topics in Sociology. Prerequisite: Consent of instructor. 6(6-0) F,S. An examination of current problems in sociology organized on a lecture-discussion basis. The content of the course will vary as changing conditions require the use of new approaches to deal with the emerging problems. Graduate Staff

SOC 592 Demographic Structure and Processes. Prerequisite: SOC 509 or equivalent. 3(3-0) S. The basic purpose of this course is to provide the student an opportunity to explore, in depth, the major demographic variables (size, composition and distribution) and basic demographic processes (fertility, mortality and migration). Attention will be given both to theoretical and methodological considerations as well as to current substantive knowledge. The specific content of the course will vary from semester to semester depending on the needs and interests of the students. Clifford, Mustian

FOR GRADUATES ONLY

SOC 601 Urban Ecology. Prerequisite: SOC 509. 3(3-0) S. The course involves an

historical approach to the development of the field as well as an analysis of the present state of the field. Because of the range of subject matter subsumed under the topic of ecology, the linkages between sociology and other disciplines concerning themselves with the subject will be delineated and examined. Davis

SOC 611 Research Methods in Sociology. Prerequisites: SOC 416, ST 311 or equivalent. 3(3-0) F. Designed to give the student a mature insight into the nature of scientific research in sociology. Assesses the nature and purpose of research designs, the interrelationship of theory and research, the use of selected techniques and their relation to research designs, and the use of modern tabulation equipment in research. McCann

SOC 613 Theory of Mass Communication. Prerequisite: SOC 533 or equivalent. 3(3-0) S. This course provides the advanced student in the social sciences with an opportunity to examine the emerging body of theory and research in the field of mass communications. Course content will treat: (1) the systems character of mass communication, (2) social communication at the individual and group level, (3) persuasive communication and social control, (4) communication and opinion change, and (5) communication and societal development. In addition to the theoretical and methodological underpinnings drawn from the behavioral sciences, the course will examine contributions from the communication arts and applied communications. Graduate Staff

SOC 621 Social Psychology. Prerequisite: Six hours of sociology. 3(3-0) S. The objective of this course is to present the major ideas of social psychology in the context of the theoretical orientations from which they have emerged. The nature and role of theory in social psychology are examined. The social psychologies of various theorists are then examined in terms of their particular approaches including the Gestalt, Field, Role, Psychoanalytic, and Reinforcement orientations and combinations of these. McCann

SOC 631 Population Analysis. Prerequisite: Six hours of sociology. 3(3-0) S. Methods of describing, analyzing and presenting data on human populations: distribution, characteristics, natural increase, migration and trends in relation to resources. Graduate Staff

SOC 632 Sociology of the Family. Prerequisite: Six hours of sociology. 3(3-0) S. Emphasis is placed on the development of an adequate sociological frame of reference for family analysis; on discovering both the uniquely cultural and common-human aspects of the family by means of cross-cultural comparisons; on historical explanations for variability in American families with special concern for the family; and on analyzing patterns of family stability and effectiveness. Graduate Staff

SOC 633 The Community. Prerequisite: Six hours of sociology. 3(3-0) S. The community is viewed in sociological perspective as a functioning entity. A method of analysis is presented and applied to eight "dimensions," with emphasis on the unique types of understanding to be derived from measuring each dimension. Finally, the effect of change on community integration and development is analyzed.
Graduate Staff

SOC 641 Statistics in Sociology. Prerequisite: ST 513 or equivalent. 3(3-0) S. The application of statistical methods of sociological research. Emphasis on selecting appropriate models, instruments and techniques for the more frequently encountered problems and forms of data. Mustian

SOC 645 Advanced Sociological Measurement. Prerequisites: SOC 611, ST 511 or ST 513. 3(3-0) S. Various issues concerning the measurement of social variables are examined and techniques are described. These issues and techniques include operationalism and epistemic correlation, levels of measurement, transformations, social indicators, scaling, dimensionality, validity, and reliability. Existing examples and potential applications in sociological research are considered.
Wimberley

SOC 646 Advanced Sociological Analysis. Prerequisites: SOC 611, ST 511 or ST 513. 3(3-0) S. Advanced analysis techniques adaptable to the needs of sociological research are examined. Special attention is given to causal analysis, the analysis of change, and aggregate *versus* individual level data analyses. Sociological examples are considered. Emerging issues and techniques are given attention. Wimberley

SOC 652 Comparative Societies. Prerequisite: Six hours of sociology. 3(3-0) S. Sociological analysis of societies around the world with particular reference to North and South America. Special emphasis is given to cultural and physical setting, population composition, levels of living, relationship of the people to the land, structure and function of the major institutions and forces making for change.
Graduate Staff

SOC 653 Theory and Development of Sociology. Prerequisites: SOC 511, consent of instructor. 3(3-0) S. Detailed analysis of methodological and substantive problems in utilizing sociological theories in varied areas, and an examination of events and trends in the development of sociology. Graduate Staff

SOC 670 Theories of Population. Prerequisites: SOC 509 and/or SOC 511 or permission of instructor. 3(3-0) F. This course provides an overview of population theory utilizing a combined chronological and topical approach. Major topics include: sociological analysis of ancient and medieval views of population; mercantilism and population; economic, utopian, philosophical and biological theories of population in the 18th century; Malthusian theory; and post-Malthusian theory, including biological, anthropological, mathematic, economic, political, historical, and especially social and social-psychological approaches. Suval

SOC 671 Social Demography. Prerequisites: Graduate standing, SOC 509 or SOC 631 or equivalents. 3(3-0) S. The basic purpose of this course is to develop on the part of the student an appreciation of the sociological variables capable of being used in demographic research and to provide an overview of the current substantive knowledge concerning social and demographic relationships. Attention will be given to the interrelationships between demographic systems, social action systems, and social aggregate systems. Graduate Staff

SOC 690 Seminar. Credits Arranged F,S. Appraisal of current literature; presentation of research papers by students; progress reports on departmental research; review of developing research methods and plans; reports from scientific meetings and conferences; other professional matters. Graduate Staff

SOC 699 Research in Sociology. Prerequisite: Consent of chairman of graduate study committee. Credits Arranged F,S. Planning and execution of research, and preparation of manuscript under supervision of graduate committee.
Graduate Staff

Soil Science

GRADUATE FACULTY

Professor C. B. McCants, *Head*

Professors: W. V. Bartholomew, S. W. Buol, M. G. Cook, C. B. Davey, J. W. Fitts, W. A. Jackson, G. L. Jones, E. J. Kamprath, R. J. Volk, J. B. Weber, S. B. Weed, W. G. Woltz, W. W. Woodhouse Jr.; *Extension Professors:* J. V. Baird, J. A. Phillips; *Professor USDA:* R. B. Daniels; *Adjunct Professors:* L. J. Metz, C. G. Wells; *Professor Emeritus:* J. F. Lutz; *Associate Professors:* F. R. Cox, G. A. Cummings, J. W. Gilliam, R. E. McCollum, P. A. Sanchez, A. G. Wollum; *Visiting Associate Professors:* A. H. Hunter, J. L. Walker, D. L. Waugh; *Assistant Professors:* C. K. Martin, C. D. Raper Jr., E. D. Seneca, R. W. Skaggs, C. D. Sopher; *Extension Assistant Professor:* D. L. Terry

The Department of Soil Science offers graduate programs leading to the Master of Science and Doctor of Philosophy degrees. These are research-oriented degrees and require a dissertation based on individual research on some aspect of the science.

Laboratories in the department are well equipped for research in all phases of the science. Service laboratories for soil and plant analyses are available, as well as special preparation rooms for soil and plant samples. Greenhouses, growth chambers, and a phytotron are easily accessible for controlled plant studies. Sites for field experiments are available on the 16 research farms and four experimental forests owned or operated in conjunction with the University. One of the largest soil testing laboratories in the United States is operated by the North Carolina Department of Agriculture in Raleigh. Special studies on various problems of soil testing can be made in conjunction with this laboratory.

This department is highly regarded for its expertise in tropical soil science. A graduate student may orient his program so that emphasis is given to the properties and management of tropical soils. With this approach, a significant portion of the thesis research is conducted in tropical regions under senior faculty supervision.

Strong supporting departments increase the graduate student's opportunities for high quality training. Opportunity for undergraduate teaching experience is available. Graduates of the department find positions in industry, government and academic institutions.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

SSC **501 Tropical Soils: Characteristics and Management.** Prerequisites: Six credits in soil science. 3(3-0) F. Characteristics of the tropical environment. Distribution and classification of tropical soils. Soil plant relationships in the tropics.

Soil management systems emphasizing shifting cultivation, flooded rice production, subsistence farming and tropical pasture management. Sanchez

SSC 511 Soil Physics. Prerequisites: PY 212, SSC 200. 4(3-3) F. Physical constitution and analyses; soil structure, soil water, soil air and soil temperature in relation to plant growth. Graduate Staff

SSC 520 Soil and Plant Analysis. Prerequisites: PY 212; CH 315; at least three soils courses including SSC 341, or consent of instructor. 3(1-6) S. Theory and advanced principles of the utilization of chemical instruments to aid research on the heterogeneous systems of soils and plants. Gilliam

SSC 522 Soil Chemistry. Prerequisites: SSC 200, one year of general inorganic chemistry. 3(3-0) S. A consideration of the chemical and colloidal properties of clay and soil systems, including ion exchange and retention, soil solution reactions, solvation of clays and electrokinetic properties of clay-water systems. Weed

SSC 532 (MB 532) Soil Microbiology. Prerequisites: MB 401, CH 220. 3(3-0) S. Soil as a medium for microbial growth, the relation of microbes to important mineral transformations in soil, the importance of biological equilibrium, and significance of soil microbes to environmental quality. Wollum

SSC 541 Soil Fertility. Prerequisite: SSC 341. 3(3-0) F. Soil conditions affecting plant growth and the chemistry of soil and fertilizer interrelationships. Factors affecting the availability of nutrients. Methods of measuring nutrient availability. Kamprath

SSC 551 Soil Morphology, Genesis and Classification. Prerequisites: GY 120, SSC 200, SSC 341. 3(3-0) F. Morphology: Study of concepts of soil horizons and soil profiles and chemical, physical and mineralogical parameters useful in characterizing them. Genesis: Critical study of soil-forming factors and processes. Classification: Critical evaluation of historical development and present concepts of soil taxonomy with particular reference to great soil groups as well as discussion of logical basis of soil classification. Buol

SSC 553 Soil Mineralogy. Prerequisites: SSC 200, SSC 341, and GY 330. 3(2-3) F. Composition, structure, classification, identification, origin, occurrence and significance of soil minerals with emphasis on primary weatherable silicates, layer silicate clays and sesquioxides. Cook

SSC 560 Advanced Soil Management. Prerequisites: SSC 200, SSC 341. 3(3-0) Sum. Studies of soil characteristics in the coastal plain, Piedmont and mountain areas of North Carolina including several field trips. Discussion of management practices that should be associated with various soils for different types of enterprises. (Offered summer 1975 and alternate years.) Cook, Kamprath, Phillips

SSC 590 Special Problems. Prerequisite: SSC 200. Credits Arranged F,S. Special problems in various phases of soils. Emphasis will be placed on review of recent and current research. Graduate Staff

FOR GRADUATES ONLY

SSC 614 (CS 614, HS 614) Herbicide Behavior in Plants and Soils. 3(3-0) F. (See crop science, page 105.)

SSC 622 Soil Physical Chemistry. Prerequisites: SSC 511, SSC 553, CH 433.

3(3-0) S. An examination in depth of current ideas in the field. Topics will include double-layer theory, molecular adsorption, ion exchange, diffusion of ions in soil-water systems, and relations between clay-mineral structures and their chemical properties. Weed

SSC 632 (MB 632) Ecology and Functions of Soil Micro-organisms. Prerequisites: MB 401, SSC 532 (MB 532) or equivalent. 3(3-0) S. A comprehensive examination of theories and concepts relative to ecology and functions of soil microorganisms. Topics include relationships of microbes to their environments, adaptive mechanisms, microbial processes in soil organic matter formation and degradation, and function of organic matter in soil systems. Subject emphasis will be determined by class interests and by current literature. (Offered 1975 and alternate years.)
Bartholomew, Davey

SSC 651 Pedology. Prerequisites: SSC 522, SSC 511; SSC 551 or equivalent. 3(3-0) F. A critical study of current theories and concepts in soil genesis, morphology and classification. (Offered 1975 and alternate years.) Graduate Staff

SSC 671 (BAE 671) Theory of Drainage: Saturated Flow. 3(3-0) Alternate F. (See biological and agricultural engineering, page 78.)

SSC 672 Soil Properties and Plant Development. Prerequisites: BCH 551, SSC 522 or equivalent. 3(3-0) S. An examination of the interrelationships of soil properties and plant characteristics which regulate inorganic ion accumulation and dry matter production in higher plants. (Offered 1974 and alternate years.) Jackson

SSC 674 (BAE 674) Theory of Drainage: Unsaturated Flow. 3(3-0) Alternate F. (See biological and agricultural engineering, page 78.)

SSC 690 Seminar. Prerequisite: Graduate standing in soil science. 1(1-0) F,S. A maximum of two semester hours is allowed toward the master's degree, but any number toward the doctorate. Scientific articles, progress reports in research and special problems of interest to soil scientists reviewed and discussed.
Graduate Staff

SSC 693 Colloquium in Soil Science. Prerequisite: Graduate standing in soil science. Credits Arranged F,S. Seminar-type discussions and lectures on specialized and advanced topics in soil science. Graduate Staff

SSC 699 Research. Prerequisite: Graduate standing in soil science. Credits Arranged F,S. A maximum of six semester hours is allowed toward the master's degree, but any number toward the doctorate. Graduate Staff

Statistics

GRADUATE FACULTY

Professor D. D. MASON, *Head*

Professors: B. B. BHATTACHARYYA, C. C. COCKERHAM, A. H. E. GRANDAGE, R. J. HADER, D. W. HAYNE, H. L. LUCAS JR., F. E. MCVAY, R. J. MONROE, L. A. NELSON, C. H. PROCTOR, C. P. QUESENBERRY, J. O. RAWLINGS, D. L. RIDGEWAY, J. A. RIGNEY, R. G. D. STEEL—*Graduate Administrator*, H. R. VAN DER VAART, T. D. WALLACE, O. WESLER; *Adjunct Professors:* A. L. FINKNER, J. T.

WAKELEY; *Professor Emeritus:* GERTRUDE M. COX; *Associate Professors:* F. G. GIESBRECHT, H. J. GOLD, M. M. GOODMAN, W. L. HAFLEY, A. R. MANSON, J. L. WASIK; *Associate Professor USFS:* B. F. SWINDEL; *Adjunct Associate Professor:* D. L. BAYLESS; *Assistant Professors:* A. R. GALLANT, T. M. GERIG, A. C. LINNERUD; *Visiting Assistant Professor:* P. M. BURROWS; *Research Associate:* J. H. GOODNIGHT

The Department of Statistics offers the Master of Science, Master of Statistics (nonthesis), Master of Biomathematics (nonthesis) and Doctor of Philosophy degrees. It has a working arrangement with the Department of Biostatistics in the School of Public Health at Chapel Hill, whereby graduate students can minor in the Division of Health Affairs, and maintains a close liaison with the Department of (Mathematical) Statistics at Chapel Hill in order to supplement the offerings in statistical theory. The three departments are affiliated with the Institute of Statistics (see page 18).

Members of the department conduct research in biomathematics, operations research, probability theory and the development and application of statistical theory. Many staff members consult with researchers in the biological, physical and social sciences and conduct their research on statistical problems encountered there.

A graduate student may minor in one of many applied departments, or in mathematics or mathematical statistics. The department has cooperated with eight other departments at Raleigh and Chapel Hill to develop a strong minor program in operations research. Details regarding the operations research program are presented on page 210. For the graduate student who wishes to minor in statistics, the department has a flexible curriculum. Many employers offer added inducements for research personnel with such a minor.

A program of training in biomathematics at the doctoral and postdoctoral levels is available in the department. This program requires that students become well grounded in four areas—mathematics, statistics, physical science and some phase of biology. Fellowships and assistantships are available. Mathematical biology and related areas are now developing rapidly and there is much opportunity for properly trained people. (For biomathematics courses, see page 79.)

The department provides computer programming and other assistance to the Agricultural Experiment Station staff in close cooperation with the campus Computing Center. It also provides a desk calculator computing service. It furnishes research and consulting services on a contract basis and this supplies live problems on which graduate students may acquire experience and maturity.

The department is located in a new building and ample space for graduate students is provided. A well-equipped desk computing laboratory is located in the graduate student area.

The computing facilities described on page 22 are fully available to students and faculty in the Department of Statistics. The department has access to this facility through a medium-speed terminal conveniently near for batch processing, with several low-speed terminals of different types, including Teletype, IBM 2741 (with plotter), and Tektronics 4010-1 graphics with a hard copy unit. Interactive com-

puting is done largely through TSO (Time Sharing Option). In addition, the University Data Acquisition, Systems and Simulation Center has various computers including the IBM System 7, PDP 11/40, the hybrid Ambilog 200, a hybrid 1130 analog unit, and additional graphics devices. This Center is available for use by graduate students in statistics.

The department has approximately 15 assistantships at stipends adjusted to the previous training and experience of the recipients. Students with a major in an applied field and at least one year of calculus, or with a major in statistics or mathematics are encouraged to apply for assistantships. Students with no advanced calculus or matrix algebra are advised that their program may be somewhat lengthened as a consequence. An adequately prepared graduate assistant can complete the master's degree in two years (in less time if he takes courses during the summer); with a master's degree in statistics, he can complete the requirements for the doctorate in two years.

Most fields of research, development, production and distribution are seeking persons trained in statistical theory and methods. The demand is equally strong from universities, agricultural and engineering experimental stations, national defense agencies, other federal agencies and a wide variety of industrial concerns. There is a need for experimental statisticians with the master's degree as well as for those with the doctorate.

North Carolina State University is represented on the Committee on Statistics of the Southern Regional Education Board. This committee sponsors a continuing series of graduate summer sessions. Each of the sponsoring institutions will accept the credits earned by students in the summer session as residence credit. Information regarding these courses may be obtained from the Department of Statistics or the Dean of the Graduate School.

FOR ADVANCED UNDERGRADUATES

ST 421, 422 Introduction to Mathematical Statistics. Prerequisite: MA 202 or MA 212 or MA 232. 3(3-0) F,S. Staff

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ST 501, 502 Basic Statistical Analysis. Prerequisite: ST 311 or equivalent or graduate standing. 3(3-0) F,S. Basic concepts of statistics; random variables, distributions, statistical measures, estimation, tests of significance, analysis of variance, elementary design and sampling, factorial experiments, multiple regression, analysis of discrete data and other topics. Intended primarily for statistics majors and Ph.D. minors and not intended as a service course for other departments. Steel

ST 507 Statistics for the Behavioral Sciences I. 3(3-0) F. The purpose of this course is to provide a general introduction to descriptive and inferential statistics. Attention will be paid to investigating the role of statistics in behavioral science research as well as presenting the techniques and principles for summarizing data. A basic introduction to inferential statistics will be made with an emphasis on the

concepts of hypothesis testing and decision making. The principles and methods will be illustrated by examples and problems from the behavioral science fields.
Wasik, Monroe

ST 508 Statistics for the Behavioral Sciences II. Prerequisite: ST 507 or consent of instructor. 3(3-0) S. The purpose of this course is to provide further consideration of the use of advanced statistical techniques used in decision making in behavioral science research. Attention will be paid to hypothesis testing and analysis of variance procedures used in the design of experiments. A part of the course will be devoted to topics relating to least squares and multiple regression analysis.
Wasik

ST 511 Experimental Statistics for Biological Sciences I. Prerequisite: ST 311 or graduate standing. 3(3-0) F,S. Basic concepts of statistical models and use of samples; variation, statistical measures, distributions, tests of significance, analysis of variance and elementary experimental design, regression and correlation, chi-square.
Staff

ST 512 Experimental Statistics for Biological Sciences II. Prerequisite: ST 511 or equivalent. 3(3-0) F,S. Covariance, multiple regression, concepts of experimental design, factorial experiments, individual degrees of freedom, confounded factorial and split-plot designs.
Staff

ST 513 Experimental Statistics for Social Sciences I. Prerequisite: ST 311 or graduate standing. 3(3-0) F. Basic concepts in collection and analysis of data. Variability of sample data, distributions, confidence limits, chi-square, t-test, analysis of variance, regression, correlation, analytic and descriptive surveys, experimental designs.
McVay

ST 514 Experimental Statistics for Social Sciences II. Prerequisite: ST 513 or equivalent. 3(3-0) S. Extension of basic statistical concepts to social experiments and surveys; sampling from finite populations and estimating using unrestricted, stratified, systematic and multistage selections; analysis of variance continued; multiple regression; covariance; experimental designs.
Proctor

ST 515, 516 Experimental Statistics for Engineers. Prerequisite: ST 361 or graduate standing. 3(3-0) F,S. General statistical concepts and techniques useful to research workers in engineering, textiles, wood technology, etc. Probability, distributions, measurement of precision, simple and multiple regression, tests of significance, analysis of variance, enumeration data, sensitivity data, life-testing experiments and experimental designs.
Hader

ST 517 Applied Least Squares. Prerequisite: ST 502 or equivalent. 3(3-0) F. Use of least squares estimation in developing numerical descriptions with linear models. Regression, analysis of variance and covariance are considered in a unified manner that does not require an extensive statistical background. Emphasis is placed on the application of these techniques to experimental situations and in broadening the range of problems to which they can be applied (particularly in terms of unequal numbers). A computer will be used for some assigned problems such as matrix inversion.
Staff

ST 521 Statistical Theory I. Corequisite: MA 425 or MA 511 and MA 405 or permission of instructor. 3(2-2) F. Discussion of the use of statistics as illustrated by an example, pointing out the need for a probabilistic framework. The probability tools for statistics: description of discrete and absolutely continuous distributions,

expected values, moments, moment generating functions, transformation of random variables, marginal and conditional distributions, independence, order statistics, multivariate distributions, concept of random sample, derivation of many sampling distributions. van der Vaart

ST 522 **Statistical Theory II.** Prerequisite: ST 521; Corequisite: MA 426 or MA 512. 3(2-2) S. General framework for statistical inference. Point estimators: biased and unbiased, minimum variance unbiased, least mean square error, maximum likelihood and least squares, asymptotic properties. Interval estimators and tests of hypotheses: confidence intervals, power functions, Neyman-Pearson lemma, likelihood ratio tests, unbiasedness, efficiency and sufficiency. van der Vaart

ST 531 **Design of Experiments.** Prerequisite: ST 502 or equivalent. 3(3-0) F. Review of completely randomized, randomized complete block and Latin square designs, and the basic concepts in the techniques of experimental design. Designs and analysis methods in factorial experiments, confounded factorials, response surface methodology, change-over design, split-plot experiments and incomplete block designs. Examples will be used to illustrate application and analysis of these designs. Monroe

ST 541 (MA 541) **Theory of Probability I.** 3(3-0) F. (See mathematics, page 188.)

ST 542 (MA 542) **Theory of Probability II.** 3(3-0) S. (See mathematics, page 188.)

ST 552 **Basic Theory of Least Squares and Variance Components.** Prerequisites: MA 405, ST 521; Corequisite: ST 522. 3(2-2) S. Theory of least squares; multiple regression; analysis of variance and covariance; experimental design models; factorial experiments; variance component models. Staff

ST 561 (EC 561) **Intermediate Econometrics.** 3(3-0) S. (See economics, page 111.)

ST 571 (BMA 571, MA 571) **Biomathematics I.** 3(3-0) F. (See biomathematics, page 80.)

ST 572 (BMA 572, MA 572) **Biomathematics II.** 3(3-0) S. (See biomathematics, page 80.)

ST 581 **Introduction to Nonparametric Statistics.** Prerequisite: ST 522. 3(3-0) F. This course will treat both theoretical and methodological material relevant to inference problems arising when sampling is from a parent family that is not assumed to have a particular functional form. Most of the course will be devoted to inference problems for the absolutely continuous family of distributions. (Offered fall, 1974 and alternate years.) Quesenberry

ST 583 **Introduction to Statistical Decision Theory.** Prerequisite: ST 522. 3(3-0) F. The theory of statistical inference will be discussed from a unified decision theoretic point of view and its relationship with the zero-sum two person game will be studied. Detailed attention will be paid to the development of techniques of statistical analysis using Bayesian approach. The major emphasis in the course will be directed towards the solution of problems using decision theoretic concepts. (Offered fall 1975 and alternate years.) Bhattacharyya

ST 591 **Special Problems.** 1-3 F,S. Development of techniques for specialized cases, particularly in connection with thesis and practical consulting problems. Staff

FOR GRADUATES ONLY

ST 606 (MA 606, OR 606) Mathematical Programming II. Prerequisite: IE 505 (MA 505, OR 505). 3(3-0) S. This course is intended for those who desire to study linear and non-linear programming from an advanced mathematical point of view. Special attention will be paid to the theoretical and computational aspects of current research problems in the field of mathematical programming, including linear programming and game theory, theory of graphs, discrete linear programming, linear programming under uncertainty and nonlinear programming.
Bhattacharyya

ST 613 Time Series Analysis I. Prerequisites: ST 522 or ST 422 and ST 502 or equivalent. 3(3-0) S. Statistical analysis of realizations of covariance stationary stochastic processes with emphasis throughout on the spectrum. Applications of the theory and methods developed are discussed and illustrated with examples. Topics include autoregressive processes, moving average processes, spectral analysis; estimation of the parameters appearing in a time series generated by a linear response function and covariance stationary errors; estimation of the spectrum and its use in the analysis of the residuals from fitted models. Gallant

ST 614 Time Series Analysis II. Prerequisite: ST 613. 3(3-0) F. Extensions of the theory and methods developed in ST 613 to multiple time series and nonlinear response functions. Topics include cross-spectral density, co-spectral density, quadrature-spectral density, coherence and phase; estimation of the parameters appearing in a time series generated by a nonlinear response function and covariance stationary errors; estimation of the cross-spectral density. Gallant

ST 617, 618 (MA 617, 618) Measure Theory and Advanced Probability. Prerequisites: MA 426; ST 521 or MA 541 or equivalent. 3(3-0) F,S. Modern measure and integration theory in abstract spaces, probability measures, random variables and expectations, conditional probability and conditional expectations, distribution functions, characteristic functions, modes of convergence, weak and strong laws of large numbers, central limit theorems and other limit laws, introduction to stochastic processes. Wesler, Bhattacharyya

ST 619 (MA 619) Topics in Advanced Probability. Prerequisites: ST 617, 618 (MA 617, 618). 3(3-0) Sum. Characteristic functions, infinitely divisible and stable laws, factorizations of probability distributions, laws of iterated logarithm, random walks, fluctuation theory, martingales, ergodic theory, Markov processes, the Poisson process, further topics in stochastic processes, applications. Wesler

ST 621 Statistics in Animal Science. Prerequisite: ST 502 or equivalent. 3(3-0) F. Sources and magnitudes of errors in experiments with animals, experimental designs and methods of analysis adapted to specific types of animal research; relative efficiency of alternate designs, amount of data required for specified accuracy, student reports on selected topics. (Offered fall 1975 and alternate years.)
Lucas, Linnerud

ST 622 (ANS 622) Principles of Biological Assays. 3(3-0) S. (See animal science, page 70.)

ST 623 Statistics in Plant Science. Prerequisite: ST 502 or equivalent. 3(3-0) F. Principles and techniques of planning, establishing and executing field and greenhouse experiments. Size, shape and orientation of plots; border effects; selection of experimental material; estimation of size of experiments for specified accuracy; scoring and subjective tests; subsampling plots and yields for laboratory analysis.
Nelson

ST 626 (GN 626) Statistical Concepts in Genetics. Prerequisite: GN 506; Corequisite: ST 502 or equivalent. 3(3-0) S. Factors bearing on rates of change in population means and variances, with special reference to cultivated plants and domestic animals; selection, inbreeding, magnitude and nature of genotypic and nongenotypic variability; experimental and statistical approaches in the analysis of quantitative inheritance. (Offered spring 1974 and alternate years.) Cockerham

ST 631 Theory of Sampling Applied to Survey Design. Prerequisites: ST 422; ST 502 or equivalent. 3(3-0) F. Principles for interpretation and design of sample surveys. Biases, variances and costs of estimators. Comparisons among simple random sample, ratio estimation, stratification, varying probabilities of selection, multistage, systematic and cluster sampling, double sampling. Response errors. Proctor

ST 637 Advanced Statistical Inference. Prerequisites: ST 522, ST 617. 3(3-0) S. This course will treat the classical areas of statistical inference, estimation and hypothesis testing, at the measure-theoretic level. Emphasis will be upon treatment of these areas in depth. Quesenberry

ST 651 (EC 651) Econometrics. 3(3-0) F. (See economics, page 113.)

ST 652 (EC 652) Topics in Econometrics. 3(3-0) S. (See economics, page 113.)

ST 671 Advanced Analysis of Variance and Variance Components. Prerequisite: ST 502 or equivalent, ST 552. 3(3-0) S. Expected mean squares, estimation of means, confidence limits, exact and approximate tests of hypotheses for balanced and unbalanced nested, crossed, and mixed classifications with random, finite, and fixed effects. Estimation of variance components and designs for estimating variance components. Heterogeneity, non-normality, correlated errors, and transformations. Giesbrecht

ST 674 Advanced Topics in Construction and Analysis of Experimental Designs. Prerequisites: ST 502 or equivalent, ST 552. 3(3-0) S. Interblock analysis of incomplete block designs, partially balanced designs, confounding, data collected at several places and times, multiple factor designs, change-over trials, analysis of groups of means. Manson

ST 682 Statistical Analysis for Linear Models. Prerequisites: ST 502 or equivalent, ST 552. 3(3-0) F. Review of basic least squares, partitioning sums of squares, weighted least squares; regression coefficients as random variables; models with redundancies, use of generalized inverses; models with restrictions; applications to disproportionate data, incomplete blocks designs and covariance analysis; arithmetic items; application to nonlinear models. Gerig

ST 691 Advanced Special Problems. Prerequisites: ST 502 or equivalent, ST 552. 1-3 F,S. Any new advance in the field of statistics which can be presented in lecture series as unique opportunities arise. Graduate Staff, Visiting Professors

ST 694 Seminar. 1(1-0) F,S. A maximum of two semester hours is allowed toward the master's degree, but any number toward the doctorate. Graduate Staff

ST 699 Research. Credits Arranged F,S. A maximum of nine semester hours is allowed toward the Master of Science degree; no limitation on semester hours in doctorate programs. Graduate Staff

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL STATISTICS COURSES

U.N.C. ST 133 Introduction to Time Series Analysis. Prerequisite: U.N.C. ST 102 or U.N.C. ST 127. 3(3-0) F,S. Topics chosen from: Time series data analysis. Fitting parametric models, such as regression-autoregression models to time series. Spectrum analysis. Filtering. Wegman

U.N.C. ST 150 Analysis of Variance with Application to Experimental Designs. Corequisite: U.N.C. ST 135. 3(3-0) S. Linear estimation. Gauss-Markoff theorem. Sums of squares. Analysis of variance and generalized t and F tests. Intrablock analysis of incomplete block designs. Balanced, lattice and Latin square designs. Chakravarti, Johnson

U.N.C. ST 170 Order Statistics. Prerequisite: U.N.C. ST 127. 3(3-0) S. Distribution and moments of order statistics. Estimation of location and scale parameters, censoring. Robust estimation. Short-cut procedures. Treatment of outliers. Extreme-value theory. (Offered 1973-1974 and alternate years.) Graduate Staff

U.N.C. ST 210 Design and Analysis of Experiments. Prerequisites: U.N.C. ST 102 and U.N.C. ST 150. 3(3-0) F. The principles of the design and analysis of experiments. Randomization, replication, local control. Randomized blocks. Latin and Graeco-Latin squares, factorial experiments. Confounding, fractional factorials, split plots, recent developments. Chakravarti, Johnson

U.N.C. ST 220 Theory of Estimation and Hypothesis Testing. Prerequisites: U.N.C. ST 132 and U.N.C. ST 135. 4(4-0) F. Bayes procedures for estimation and testing. Minimax procedures. Unbiased estimators. Unbiased tests and similar tests. Invariant procedures. Sufficient statistics. Confidence sets. Large sample theory. Hoeffding

U.N.C. ST 221 Sequential Analysis. Prerequisites: U.N.C. ST 132 and U.N.C. ST 135. 3(3-0) F. Hypothesis testing and estimation when the sample size depends on the observations. Sequential probability ratio tests. Sequential design of experiments. Optimal stopping. Stochastic approximation. Simons

U.N.C. ST 222 Nonparametric Inference. Prerequisites: U.N.C. ST 132, U.N.C. ST 135 and U.N.C. ST 112. 3(3-0) S. Estimation and testing when the functional form of the population distribution is unknown. Rank, sign, and permutation tests. Optimum non-parametric tests and estimators. Hoeffding

U.N.C. ST 232 General Theory of Statistical Decision. Prerequisites: U.N.C. ST 135 and U.N.C. ST 112. 3(3-0) S. Selected topics in the general theory of statistical decisions, based on the work of Abraham Wald. (Offered 1973-1974 and alternate years.) Hoeffding

U.N.C. ST 235 Stochastic Processes. Prerequisites: U.N.C. ST 112 and U.N.C. ST 132. 3(3-0) S. Advanced theoretic course including topics selected from: Foundations of stochastic processes, Renewal processes, Stationary processes, Markov processes, Martingales, Point processes. (Offered 1973-1974 and alternate years.) Leadbetter, Smith

U.N.C. ST 237 Time Series Analysis. Prerequisites: U.N.C. ST 112 and U.N.C. ST 132. 3(3-0) S. Analysis of time series data by means of particular models such as autogressive and moving average schemes. Spectral theory for stationary processes and associated methods for inference. Stationarity testing. (Offered 1974-1975 and alternate years.) Leadbetter, Wegman

U.N.C. ST 251 Combinatorial Problems of the Design of Experiments. Prerequisite: U.N.C. ST 150. 3(3-0) F. Finite fields and finite geometries. Construction of orthogonal Latin squares and balanced incomplete block designs. Confounding, construction and analysis of symmetrical and functional factorial designs.
Chakravarti, Smith

U.N.C. ST 252 Information Theory. Prerequisite: U.N.C. ST 134. 3(3-0) S. Transmission of information, entropy, message ensembles, discrete sources, transmission channels, channel encoding and decoding for discrete channels. Chakravarti

U.N.C. ST 253 Error Correcting Codes. Prerequisite: U.N.C. ST 251 or permission of the instructor. 3(3-0) S. Linear codes and their error-correcting capabilities. Hamming codes. Reed-Muller codes. Cyclic codes. Bose-Chaudhuri codes. Burst error correction. Majority logic decoding. Chakravarti, Smith

U.N.C. ST 254 Special Topics in Design of Experiments I. Prerequisite: U.N.C. ST 150. 3(3-0) F. Response surface designs. Conditions for rotatability. Construction and analysis of rotatable designs of the second and third order. Interblock analysis. General analysis of covariance. Missing plot techniques. Chakravarti

U.N.C. ST 255 Special Topics in the Design of Experiments II. Prerequisite: U.N.C. ST 251. 3(3-0) S. Combinatorial properties and construction of balanced, group divisible and partially balanced designs. Impossibility proofs. Orthogonal Latin squares of non-prime power orders. Orthogonal arrays. Asymmetrical fractionally replicated designs. Chakravarti

U.N.C. ST 260 Multivariate Analysis. Prerequisites: U.N.C. ST 135 and matrices. 3(3-0) F. Characterization and properties of a multivariate normal distribution. Related distributions. Tests and confidence intervals. Multivariate analysis of variance, covariance and regression. Association between subsets of a multivariate normal set. Factor analysis. Johnson

U.N.C. ST 261 Advanced Parametric Multivariate Analysis. Prerequisite: U.N.C. ST 260. 3(3-0) S. Distribution problems involved in the normal theory analysis of general multivariate linear models including the growth curves. An introduction to zonal polynomials and orthogonal groups. Union-intersection principle and its role in multivariate analysis. (Offered 1974-1975 and alternate years.) Graduate Staff

U.N.C. ST 262 Introductory Nonparametric Multivariate Analysis. Prerequisite: U.N.C. ST 222 and U.N.C. ST 260. 3(3-0) F. The problem of symmetry in the multivariate case. Nonparametric tests for ANOVA and MANOVA in one-way layouts. Robust estimation of location and of contrasts in one-way MANOVA. Large sample properties of the tests and estimates. Graduate Staff

U.N.C. ST 263 Advanced Nonparametric Multivariate Analysis. Prerequisite: U.N.C. ST 262. 3(3-0) S. Robust nonparametric inference in various multifactor multiresponse experiments. The problem of multidimensional independence. Nonparametric inference in general linear models. (Offered 1973-1974 and alternate years.) Graduate Staff

U.N.C. ST 300, 301 Seminar in Statistical Literature. Prerequisite: U.N.C. ST 135. 1(1-0) F,S. Graduate Staff

U.N.C. ST 310, 311 Seminar in Theoretical Statistics. Prerequisite: U.N.C. ST 135. 3(3-0) F,S. Graduate Staff

U.N.C. ST 321, 322 Special Problems. Prerequisite: Permission of the instructor. 3(3-0) F,S. Graduate Staff

U.N.C. ST 331, 332 **Advanced Research.** Prerequisite: Permission of the instructor. 3(3-0) F,S. Graduate Staff

TEXTILES

GRADUATE FACULTY

Professor D. W. CHANEY, *Dean*

Professors: J. F. BOGDAN—*Head of the Department of Textile Technology,* K. S. CAMPBELL, D. M. CATES, R. D. GILBERT—*Chairman of the Graduate Studies Committee for the Fiber and Polymer Science Program,* G. GOLDFINGER, D. S. HAMBY—*Director, Textiles Extension and Continuing Education,* S. P. HERSH—*Graduate Administrator in Textile Technology,* P. R. LORD, J. A. PORTER JR., H. A. RUTHERFORD—*Head of the Department of Textile Chemistry,* M. R. SHAW—*Assistant Dean for Textile Research; Professor Emeritus:* R. W. WORK; *Adjunct Professors:* H. R. MARK, A. M. SOOKNE; *Associate Professors:* W. D. COOPER, J. A. CUCULO, A. H. M. EL-SHIEKH, P. D. EMERSON—*Head, Textile Machine Design and Development,* T. W. GEORGE, T. H. GUION, B. S. GUPTA, W. K. LYNCH, M. H. M. MOHAMED, R. MCGREGOR—*Graduate Administrator in Textile Chemistry,* T. G. ROCHOW, W. C. STUCKEY JR., M. H. THEIL, W. K. WALSH; *Research Associate:* C. E. BRYAN; *Assistant Professors:* P. BROWN, R. E. FORNES, P. L. GRADY, C. D. LIVENGOOD, D. M. POWELL, M. L. ROBINSON, P. A. TUCKER JR.; *Adjunct Assistant Professors:* D. H. BLACK, L. A. GRAHAM

The School of Textiles offers programs leading to the Master of Science degree in textile chemistry and in textile technology, the professional degree of Master of Textile Technology, and the Doctor of Philosophy in fiber and polymer science. (For a description of the Fiber and Polymer Science program, see page 149.)

Students otherwise meeting the requirements of the Graduate School and with Bachelor of Science degrees with majors in textiles, the physical sciences or engineering will normally qualify for the graduate degree programs.

The minimum requirement for a Master of Textile Technology degree is the satisfactory completion of 33 semester hours of advanced courses. There is no thesis or foreign language requirement. This program offers the student advanced professional training with emphasis on management. Students pursuing this degree are encouraged to minor in economics or industrial engineering.

The programs of study for the Master of Science degree include a minimum of 30 semester hours of advanced courses, including six semester hours devoted to a thesis based on research conducted by the student. There is no foreign language requirement. The plan of course work and the research activities for the Master of Science degree are designed to prepare the student for a career in research, development or other technical phases of the textile and allied industries. Students may minor in any one of a number of associated fields.

Programs of study may be arranged to develop a broad background in three gen-

eral areas: advanced textile technology; production and marketing management of textiles; and textile chemistry. Those students interested in the first of these may emphasize areas such as fiber and yarn technology, fabric technology, knitting technology, and testing or quality control. Programs leading to the Master of Science degree in textile chemistry emphasize fiber and polymer chemistry. In the area of marketing and production management, the program emphasizes the applications of quantitative decision methods including operations research and computer techniques to the textile industry. Programs in this area normally terminate within the School of Textiles with either the Master of Textile Technology or Master of Science degree in textile technology, but may be structured to provide suitable backgrounds for students wishing to do further graduate work in the areas of economics, industrial management, industrial engineering or business administration.

Textiles (General Courses)

FOR ADVANCED UNDERGRADUATES

T 492 Problems in Science and Technology. Prerequisite: Junior standing. 1(0-2) S.

T 493 Industrial Internship in Textiles. Prerequisite: Junior or senior in good standing. 3-6 Sum.

T 500 Advanced Microscopy. Prerequisite: T 300 or consent of instructor. 3(1-4) F,S. The art and science of light and electron microscopy and introduction to microradiography; theoretical and practical aspects of visibility resolution and contrast. Laboratory practice in assembly, testing and using various microscopes and accessories in describing, identifying and micrographing crystalline, oriented or amorphous materials, especially those which are of interest to the student. Laboratory work may include special projects for independent investigations. Rochow

T 501 Resinography. Prerequisite: T 300 or T 500 and TX 460 or TX 560 or TC 461. 3(1-4) F,S. Lectures, laboratory and discussion regarding structure and morphology of resins, fibers, elastomers and composites. Such materials will be studied by reflected light or electrons and by transmitted light or electrons. Other methods of diffraction and spectrometry will be discussed. Crystallographic and optical properties will be emphasized. Rochow

T 506 Color Science. Prerequisite: Senior in textile chemistry or graduate student. 3(2-2) F. A thorough discussion of color theory with particular emphasis on color measurement. Color and color difference calculations. From the data of the basic color matching experiments the description of a colorspace and its transformation into the CIE color space will be followed in detail. The basis of color difference calculations will be discussed. Color matches and color differences will be calculated based on experimental data obtained in the course. Goldfinger

Textile Chemistry

(For a listing of graduate faculty and other information see textiles, page 260 .)

FOR ADVANCED UNDERGRADUATES

TC 401 Textile Industry and the Environment. Prerequisite: Consent of instructor. 3(3-0) S.

TC 403, 404 Textile Chemical Technology. Prerequisites: (403) CH 223, TC 303. 3(3-0) F,S.

TC 405, 406 Textile Chemical Technology Laboratory. Prerequisites: TC 403, TC 404. 2(0-6) F,S.

TC 411 Textile Chemical Analysis I. Prerequisite: TC 301. 3(2-2) S.

TC 412 Textile Chemical Analysis II. Prerequisite: CH 315. 3(2-3) S.

TC 461 (CH 461) Chemistry of Fibers. Prerequisite: CH 223. 3(3-0) F.

TC 490 Special Topics in Textile Chemistry. 1-6 F,S.

TC 491 Seminar in Textile Chemistry. Prerequisite: TC 403. 1(0-2) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

TC 504 Fiber Formation-Theory and Practice. Prerequisites: MA 301, PY 208 or consent of instructor. 3(3-0) F. A practical and theoretical analysis of the chemical and physical principles underlying the conventional methods of converting bulk polymer to useful fiber; rheology; melt, dry and wet polymer extrusion; fiber drawing; heat setting; application of general theory to unit processes. Cuculo

TC 505 Theory of Dyeing. Prerequisite: CH 433 or consent of instructor. 3(3-0) S. Mechanisms of dyeing. Application of thermodynamics to dyeing systems. Kinetics of diffusion in dyeing processes. McGregor

TC 561 Organic Chemistry of High Polymers. Prerequisites: TC 461 (CH 461), CH 331 or CH 431. 3(3-0) S. Principles of step- and chain-growth polymerizations; copolymerization theory; homogeneous free radical polymerization; emulsion polymerization; Ziegler-Natta polymerization; ionic polymerization. Gilbert, Theil

TC 562 (CH 562) Physical Chemistry of High Polymers—Bulk Properties. Prerequisites: CH 220 or CH 223; CH 331 or CH 431. 3(3-0) F. Molecular weight description; states of aggregation and their interconversion; rubbery, glassy and crystalline states; rubber elasticity; molecular friction; diffusion and viscosity; dynamics of network response; retardation- and relaxation-time spectra; thermodynamics of nucleation; kinetics of crystallization. Cates, Walsh

TC 569 (CHE 569) Polymers, Surfactants and Colloidal Materials. 3(3-0) F. (See chemical engineering, page 87.)

FOR GRADUATES ONLY

TC 662 Physical Chemistry of High Polymers—Solution Properties. Prerequisites: CH 433, TC 562 (CH 562). 3(3-0) S. Sorption and diffusion; thermodynamics of polymer solutions; phase equilibria; configurational and frictional properties; methods of determining molecular weight. Cates, Walsh

TC 669 (CHE 669) Diffusion in Polymers. 2(2-0) S. (See chemical engineering, page 88.)

TC 671 (CHE 671) Special Topics in Polymer Science. 1-3 F. (See chemical engineering, page 88.)

TC 691 (TX 691) Special Topics in Fiber Science. 1-3 S. (See textile technology, page 266.)

TC 698 Seminar for Textile Chemistry. 1 F,S. Discussion of scientific articles and presentations; review and discussion of student papers and research problems.
Graduate Staff

TC 699 Textile Research for Textile Chemistry. Credits Arranged. Individual research in the field of textile chemistry. Graduate Staff

Textile Technology

(For a listing of graduate faculty and other information, see textiles, page 260.)

FOR ADVANCED UNDERGRADUATES

TX 405 Non-Conventional Fabric Structures. Prerequisites: Senior standing and consent of instructor. 3(3-0) F,S.

TX 420 Modern Developments in Yarn Manufacturing Systems. Prerequisite: Senior standing. 3(3-0) F,S.

TX 425 Textured Yarn Production and Properties. Prerequisites: TX 211, TX 220. 3(2-2) F,S,Sum.

TX 426 Long Staple and Tow Systems. Prerequisites: TX 211, TX 220. 3(2-2) F, S,Sum.

TX 431 Special Topics in Testing. Prerequisites: TX 330, senior or graduate standing. 3(2-2) F.

TX 441 Advanced Weft Knitting. Prerequisite: TX 340. 3(2-2) F,S,Sum.

TX 447 Advanced Design of Knitting Structures. Prerequisite: TX 340. 2(0-4) F,S.

TX 449 Warp Knitting Systems. Prerequisite: TX 340. 3(2-2) F,S.

TX 450 Advanced Design and Weaving. Prerequisite: TX 350. 3(2-2) F,S.

TX 451 Complex Woven Structures. Prerequisite: TX 450. 3(2-2) S.

TX 460 Physical Properties of Textile Fibers. Prerequisites: MA 212, PY 212. 3 (3-0) F,S.

TX 470 Fabric Styling and Design. Prerequisites: Junior or senior standing and consent of instructor. 2(2-0) F,S.

TX 480 Textile Cost Control. Prerequisites: EC 202, TX 320, TX 350. 3(3-0) F,S, Sum.

TX 482 (EC 482) Sales Management for Textiles. Prerequisite: TX 380. 3(3-0) F,S.

TX 484 Management Decision Making for the Textile Firm. Prerequisite: TX 482 (EC 482). 3(3-0) F,S.

TX 490 Development Project in Textile Technology. Prerequisites: Senior standing, consent of instructor. 2-3 F,S,Sum.

TX 491 Special Topics in Textiles. Prerequisite: Senior standing. 1-3 F,S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

TX 530 Textile Quality Control. Prerequisite: TX 330 or consent of instructor. 3 (3-0) S. Quality control systems for textile operations with emphasis on sampling plans for attributes and variables and on interpretation of data as related to identifying sources of product variability. Stuckey

TX 550 Fabric Analytics. Prerequisite: TX 350 or graduate standing. 3(3-0) F,S. Development of a numerical system for characterizing designs. Permutations and combinations of weave elements. Correlation of fiber and yarn properties with those of the fabric. Engineering design of fabrics. Relationship between fabrics having geometrical similarity and the prediction of their physical properties. Bogdan

TX 560 Structural and Physical Properties of Fibers. Prerequisite: MA 301. 3 (3-0) F. Advanced study of the structure and physical properties (moisture, thermal, optical, frictional and electrical) of textile fibers. Theoretical relations and advanced techniques are presented and discussed. Gupta

TX 561 Mechanical and Rheological Properties of Fibrous Material. Prerequisite: MA 301. 3(2-2) S. In-depth study of the stress-strain, bending, torsional, dynamic and rheological behavior of natural and man-made fibers. Theoretical relations and advanced techniques are presented and discussed. Gupta

TX 585 (EC 585) Market Research in Textiles. Prerequisites: MA 405, ST 421. 3 (3-0) S. A study and analysis of the quantitative methods employed in market research in the textile industry. The function of market research and its proper orientation to management and decision-making. Cooper

TX 586 Textile Labor Management. Prerequisite: Permission of instructor. 3(3-0) F,S,Sum. A study of labor management problems in the textile industry, with particular emphasis directed toward the roll of production supervision in a non-union textile plant. A study of NLRB decision and court opinions involving textile corporations. Powell

TX 590 Special Projects in Textiles. Prerequisites: Senior standing or graduate standing, consent of instructor. 2-3 F,S,Sum. Special studies in either the major or minor field of the advanced undergraduate or graduate student. These studies will include current problems of the industry, independent investigations, seminars and technical presentation, both oral and written. Graduate Staff

TX 591 Special Topics. Prerequisite: Consent of instructor. 1-4 F,S. An intensive treatment of selected topics involving textile technology. Graduate Staff

TX 598 Textile Technology Seminar. Prerequisites: Senior standing, consent of instructor. 2(2-0) S. Lecture and discussion of current topics relating to the textile industry. Graduate Staff

FOR GRADUATES ONLY

TX 601 Staple Fiber Structures I. Prerequisite: Graduate standing. 3(2-2) S. Studies of advanced techniques in textile production; the technological aspects of fiber properties in relation to processing; studies of research findings and application of these to processing equipment. Lord

TX 602 Staple Fiber Structures II. Prerequisite: Graduate standing. 3(2-2) F,S, Sum. Problems dealing with advanced textile production and the technological implications of fiber processing will be assigned for study and investigation. Attention will be given to the preparation of reports for oral and written presentation. Graduate Staff

TX 621 Textile Testing III. Prerequisite: TX 530 or equivalent. 2(2-0) S. Design of textile laboratories, including conditioning equipment and instruments required for specific needs; performance of tests and analysis of data on industrial problems; specialized physical tests; interlaboratory tests and analysis; study of A.S.T.M. specifications and work on task groups for A.S.T.M. Gupta

TX 631 Synthetic Fibers. Prerequisite: TX 425 or TX 426 or equivalent. 2(1-2) F, S,Sum. Lectures and projects on advanced problems associated with the properties and processing of man-made continuous filament and staple fiber yarns. Hersh

TX 641, 642 Advanced Knitting Systems and Mechanisms. Prerequisite: TX 441 or equivalent. 3(3-0) F,S. A critical study of inventions which have contributed to the development of the modern knitting industry; knitting needles and their adaption for specific uses; means for mounting them for individual and *en masse* operation; construction and functioning of cooperating elements including sliders, jacks, sinkers, dividers, pressing elements, narrowing and tensioning and draw-off motions, regulating mechanisms, timing and control chains and cams. Use will be made of patent literature which covers important developments in the hosiery industry. Brown

TX 643, 644 Knitting Technology. Prerequisites: Graduate standing, eight hours in knitting technology. 3(1-4) F,S. Problems of specific interest to the knitting industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication. Graduate Staff

TX 651, 652 Fabric Development and Construction. Prerequisite: Graduate standing. 3(1-4) F,S. Application of advanced technology to the development and construction of woven fabrics.

TX 663 (MAE 663) Mechanics of Twisted Structures. Prerequisites: EM 301, TX 560. 3(3-0) F. Study of the basic mechanics of fibrous assemblies. Geometry and mechanics of twisted structures (yarns, cords, braids...) and the translation of fiber properties into structural behavior. El-Shiekh

TX 664 (MAE 664) Mechanics of Fabric Structures. Prerequisite: TX 663 (MAE 663). 3(3-0) S. Analysis of the geometry and behavior of woven, knitted and nonwoven fabrics under various stress conditions and end use applications. El-Shiekh

TX 680 Special Projects in Textile Management. Prerequisite: TX 585 (EC 585). 1-3 F,S,Sum. Special studies in textile management covering current problems of the industry, independent investigations, seminars and technical presentations, both oral and written.
Cooper

TX 686 Advanced Textile Labor Management Seminar. Prerequisite: TX 586. 3 (3-0) F,S. A study of advanced labor management problems in the textile industry, with particular emphasis directed toward the application of the Occupational Safety and Health Act.
Powell

TX 691 (TC 691) Special Topics in Fiber Science. Prerequisite: Consent of instructor. 1-3 S. The study of selected topics of particular interest in various advanced phases of fiber science.
Graduate Staff

TX 698 Seminar. 1(1-0) F,S. Discussion of scientific articles of interest to the textile industry; review and discussion of student papers and research problems.
Graduate Staff

TX 699 Textile Research. Credits Arranged. Problems of specific interest to the textile industry will be assigned for study and investigation. The use of experimental methods will be emphasized. Attention will be given to the preparation of reports for publication. The master's thesis may be based upon the data obtained.
Graduate Staff

Toxicology

GRADUATE FACULTY

Professors: W. C. Dauterman, W. E. Donaldson, D. S. Grosch, F. E. Guthrie, D. W. Hayne, E. Hodgson, A. R. Main, R. J. Monroe, D. E. Moreland, J. J. Perry, T. J. Sheets; *Adjunct Professor:* J. R. Fouts

The combined impact of population increase and urbanization has magnified the problem of environmental contamination in recent years. As technology attempts to keep pace with the increased demands of our complex civilization, additional toxicants will be introduced which may affect man and other animals. The need for increased scrutiny of toxic agents and an understanding of their mode of toxic action (especially in trace amounts) is evidenced by recent findings summarized in many reports by government and professional organizations.

A graduate minor in toxicology at the master's or doctor's level which provides the coordination necessary to offer the student an excellent background in toxicology is available. This is an interdepartmental program which draws faculty from the Departments of Biochemistry, Botany, Crop Science, Entomology, Genetics, Microbiology, Poultry Science, Statistics and Zoology. Students majoring in these and related subject matter departments may elect the toxicology minor.

Requirements for a minor at the M.S. level will be either TOX 510 or TOX 515 and for the Ph.D. degree both TOX 510 and TOX 515. Additional courses from the supplementary list will be added at the discretion of the faculty member representing the minor (the same faculty member cannot represent both the major and

minor). The supplementary list includes: BCH 452, CH 428, GN 532 (ZO 532), BCH 551, BCH 557, BCH 652, ST 511, ZO 614 and ENT 622.

The Toxicology Minor Program is administered by a Toxicology Advisory Committee whose chairmanship is on a rotational basis. Additional information about the program may be obtained by writing to one of the faculty mentioned above.

TOX 510 Introduction to Biochemical Toxicology. Prerequisites: Biochemistry, senior standing. 2(2-0) F. Emphasis is placed on the molecular events that occur during the toxic action of xenobiotics, including penetration phenomena, and the enzymatic mechanisms involved in detoxication.

TOX 515 Environmental Toxicology. Prerequisite: Two years of biology. 2(2-0) S. The nature, distribution and significance of microchemical contamination will be discussed.

TOX 590 Special Problems in Toxicology. Prerequisite: Graduate standing. 1-3.

TOX 690 Toxicology Seminar. Prerequisite: Graduate standing. 1(1-0) S.

Urban Design

GRADUATE FACULTY

Professors: R. P. Burns Jr., C. E. McKinney, R. R. Wilkinson; *Associate Professors:* P. Batchelor, R. H. Clark, H. Sanoff

The Urban Design program has been conceived as an area of specialization and concentration in support of growing professional activity in the planning and design of contemporary urban environments. Urban design is an interdisciplinary area involving two major professional and academic disciplines—architecture and city planning—and in recent years the technologically advanced nations in the world have begun to utilize urban design as a means of resolving problems related to the physical growth and development of cities. Acting on a manifest need for specialized skills in urban design, the Department of Architecture of the School of Design at North Carolina State University has combined its resources with those of the Department of City and Regional Planning at the University of North Carolina in Chapel Hill. Thus, the urban design program is a joint graduate program utilizing a diversified body of interdisciplinary expertise.

The urban design program admits qualified candidates from both design and non-design backgrounds. Depending on the extent of preparation, a student may spend from four to six academic semesters in course work. In addition, a period of internship is required in agencies or professional consultants' offices where urban design and planning problems are being handled. This period of internship can be waived upon evidence of equivalent prior experience, or it can be undertaken during the student's program of study as summer work experience.

Students in urban design have access to electives in many of the professional and

non-professional courses offered in architecture, landscape architecture and product design. Moreover, the growing concept of interdisciplinary education has broadened the scope of an urban design education to the point where there are many minor fields of study. Therefore, students enrolled in the program are able to choose among a wide range of minor areas of specialization, some of which are: urban physical systems, urban redevelopment, urban technology, housing systems, production technology, natural systems and environmental policy planning.

The Urban Design Program does identify with the societal needs of the community, state, and region and sees the design studio as offering an appropriate opportunity for addressing society's most critical environmental conditions. In recent semesters studio options have included urban renewal and new towns design, programming, planning, and design of urban physical systems, and other related problems.

The program will require all students to undertake the normal two-year master's program of a minimum of 48 credit hours of course work of which 50 percent will be in the major field, 25 percent in the minor field, and the remainder in independent research. Course work in the minor field will be selected to reinforce the student's individual abilities and long-range career goals.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

UD 501 Introductory Problems in Urban Design. Prerequisite: Graduate standing. 3(0-6) F. Introduction to descriptive analysis of physical and socio-economic phenomena of urban environments, and application of research methods in the definition and resolution of urban design problems.

UD 502 Urban Design Workshop I. Prerequisite: UD 501. 3(0-6) S. A complete synthesis of design factors influencing an environmental system or an urban complex.

UD 510 Theory of Urban Form. Prerequisite: Graduate standing or advanced undergraduate standing. 3(3-0) S. Survey of interdisciplinary theory of urban growth and evolution with about one-half of the class periods devoted to historical development of theory, and the other half devoted to contemporary quantitative models of urban form.

UD 520 Theory and Principles of Urban Design. Prerequisite: Graduate standing. 3(3-0) S. An examination of the nature of the design process in urban environments with special emphasis on contemporary theory and practice.

UD 590 Special Topics in Urban Design I. Prerequisite: Fourth year standing. 1-6 F,S. This course provides a flexible means for investigation into areas of special interest related to urban design. It is intended primarily to encourage independent study and research.

UD 595 Environmental Perception. Prerequisite: Graduate standing. 3(3-0) S. The course is designed to acquaint the student with the theories and research on the perception of urban environments. Emphasis is placed on the visual attributes as well as user perceptions of the environment with a focus on the structuring of research to explore these dimensions.

FOR GRADUATES ONLY

UD 601 Urban Design Workshop II. Prerequisite: UD 502. 6(0-12) F. Analysis of complex environmental problems ranging in scale from area redevelopment to new towns design.

UD 602 Advanced Problems in Urban Design. Prerequisite: UD 601. 6(0-12) S. Investigation of current urban design problems with special emphasis on individual research and investigation.

UD 690 Special Topics in Urban Design II. Prerequisite: Interdisciplinary core and integrative core in urban design. 1-6 F,S. A course designed to allow for independent study and research in areas of special interest for graduate students in urban design only.

Water Resources

(An interdepartmental, intercampus graduate program)

WATER RESOURCES COMMITTEE—RALEIGH CAMPUS

DR. E. H. WISER (Biological and Agricultural Engineering), *Chairman*

DR. W. J. BLOCK (Politics), DR. M. T. HUISH (Zoology), DR. D. W. HAYNE (Statistics), PROF. D. H. HOWELLS (Water Resources Research Institute)—*Secretary*, DR. V. A. JONES (Food Science), DR. J. W. GILLIAM (Soil Science), DR. T. E. MAKI (Forestry), DR. D. B. MARSLAND (Chemical Engineering), DR. W. T. MCKEAN JR. (Wood and Paper Science), DR. H. H. NEUNZIG (Entomology), PROF. H. A. RUTHERFORD (Textile Chemistry), DR. E. D. SENECA (Botany), DR. J. A. SEAGRAVES (Economics), DR. T. J. SHEETS (Pesticide Residue Research Laboratory), PROF. C. SMALLWOOD (Civil Engineering), DR. C. W. WELBY (Geosciences), PROF. R. R. WILKINSON (Landscape Architecture)

Water resources management is a major issue throughout the country, and national policy supports strong water resources programs at all levels of government. These are multidisciplinary and require understanding of the complex effects of conservation and development. They require well-trained specialists in engineering and the physical, biological and social sciences who also possess a sound grasp of overall objectives and a full appreciation of the respective roles of the participating disciplines.

Water resources is generally considered to be an area of specialization and not a discipline. Graduate education provides an opportunity for broad training in water-related subjects along with intense study in the major disciplines. Students are encouraged to reach beyond their own departments for courses to extend their range of understanding and to participate in water resources courses and seminars designed to develop interdisciplinary communication and a basis for future working relationships.

A large number of courses related to water resources conservation, development

and management are currently offered on the North Carolina State University and University of North Carolina at Chapel Hill campuses. In order to capitalize on the combined training resources of both campuses and to offer them in an organized way to graduate students seeking interdisciplinary training in this field, an intercampus graduate minor in water resources has been established.

The program offers a strong graduate minor in water resources, with the major in any of the basic disciplines contributing to water resources planning, conservation, development and management. The graduate courses currently offered on both campuses have been separated into the following general areas:

Water law and institutions
Planning of water resources and related systems
Municipal and industrial water management
Agricultural and forest water management
Aquatic biology and ecology
Hydrology and hydrogeology

Graduate students majoring in any discipline closely allied with one of the designated water resource areas will be qualified for admission to the program. They will be expected to select their water resources minor courses from one or more areas outside their major. The cohesive elements in the graduate program will be two interdisciplinary core courses including a water resources seminar and a course in water resources planning or water resources economics.

The minimal course requirements for a graduate minor in water resources are:

Master's Degree—The two core courses in water resources plus two courses in water resource areas outside the major discipline approved by the student's advisory committee;

Ph.D. Degree—The two core courses in water resources plus five other courses in water resource areas outside the major discipline approved by the student's advisory committee. The complete listing of courses available under this program is as follows:

WATER RESOURCES CORE COURSES

*Campus	Course	Title
R	**CE 591**	**Civil Engineering Seminar.** (Water Resources Seminar)
	or	
CH	**ENVR 183**	**Water Resources Seminar.**
R	**EC 515**	**Water Resources Economics.**
	or	
CH	**PLAN 234 (ENVR 284)**	**Planning of Natural Resource and Environmental Systems.** (Including Water Resource Systems)

LAW AND INSTITUTIONS OF WATER RESOURCES

R	**PS 502 (ED 502)****	**Public Administration.**
R	**PS 511**	**The Budgetary Process.**
R	**PS 516**	**Public Policy Analysis.**

R	PS 542	Governmental Planning.
R	PS 552	Seminar in Management Systems.
CH	PLAN 230	Planning Law.
CH	ENVR 283** (PLAN 233**)	Natural Resource Law and Policy.
CH	POLI 101***	Public Administration.
CH	POLI 238	Intergovernmental Relations.
CH	POLI 181	National Policy and Administration.

PLANNING OF WATER RESOURCES AND RELATED SYSTEMS

R	CE 575**	Civil Engineering Systems.
R	EC 490	Senior Seminar in Economics.
CH	ENVR 214	Environmental Issues and Decisions.
CH	ENVR 215	Environmental Assessment.
CH	ENVR 217**	Systems Analysis in Environmental Planning.
CH	ENVR 277	Engineering Project Design.
CH	GEOG 156	Geography of Natural Resources.
CH	PLAN 219	Environmental Systems Analysis.
CH	PLAN 232 (ENVR 282)**	Public Investment Theory.
CH	PLAN 241	Environmental Planning.

MUNICIPAL AND INDUSTRIAL WATER MANAGEMENT

R	BAE 578 (CE 578)	Agricultural Waste Management.
R	CE 484	Water Resources Engineering II.
R	CE 571	Theory of Water and Waste Treatment.
R	CE 572	Unit Operations and Processes in Wastes Engineering.
R	CE 573	Analysis of Water and Wastes.
R	CE 574 (NE 574)	Environmental Consequences of Nuclear Power.
R	CE 671	Advanced Water Supply and Waste Water Disposal.
R	CE 672	Advanced Water and Waste Treatment.
R	CE 673	Industrial Water Supply and Waste Disposal.
R	CE 674	Stream Sanitation.
R	TC 401	The Textile Industry and the Environment.
R	FS 690	Seminar in Food Science.
R	WPS 525	Pollution Abatement in Forest Products Industries.
CH	ENVR 122	Water Chemistry.
CH	ENVR 171**	Principles of Water Quality Management.
CH	ENVR 174	Water and Waste Treatment Processes.
CH	ENVR 223	Trace Analysis.
CH	ENVR 231**	Environmental Microbiology.
CH	ENVR 272**	Water Supply and Wastewater Disposal Systems.
CH	ENVR 273	Water and Wastewater Treatment Plant Design.
CH	ENVR 275	Industrial Water Quality Management.

AGRICULTURAL AND FOREST WATER MANAGEMENT

R	BAE 321	Irrigation, Terracing and Erosion Control.

R	BAE 472	Agricultural Water Management.
R	FOR 452	Silvics.
R	FOR 472	Renewable Resource Management.
R	FOR 501	Forest Influences and Watershed Management.
R	FOR 692	Advanced Forest Management Problems.
R	RRA 440	Recreation Resources Inventory and Planning.
R	SSC 461**	Soil and Water Conservation.

AQUATIC BIOLOGY AND ECOLOGY

R	BAE 570 (CE 570, MB 570)	Sanitary Microbiology.
R	BO 560 (ZO 560)**	Principles of Ecology.
R	BO 574 (MB 574)	Phycology.
R	MAS 529 (ZO 529)	Biological Oceanography.
R	MAS 693	Special Topics in Marine Sciences. (Estuarine Ecology)
R	ZO 420	Fishery Science.
R	ZO 519**	Limnology.
R	ZO 619	Advanced Limnology.
R	ZO 621	Fishery Science.
CH	BOTN 114	Algae.
CH	BOTN 141	Ecology.
CH	BOTN 216	Marine Algae.
CH	ENVR 132**	Limnology and Water Pollution.
CH	ENVR 225 (MSCS 105)	Chemical Oceanography.
CH	ENVR 233	Microbial Ecology.
CH	ENVR 235	Ecology of Phytoplankton.
CH	ZOOL 108	Ecology.
CH	ZOOL 109**	Introduction to Hydrobiology.
CH	ZOOL 126 (MSCS 101)**	Oceanography.
CH	ZOOL 140 S (MSCS 104 S)**	Biological Oceanography.
CH	ZOOL 141 S	Special Problems in Marine Biology.
CH	ZOOL 146	Marine Ecology.
CH	ZOOL 213	Advanced Marine Ecology.
CH	ZOOL 226	Ecological and General Systems Theory.

HYDROLOGY AND HYDROGEOLOGY

R	BAE 671 (SSC 671)	Theory of Drainage: Saturated Flow.
R	BAE 674 (SSC 674)	Theory of Drainage: Unsaturated Flow.
R	CE 383**	Water Resources Engineering I.
R	CE 580	Flow in Open Channels.
R	CE 581 (MAS 581)	Introduction to Oceanographic Engineering.
R	CE 643	Hydraulics of Ground Water.
R	CE 644	Ground Water Engineering.
R	GY 400	Environmental Geology.
R	GY 563	Applied Sedimentology Analysis.
R	GY 565**	Hydrogeology.
R	GY 567	Geochemistry.
R	GY 581	Geomorphology.
R	OY 487 (MAS 487, CE 487)	Physical Oceanography.
R	GY 584 (MAS 584)	Marine Geology.
R	MY 411	Introductory Meteorology.
R	MY 486	Weather and Climate.
R	MY 555	Meteorology of the Biosphere.

R	SSC 511	**Soil Physics.**
CH	ENVR 281	**Topics in Advanced Hydrology.**
CH	GEOG 110	**Meteorology.**
CH	GEOG 112	**Micrometeorology.**
CH	GEOG 115	**Climatology.**
CH	GEOG 117	**Soils.**
CH	GEOG 156	**Natural Resources.**
CH	GEOL 104	**Geomorphology.**
CH	GEOL 142	**Principles of Geochemistry.**
CH	GEOL 173 (MSCS 103)	**Geological Oceanography.**
CH	GEOL 242	**Physical Geochemistry.**
CH	GEOL 247	**Sedimentation.**
CH	GEOL 250	**Advanced Sedimentation.**
CH	MSCS 102	**Physical Oceanography.**
CH	MSCS 206	**Seminar on Oceanography.**

* Courses bearing the prefix "R" are taught at Raleigh and those bearing "CH" at Chapel Hill. Unlisted courses can be substituted for listed courses with the approval of the student's advisory committee.

** Courses from which requirements for master's degree minor will normally be met. Substitutions can be made with approval of the student's advisory committee.

*** Prerequisites can be waived for graduate students with water resources minor.

Request for information regarding the water resources graduate programs should be directed to the Chairman of the Water Resources Committee, the departments represented on the Water Resources Committee or the Water Resources Research Institute, 124 Riddick Building, North Carolina State University, Raleigh, N.C. 27607.

Wood and Paper Science

GRADUATE FACULTY

Professor I. S. GOLDSTEIN, *Head*

Professors: R. M. CARTER, E. B. COWLING, E. L. ELLWOOD—*Dean School of Forest Resources;* C. A. HART, R. G. HITCHINGS, R. J. THOMAS; *Extension Professor:* A. C. BAREFOOT JR.; *Professor Emeritus:* A. J. STAMM; *Adjunct Professor:* P. KOCH; *Associate Professors:* H. CHANG, J. S. GRATZL, M. P. LEVI, W. T. MCKEAN JR., R. G. PEARSON, R. H. REEVES, D. H. J. STEENSEN; *Associate Professor Emeritus:* C. G. LANDES; *Adjunct Associate Professors:* K. P. KRINGSTAD, R. K. STEVENS; *Assistant Professor:* M. W. KELLY; *Extension Assistant Professor:* F. J. HILL; *Research Associate:* C. L. CHEN

Graduate study programs leading to the Master of Science and the Doctor of Philosophy degrees are offered for students in a wide variety of areas in the field of wood and paper science. The Master of Wood and Paper Science is available for students who do not wish to emphasize research in their graduate study program.

Because the field of wood and paper science is a derived science, considerable emphasis is placed upon developing a strong minor in the graduate program in any one or more of the supporting disciplines such as organic chemistry, polymer chemistry, chemical engineering, mathematics, statistics, biology, engineering mechan-

ics, mechanical engineering, physics, economics or business administration.

Areas of study and research in pulp and paper science and technology cover wood and fiber chemistry, lignin and carbohydrate chemistry, pulping chemistry, pollution abatement processes, fiber and paper properties, and paper coatings and additives. In wood science and technology, study and research areas include wood physics (especially wood liquid relations), wood chemistry, wood biology, wood mechanics and engineering, manufacturing processes, operations research applications, wood industry economics and marketing.

Modern facilities are completely equipped to conduct education and research in all forms of wood and fiber processing. Included are specialized laboratories for study of wood physics, wood anatomy, wood processing, wood engineering, wood chemistry, pulping, papermaking, paper testing and paper coating. Equipment available includes optical and electron microscopes, a range of spectrophotometers, an ultracentrifuge, membrane osmometers, electron spin resonance and nuclear magnetic resonance apparatus.

Prerequisites for graduate study in the department are an undergraduate degree in wood science, pulp and paper science or in related disciplines such as any of a number of branches of science or engineering.

FOR ADVANCED UNDERGRADUATES

WPS 403 Paper Process Analysis. Prerequisite: WPS 321, 322. 3(0-6) S.

WPS 411, 412 Pulp and Paper Unit Processes I, II. Prerequisite: CHE 301, 302. 3 (3-0) F,S.

WPS 413 Paper Properties and Additives. 3(1-6) F.

WPS 423 (FOR 423) Logging and Milling. Prerequisite: Junior standing. 3(2-3) F.

WPS 434 Wood Operations. Prerequisites: WPS 301, 302. 3(2-3) F.

WPS 435 (FOR 435) Systems Analysis in Forest Products. Prerequisite: Senior standing. 3(3-0) S.

WPS 441 Introduction to Wood Mechanics. Prerequisite: MA 212, PY 221 or PY 211. 2(2-0) F.

WPS 442 Wood Mechanics and Design. Prerequisite: EM 211 or WPS 441. 3(2-3) S.

WPS 461 Paper Converting. Prerequisite: Junior standing. 1(1-0) S.

WPS 463 Plant Inspections. Prerequisite: Senior standing in pulp and paper. 1(0-3) S.

WPS 471 Pulping Process Analysis. 3(1-6) F.

WPS 481 Pulping Processes and Products. Prerequisites: WPS 202, CH 103. 2 (2-0) S.

WPS 491 (FOR 491) Senior Problems in Forest Resources. Prerequisite: Consent of department. Credits Arranged.

WPS 492 (FOR 492) Senior Problems in Forest Resources. Prerequisite: Consent of department. Credits Arranged.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

WPS 513 Tropical Woods. Prerequisites: WPS 203, 301. 2(1-3) F. Structure, identification, properties, characteristics and use of tropical woods, especially those used in plywood and furniture. Staff

WPS 521, 522 Chemistry of Wood and Wood Products. Prerequisites: CH 315, CH 331, WPS 202, PY 212. 3(2-3) F,S. Fundamental chemistry and physics of wood and wood components; pulping principles; electrical and thermal properties. Staff

WPS 525 Pollution Abatement in Forest Products Industries. Prerequisite: Graduate or advanced undergraduate standing in science or engineering curricula. 3(3-0) S. Pollution sources, inplant control and treatment of water and air pollution in forest products with concentration on the pulp and paper industry. McKean

WPS 533 Advanced Wood Structure and Identification. Prerequisite: WPS 202. 2 (1-3) F. Advanced microscopic identification of the commercial woods of the United States and some tropical woods; microscopic anatomical features and laboratory techniques. Thomas

WPS 591 Wood and Paper Science Problems. Prerequisite: Senior or graduate standing. Credits Arranged. Assigned or selected problems in the field of silviculture, logging, lumber manufacturing, pulp technology or forest management. Staff

WPS 599 Methods of Research in Wood and Paper Science. Prerequisite: Senior or graduate standing. Credits Arranged. Research procedures, problem outlines, presentation of results; consideration of selected studies by forest research organizations; sample plot techniques. Staff

FOR GRADUATES ONLY

WPS 604 Timber Physics. Prerequisite: WPS 441. 3(3-0) F,S. Density, specific gravity and moisture content variation affecting physical properties; physics of drying at high and low temperatures; thermal, sound, light and electrical properties of wood. Hart

WPS 605 Design and Control of Wood Processes. Prerequisite: WPS 604. 3(3-0) F,S. Design and operational control of equipment for processing wood. Staff

WPS 606 Wood-Process Analysis. Prerequisite: WPS 604. 3(3-0) F. Analysis of wood process through the solution of comprehensive problems involving the physics of temperature and moisture relations. Staff

WPS 607 Advanced Quality Control. Prerequisites: WPS 606, ST 515. 3(3-0) S. Advanced statistical quality control as applied to wood processing. Barefoot

WPS 691 (FOR 691) Graduate Seminar. Prerequisite: Graduate standing. 1(1-0)

F,S. Presentation and discussion of progress reports on research, special problems and outstanding publications. Graduate Staff

WPS 693 Advanced Wood Technology Problems. Prerequisite: Graduate standing. Credits Arranged. Selected problems in the field of wood technology. Graduate Staff

WPS 699 (FOR 699) Problems and Research. Prerequisite: Graduate standing. Credits Arranged. Specific problems that will furnish material for a thesis. Graduate Staff

Zoology

GRADUATE FACULTY

Professor D. E. Davis, *Head*

Professors: F. S. Barkalow Jr., B. J. Copeland, D. S. Grosch, R. Harkema, W. W. Hassler, D. W. Hayne, J. E. Hobbie, C. F. Lytle, B. S. Martof, L. E. Mettler, G. C. Miller, T. L. Quay, D. E. Smith; *Professor Emeritus:* B. B. Brandt; *Adjunct Professors:* D. H. K. Lee, T. R. Rice, P. N. Witt; *Associate Professors:* Phyllis C. Bradbury, M. T. Huish, J. F. Roberts; *Adjunct Associate Professors:* J. G. Vandenbergh, D. A. Wolfe; *Assistant Professors:* G. T. Barthalmus, K. E. Muse, G. B. Pardue, G. G. Shaw, J. M. Whitsett, T. G. Wolcott; *Adjunct Assistant Professors:* F. A. Cross, G. R. Huntsman, G. W. Thayer; *Visiting Assistant Professor:* W. L. Rickards III

The Department of Zoology offers to qualified students the opportunity to earn the Master of Science and the Doctor of Philosophy degrees. Students may specialize in many areas: behavior, general ecology, population dynamics, limnology, marine biology, fisheries biology, wildlife biology, taxonomy and ecological life histories of parasites, comparative morphology and systematics of vertebrates, cellular and comparative physiology, and endocrinology. For certain specialities, a Master's degree without a thesis is awarded.

The department is located in Gardner Hall where facilities for a wide variety of research activities are available. Opportunity for many types of ecological studies is provided in the extensive natural areas of state parks; some are only six miles from campus. Several off-campus laboratories are available to students and staff.

By mutual agreement, a student may choose to do research with any member of the graduate staff. A student will make up a plan of study after discussing his interests and objectives with his major professor and advisory committee. Those courses will be selected that best prepare one for one's particular interests. Advanced courses in other departments provide a variety of subjects for minor fields of study: biochemistry, biomathematics, botany, ecology, entomology, genetics, psychology, statistics and other related sciences. The student is given the opportunity to develop a high order of independent thought, broad knowledge, technical skills and thorough training in investigative techniques. Strong emphasis is placed on active participation in seminars, practice in the methods of original research and preparation of manuscripts for publication in scientific journals.

A prospective student must submit Graduate Record Examination scores for the verbal, quantitative and advanced tests with the application for admission.

SPECIAL FACILITIES FOR MARINE RESEARCH

The Pamlico Marine Laboratory near Aurora, North Carolina, is located on the Pamlico River Estuary not far from Pamlico Sound. The research concerns both basic marine ecology and the effects of man's activities on the natural estuarine environment, particularly industrial and domestic pollution.

The Mid-Atlantic Coastal Fisheries Research Center at Beaufort, North Carolina is supported by the National Marine Fisheries Service and by the Atomic Energy Commission. After consultation with his adviser a student may arrange to conduct research at the facilities at Beaufort.

The Hatteras Marine Laboratory is located at the southern end of Hatteras Island, North Carolina, where a variety of interesting biological habitats occur. Cape Hatteras is the closest point to the Gulf Stream north of Daytona Beach, Florida. Both northern and southern faunas are found in adjacent waters.

FOR ADVANCED UNDERGRADUATES

ZO 400 Biological Basis of Man's Environment. Prerequisite: Junior standing. 3 (2-2) F,S.

ZO 401 (ENT 401) Bibliographic Research in Biology. 1(1-0) F. (See entomology, page 147.)

ZO 414 (BO 414) Cell Biology. 3(3-0) F. (See botany, page 81.)

ZO 415 Cellular and Animal Physiology Laboratory. Corequisite: ZO 414 or ZO 421. 2(0-5) F,S.

ZO 420 Fishery Science. Prerequisites: ZO 201, ZO 360. 3(2-3) F.

ZO 421 Vertebrate Physiology. Prerequisites: CH 223, PY 212, ZO 201. 3(3-0) F,S.

ZO 441 Ichthyology. Prerequisite: ZO 223 or ZO 351. 3(2-3) S.

FOR GRADUATES AND ADVANCED UNDERGRADUATES

ZO 501 Ornithology. Prerequisites: ZO 223 or ZO 351, ZO 421. 3(2-3) F,S. The biology of birds: systematics, physiology, life histories, ecology and behavior.

Quay

ZO 503 (PSY 503) Comparative Psychology. 3(3-0) S. (See psychology, page 236.)

ZO 510 Adaptive Behavior of Animals. Prerequisite: ZO 421 or consent of instructor. 4(3-3) F. The comparative study of animal behavior including a treatment of physiological mechanisms and adaptive significance. Both invertebrates and vertebrates are studied.

Whitsett

ZO 513 (PHY 513) Comparative Physiology. Prerequisites: ZO 421 or consent of instructor. 4(3-3) S. A comparative study of the organ systems of vertebrates and

the physiological processes involved in maintaining the homeostatic state. The various compensatory mechanisms employed during environmental stress are included. Lee

ZO 515 Growth and Reproduction of Fishes. Prerequisites or corequisites: GN 411, ZO 420, ZO 421, ZO 441. 3(2-3) S. The biology of fishes: physiology, anatomy, pathology, behavior and genetics. This course is designed especially for graduate students in fisheries. Several trips to research laboratories are taken. (Offered in spring 1975 and alternate years.) Pardue

ZO 517 Population Ecology. Prerequisites: ZO 360 (BO 360) and ST 511 or equivalent. 3(3-0) S. The dynamics of natural populations. Current work, theories and problems dealing with population growth, fluctuation, limitation and patterns of dispersion, the ecological niche, food chains and energy flow. Emphasis on methods of study. Hayne

ZO 519 Limnology. Prerequisite: ZO 360 (BO 360) or equivalent. 4(3-3) F. A study of inland waters. Lectures dealing with physical, chemical and biological factors that affect freshwater organisms. General principles are illustrated in the laboratory and on field trips. Hobbie

ZO 524 (PO 524) Comparative Endocrinology. 4(3-3) S. (See poultry science, page 232.)

ZO 529 (MAS 529) Biological Oceanography. Prerequisite: ZO 360 (BO 360) or consent of instructor. 3(3-0) S. A comprehensive course stressing the dynamic interrelationships between organisms of the sea and their physical and chemical environment. The latter part of the course will examine fundamental concepts in biological oceanography and will particularly stress experimental methods.

ZO 532 (GN 532) Biological Effects of Radiations. 3(3-0) S. (See genetics, page 158.)

ZO 540 (GN 540) Evolution. 3(3-0) F. (See genetics, page 158.)

ZO 542 Herpetology. Prerequisites: ZO 223 or ZO 351, ZO 421. 3(2-3) S. The biology of the amphibians and reptiles: systematics, life history, anatomy, behavior, physiology and ecology. Martof

ZO 544 Mammalogy. Prerequisites: ZO 223 or ZO 351, consent of instructor. 3 (2-3) S. The classification, identification and ecology of the major groups of mammals. Barkalow

ZO 550 (GN 550) Experimental Evolution. 3(3-0) F. (See genetics, page 159.)

ZO 553 Principles of Wildlife Science. Prerequisite: ZO 360 (BO 360). 3(2-3) F. The principles of wildlife management and their application are studied in the laboratory and in the field. Doerr

ZO 555 (MB 555) Protozoology. Prerequisite: Consent of instructor. 4(2-6) S. The biology of the Protozoa: lectures include morphology, physiology, ecology, genetics, reproduction, evolution, systematics and life-cycles of both free-living and parasitic taxa; laboratory will stress recognition of selected forms and demonstrate techniques used to prepare specimens for microscopic examination. Bradbury

ZO 560 (BO 560) Principles of Ecology. Prerequisite: Three semesters of college-level biology courses. 4(3-3) F. A consideration of the principles of ecology at the

graduate level. Each of the major subject areas of ecology is developed in sufficient depth to provide a factual and philosophical framework for the understanding of ecology. Shaw, Blum

ZO 575 (PHY 575, ENT 575) Physiology of Invertebrates. 3(3-0) F. (See physiology, page 220.)

ZO 581 Helminthology. Prerequisites: ZO 223 or ZO 351, ZO 315 or equivalent. 4 (2-4) F. The study of the morphology, biology and control of the parasitic helminths. Miller

ZO 582 (ENT 582) Medical and Veterinary Entomology. 3(2-3) S. (See entomology, page 149.)

ZO 590 Special Studies. Prerequisites: Twelve hours zoology, consent of instructor. Credits Arranged F,S. A directed individual investigation of a particular problem in zoology, accompanied by a review of the pertinent literature. A maximum of three hours is allowed toward the master's degree. Graduate Staff

ZO 592 Topical Problems. Prerequisite: Consent of instructor. 1-3 F,S. Organized, formal lectures and discussion of a special topic. Graduate Staff

FOR GRADUATES ONLY

ZO 603 Advanced Parasitology. Prerequisite: ZO 581. 3(2-3) S. The study of the theoretical and practical aspects of parasitism; taxonomy, physiology and immunology of animal parasites. Harkema, Roberts

ZO 610 Current Aspects of Animal Behavior. Prerequisite: ZO 510 or equivalent. 4 (3-3) S. Lectures, discussions, seminars and laboratories. The course will treat in detail selected aspects of the behavior of invertebrates and vertebrates. The relationship of behavior to physiology, ecology and other related biological fields will be emphasized. Whitsett

ZO 614 Advanced Cell Biology. Prerequisite: ZO 414 (BO 414) or equivalent. 3 (3-0) S. A study of the current problems of cell biology including the problems of the molecular organization and functions of membrane systems, subcellular organelles and specialized cells. Roberts, Smith

ZO 619 Advanced Limnology. Prerequisite: ZO 519. 3(1-6) S. A study of primary productivity, population interactions and effects of pollution. An experimental approach is used in the laboratory. Hobbie

ZO 621 Fishery Science. Prerequisite: ST 511, ZO 420, a course in calculus. 3 (2-3) F. An analysis of fishery research methods. Population enumeration and dynamics. The relationship between fluctuations in natural populations and environmental factors. (Offered 1974 and alternate years.) Hassler

ZO 660 (BO 660) Advanced Topics in Ecology I. 4(3-3) S. (See botany, page 84.)

ZO 661 (BO 661) Advanced Topics in Ecology II. Prerequisite: ZO 560 (BO 560) or equivalent. 4(3-3) S. Reports and seminar discussions of five major topics, such as secondary productivity, competitive exclusion, predator-prey and other interspecies relationships, regulation of populations, physiological ecology and management of resources. Some field trips. Laboratory provides experience in analysis of ecological systems, modeling and computer simulation. (Offered 1973 and alternate years.) Graduate Staff

ZO 690 Seminar. 1(1-0) F,S. The presentation and defense of original research and current literature. Graduate Staff

ZO 699 Research in Zoology. Prerequisite: Twelve semester credits in zoology and approval of instructor. Credits Arranged. F,S.

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UNIVERSITY DISRUPTIONS POLICY AND PROCEDURES

POLICIES, PROCEDURES, AND DISCIPLINARY ACTIONS IN CASES OF DISRUPTION OF THE EDUCATIONAL PROCESS

The following statements concerning policies, procedures, and disciplinary actions in cases of disruption of the educational process were approved by the Trustees of the University of North Carolina and as such they remain in effect until modified by action by the Board of Governors of the new University system or by the Trustees of North Carolina State University.

Section 1. Policies Relating to Disruptive Conduct

The University of North Carolina has long honored the right of free discussion and expression, peaceful picketing and demonstrations, the right to petition and peaceably to assemble. That these rights are a part of the fabric of this institution is not questioned. They must remain secure. It is equally clear, however, that in a community of learning willful disruption of the educational process, destruction of property, and interference with the rights of other members of the community cannot be tolerated. Accordingly, it shall be the policy of the University to deal with any such disruption, destruction or interference promptly and effectively, but also fairly and impartially without regard to race, religion, sex or political beliefs.

Section 2. Definition of Disruptive Conduct

(a) Any faculty member (the term "faculty member", wherever used in this policy shall include regular faculty members, full-time instructors, lecturers, and all other persons exempt from the North Carolina State Personnel System [Chapter 126 of the General Statutes as amended] who receive compensation for teaching, or other instructional functions, or research at the University), any graduate student engaged in the instructional program, or any student who, with the intent to obstruct or disrupt any normal operation or function of the University or any of its component institutions, engages, or incites others to engage, in individual or collective conduct which destroys or significantly damages any University property, or which impairs or threatens impairment of the physical well-being of any member of the University community, or which, because of its violent, forceful, threatening or intimidating nature or because it restrains freedom of lawful movement, otherwise prevents any member of the University community from conducting his normal activities within the University, shall be subject to prompt and appropriate disciplinary action, which may include suspension, expulsion, discharge or dismissal from the University.

The following, while not intended to be exclusive, illustrate the offenses encompassed herein, when done for the purpose of obstructing or disrupting any normal operation or function of the University or any of its component institutions: (1) occupation of any University building or part thereof with intent to deprive others of its normal use; (2) blocking the entrance or exit of any University building or corridor or room therein with intent to deprive others of lawful access to or from, or use of, said building or corridor or room; (3) setting fire to or by any other means destroying or substantially damaging any University building or property, or the property of others on University premises; (4) any possession or display of, or attempt or threat to use, for any unlawful purpose, any weapon, dangerous instrument, explosive, or inflammable material in any University building or on any University campus; (5) prevention of, or attempt to prevent by physical act, the attending, convening, continuation or orderly conduct of any University class or activity or of any lawful meeting or assembly in any University building or on any

University campus; and (6) blocking normal pedestrian or vehicular traffic on or into any University campus.

(b) Any person engaged in the instructional program who fails or refuses to carry out validly assigned duties, with the intent to obstruct or disrupt any normal operation or function of the University or any of its component institutions, shall be subject to prompt and appropriate disciplinary action under this policy if (but only if) his status is such that he is not subject to the provisions of Section 603 of Chapter VI of the Code of the University of North Carolina.

Section 3. Responsibilities of Chancellors

(a) When any Chancellor has cause to believe than any of the provisions of this policy have been violated, he shall forthwith investigate or cause to be investigated the occurrence, and upon identification of the parties involved shall promptly determine whether any charge is to be made with respect thereto.

(b) If he decides that a charge is to be made, he shall, within thirty (30) days after he has information as to the identity of the alleged perpetrator of the offense but in no event more than twelve (12) months after the occurrence of the alleged offense, (i) refer the case to the appropriate existing University judicial body, [See Faculty Hearing Committee in Chapter VIII below] or (ii) refer the matter to a Hearing Committee drawn from a previously selected Hearings Panel [See Hearings Panel in Chapter VIII below] which, under this option, is required to implement action for violation of Section 2 (a) or (b) of this Chapter. If the case is referred to an existing University judicial body under (i) above, the procedural rules of that body shall be followed, and subsections (c) through (f) below shall not be applicable. If the matter is referred to a Hearing Committee under (ii) above, the procedural rules prescribed in subsections (c) through (f) below shall be followed.

(c) The accused shall be given written notice by personal service or registered mail, return receipt requested, stating:

(1) The specific violations of this policy with which the accused is charged.

(2) The designated time and place of the hearing on the charge by the Hearing Committee, which time shall be not earlier than seven (7) nor later than ten (10) days following receipt of the notice.

(3) That the accused shall be entitled to the presumption of innocence until found guilty, the right to retain counsel, the right to present the testimony of witnesses and other evidence, the right to cross-examine all witnesses against him, the right to examine all documents and demonstrative evidence adverse to him, and the right to a transcript of the proceedings of the hearing.

(d) The Hearing Committee shall determine the guilt or innocence of the accused. If the person charged is found guilty, the Hearing Committee shall recommend to the Chancellor such discipline as said body determines to be appropriate. After considering such recommendation the Chancellor shall prescribe such discipline as he deems proper. In any event, whether the person is found guilty or not guilty, a written report shall be made by the Chancellor to the President within ten (10) days.

(e) Any person found guilty shall have ten (10) days after notice of such finding in which to appeal to the President of the University. Such an appeal if taken shall be upon the grounds set forth in Section 5.

(f) Any accused person who, without good cause, shall fail to appear at the time and place fixed for the hearing of his case by the Hearing Committee shall be suspended indefinitely or discharged from University employment.

(g) A Chancellor, unless so ordered or otherwise prevented by court, shall not be precluded from carrying out his duties under this policy by reason of any pending action in any State or Federal court. Should a delay occur in prosecuting the charge against the accused because the accused or witnesses that may be necessary to a determination of the charge are involved in State or Federal court actions, the time limitations set forth above in this Section 5-3 shall not apply.

(h) Conviction in any State or Federal court shall not preclude the University or

any of its officers from exercising disciplinary action in any offense referred to in this policy.

(i) Nothing contained in this policy shall preclude the President or any Chancellor from taking any other steps, including injunctive relief or other legal action, which he may deem advisable to protect the best interests of the University.

Section 4. Aggravated Acts or Threatened Repetition of Acts

(a) The Chancellor of each of the component institutions of the University shall appoint an Emergency Consultative Panel which shall be composed of not less than three (3) nor more than five (5) faculty members and not less than three (3) nor more than five (5) students who shall be available to advise with the Chancellor in any emergency. No member of such Panel shall serve for more than one (1) year unless he be reappointed by the Chancellor. The Chancellor may make appointments, either temporary or for a full year, to fill any vacancies which may exist on the Panel.

(b) If, in the judgment of the Chancellor, there is clear and convincing evidence that a person has committed any of the acts prohibited under this policy which, because of the aggravated character or probable repetition of such act or acts, necessitates immediate action to protect the University from substantial interference with any of its orderly operations or functions, or to prevent threats to or acts which endanger life or property, the Chancellor, with the concurrence as hereinafter provided of the Emergency Consultative Panel established pursuant to (a) above, may forthwith suspend such person from the University and bar him from the University campus; provided, however, that in the event of such suspension the person suspended shall be given written notice of the reason for his suspension, either personally or by registered mail addressed to his last known address, and shall be afforded a prompt hearing, which, if requested, shall be commenced within ten (10) days of the suspension. Except for purposes of attending personally any hearings conducted under this policy, the bar against the appearance of the accused on the University campus shall remain in effect until final judgment has been rendered in his case and all appellant proceedings have been concluded, unless such restriction is earlier lifted by written notice from the Chancellor.

(c) A quorum of the Emergency Consultative Panel provided for in (a) above shall consist of not less than four (4) of its members, and the required concurrence shall have been obtained if a majority of such quorum shall indicate their concurrence. The Chancellor shall meet personally with members of such Panel at the time he seeks concurrence, if it is feasible to do so. However, if the circumstances are such that the Chancellor deems it not to be feasible to personally assemble such members, then he may communicate with them or the required number of them individually by telephone or by such other means as he may choose to employ, in which event he may proceed as provided in (b) above after the required majority of such members have communicated their concurrence to him.

(d) In the Chancellor's absence or inability to act, the President may exercise the powers of the Chancellor specified in this Section 4 in the same manner and to the same extent as could the Chancellor but for such absence or inability to act.

Section 5. Right of Appeal

Any person found guilty of violating the provisions of this policy by the Hearing Committee referred to in Section 3 shall have the right to appeal the finding and the discipline imposed upon him to the President of the University. Any such appeal shall be in writing, shall be based solely upon the record, and shall be limited to one or more of the following grounds:

(1) That the finding is not supported by substantial evidence;
(2) That a fair hearing was not accorded the accused; or
(3) That the discipline imposed was excessive or inappropriate.

It shall be the responsibility of the President to make prompt disposition of all such appeals, and his decision shall be rendered within thrity (30) days after receipt of the complete record on appeal.

Section 6. No Amnesty

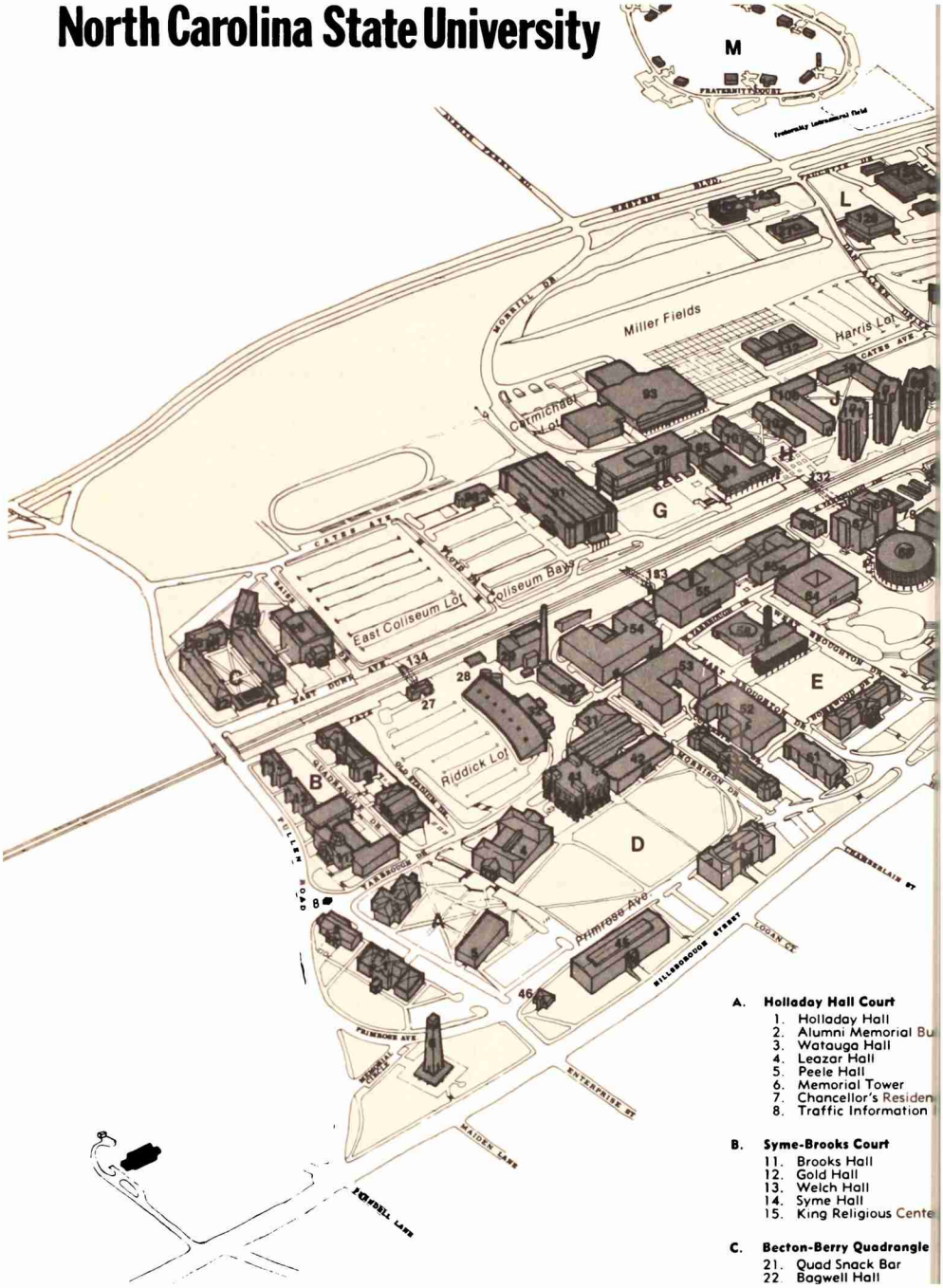
No administrative official, faculty member, or student of the University shall have authority to grant amnesty or to make any promise as to prosecution or non-prosecution in any court, State or Federal, or before any student, faculty, administrative, or Trustee committee to any person charged with or suspected of violating Section 5-2 (a) or (b) of these Bylaws.

Section 7. Publication

The provisions of this policy shall be given wide dissemination in such manner as the President or Chancellors may deem advisable, and shall be printed in the official catalogues which may be issued by each component institution of the University.

INDEX

North Carolina State University



A. Holladay Hall Court

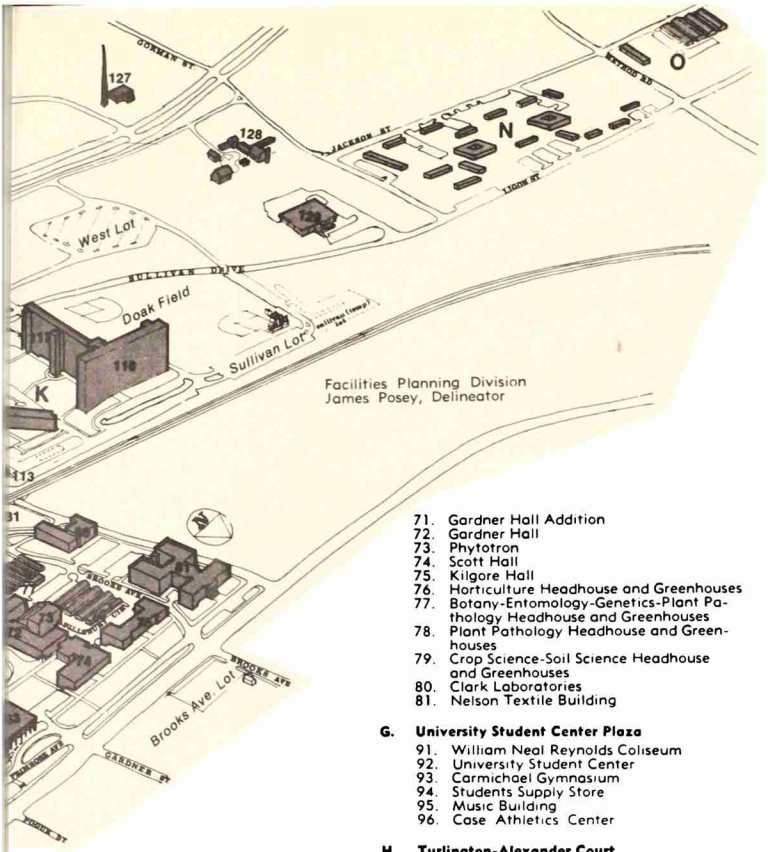
1. Holladay Hall
2. Alumni Memorial Bu
3. Watauga Hall
4. Leazar Hall
5. Peele Hall
6. Memorial Tower
7. Chancellor's Residen
8. Traffic Information

B. Syme-Brooks Court

11. Brooks Hall
12. Gold Hall
13. Welch Hall
14. Syme Hall
15. King Religious Cente

C. Becton-Berry Quadrangle

21. Quad Snack Bar
22. Bagwell Hall



23. Berry Hall
24. Clark Hall Infirmary
25. Becton Hall
26. Frank Thompson Theater
27. Field House
28. Car Wash
29. Power Plant
30. Laundry
31. Park Shops
32. Morris Building and West Riddick Stands

Court of North Carolina

41. Poe Hall
42. Page Hall
43. 1911 Building
44. Winston Hall
45. Tompkins Hall
46. Primrose Hall

Gardner Arboretum

51. Ricks Hall
52. Withers Hall
53. Daniels Hall
54. Riddick Engineering Laboratories
55. Mann Hall
56. Burlington Engineering Laboratories
57. Patterson Hall

University Plaza

61. D.H. Hill Library—original wing
62. D.H. Hill Library—book stack tower
63. D.H. Hill Library—Erdahl-Cloyd wing
64. Polk Hall
65. Broughton Hall
66. Bureau of Mines
67. Cox Hall
68. Harrelson Hall
69. Dabney Hall
70. Williams Hall

71. Gardner Hall Addition
72. Gardner Hall
73. Phytotron
74. Scott Hall
75. Kilgore Hall
76. Horticulture Headhouse and Greenhouses
77. Botany-Entomology-Genetics-Plant Pathology Headhouse and Greenhouses
78. Plant Pathology Headhouse and Greenhouses
79. Crop Science-Soil Science Headhouse and Greenhouses
80. Clark Laboratories
81. Nelson Textile Building

G. University Student Center Plaza

91. William Neal Reynolds Coliseum
92. University Student Center
93. Carmichael Gymnasium
94. Students Supply Store
95. Music Building
96. Case Athletics Center

H. Turlington-Alexander Court

101. Alexander Hall
102. Turlington Hall

J. Tucker-Owen Court

106. Owen Hall
107. Tucker Hall
108. Harris Cafeteria
109. Bowen Hall
110. Metcalf Hall
111. Carroll Hall
112. Physical Plant Maintenance Shop
113. Print Shop

K. Lee-Bragaw Court

116. Bragaw Hall
117. Lee Hall
118. Sullivan Hall

L. Western Boulevard Court

121. Hodges Wood Products Laboratory
122. Biltmore Hall
123. Robertson Wing of Biltmore Hall
124. Weaver Laboratories
125. Grinnells Animal Health Laboratory
126. Schaub Food Science Building
127. WUNC-TV
128. Agricultural Experiment Station—Old Central Station
129. Central Stores

Railroad Underpasses

131. Pedestrian Underpass—Dan Allen Drive
132. Pedestrian Underpass—Students Supply Store
133. Pedestrian Underpass—Coliseum
134. Pedestrian Underpass—Riddick Lot

M. Fraternity Court

N. McKimmon Village (Married Student Housing)

O. 840 Method Road Greenhouses

North Carolina State University Bulletin
The Graduate School
P. O. Box 5335
Raleigh, North Carolina 27607

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