THE UNIVERSITY OF ARIZONA
TUCCSON, ARIZONA

GRADUATE CATALOG
1987-88, 1988-89
THE UNIVERSITY OF ARIZONA
TUeSON, ARIZONA

GRADUATE CATALOG
1987-88, 1988-89
All colleges and departments establish certain academic requirements which must be met before a degree is granted. These requirements concern such things as curricula and courses, majors and minors, and campus residence. Advisers, directors, department heads, and deans are available to help the student understand and arrange to meet these requirements, but the student is responsible for fulfilling them. At the end of a student's course of study, if requirements for graduation have not been satisfied, the degree will not be granted. For this reason it is important for each student to be acquainted and remain currently informed about all regulations and to be responsible for completing requirements. Courses, programs, and requirements described in the catalog may be suspended, deleted, restricted, supplemented, or changed in any other manner at any time at the sole discretion of the University and the Arizona Board of Regents. The catalog does not establish a contractual relationship but it summarizes the total requirements which the student must presently meet before qualifying for a faculty recommendation to the Arizona Board of Regents to award a degree.

The determination of acceptability of credit for course work completed at another institution of higher learning, whether the other institution is accredited or not, is made solely at the discretion of this institution as guided by its academic policy bodies. Students are advised to check with the Office of Admissions to determine the acceptability of credit from other institutions and its applicability toward a program of study at the University of Arizona.

The University of Arizona does not discriminate on the basis of sex, age, race, religion, color, national origin, Vietnam Era Veterans' status, or disability in its admissions, employment and educational programs or activities, and is required by Title IX of the Education Amendments of 1972, Title VII of the Civil Rights Act of 1964, Sections 503 and 504 of the Rehabilitation Act of 1973, the Age Discrimination in Employment Act of 1967, and the Vietnam Era Veterans' Readjustment Assistance Act of 1972 not to discriminate in such manner. Inquiries concerning the application of said regulations to the University of Arizona may be referred to Dr. Doris J. Ford, Affirmative Action Officer, Administration 501, phone (602) 621-3081. In compliance with the Family Education Rights and Privacy Act of 1974, the University of Arizona guarantees that the parents of dependent children will have a right to information about their offspring without having to gain the student's consent.

Announcements in this catalog concerning regulations, fees, curricula, or other matters, are subject to change without notice. Inquiries regarding admission to the Graduate College should be addressed to:

Graduate Admissions Office
Administration 107
The University of Arizona
Tucson, Arizona 85721
(602) 621-3132

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DIRECTIONS FOR CORRESPONDENCE

Prospective graduate students are asked to correspond with officials of the University as follows:

The Graduate College Admissions Office concerning admission to the regular and summer sessions, progress of pending admission applications, and general regulations.

Head of particular department for further information on departmental course offerings, degree programs, graduate assistantships, and tuition and academic scholarships.

Director of Extended University and the Summer Session for announcements of continuing education programs.

Coordinator of Summer Session for summer session announcements.

Dean of the College of Education for guidance relative to course offerings in education, requirements for certification of teachers.

Director of Student Financial Aid for information about loans, college work-study programs, and other forms of financial assistance.

Director of Career and Placement Services for information on part-time employment, teaching positions.

Director of Residence Life for information on living accommodations.

Registrar concerning transcripts.
ACADEMIC DIVISIONS OF THE UNIVERSITY

COLLEGE OF AGRICULTURE. School of Family and Consumer Resources (with divisions of Child Development and Family Relations; Clothing, Textiles and Interior Design; Counseling and Guidance; Home Economics Education/Consumer Studies); School of Renewable Natural Resources (with divisions in Landscape Resources, Range Resources, Forest-Watershed Resources, Wildlife, Fisheries and Recreation Resources). Departments of: Agricultural Economics; Agricultural Education; Agricultural Engineering; Animal Sciences; Entomology; Nutrition and Food Science; Plant Pathology; Plant Sciences; Soil and Water Science; Veterinary Science. University Departments of: Biochemistry; Microbiology and Immunology; Molecular and Cellular Biology.

COLLEGE OF ARCHITECTURE.

COLLEGE OF ARTS AND SCIENCES. School of Music. Departments of: Anthropology; Art; Astronomy; Atmospheric Sciences; Chemistry; Classics; Communication; Computer Science; Drama; Ecology and Evolutionary Biology; English; French and Italian; Geography and Regional Development; Geosciences; German; Graduate Library School; History; Journalism; Linguistics; Mathematics; Media Arts; Oriental Studies; Philosophy; Physics; Planetary Sciences; Political Science; Psychology; Russian and Slavic Languages; Sociology; Spanish and Portuguese; Speech and Hearing Sciences; Statistics. University Departments of Biochemistry; Microbiology and Immunology; Molecular and Cellular Biology. Committee on Dance.

COLLEGE OF BUSINESS AND PUBLIC ADMINISTRATION. Departments of: Accounting; Economics; Finance and Real Estate; Management and Policy; Management Information Systems; Marketing.

COLLEGE OF EDUCATION. Divisions of: Educational Foundations and Administration; Language, Reading and Culture; Special Education and Rehabilitation; and Teaching and Teacher Education.

COLLEGE OF ENGINEERING AND MINES. Departments of: Aerospace and Mechanical Engineering; Chemical Engineering; Civil Engineering and Engineering Mechanics; Electrical and Computer Engineering; Hydrology and Water Resources; Materials Science and Engineering; Mining and Geological Engineering; Nuclear and Energy Engineering; Systems and Industrial Engineering.

COLLEGE OF LAw.

COLLEGE OF MEDICINE. Departments of: Anatomy; Anesthesiology; Family and Community Medicine; Internal Medicine; Neurology; Obstetrics-Gynecology; Ophthalmology; Pathology; Pediatrics; Pharmacology; Physiology; Psychiatry; Radiation Oncology; Radiology; Surgery. University Departments of: Biochemistry; Microbiology and Immunology; Molecular and Cellular Biology.

COLLEGE OF NURSING.

COLLEGE OF PHARMACY. Departments of: Pharmaceutical Sciences; Pharmacology and Toxicology; Pharmacy Practice.

GRADUATE COLLEGE. Committees on: American Indian Studies; Animal Physiology; Applied Mathematics; Arid Lands Resource Sciences; Bioengineering; Business Administration; Comparative Literature and Literary Theory; Environment and Behavior; Genetics; Gerontology; History and Philosophy of Science; Latin American Studies; Medieval Studies; Nutritional Sciences; Optical Sciences; Pharmacology and Toxicology; Planning; Plant Protection; Remote Sensing; Romance Languages; Toxicology.

GENERAL DEPARTMENTS. Exercise and Sport Sciences; School of Health-Related Professions; School of Military Science, Naval Science, and Military Aerospace Studies.

UNIVERSITY DEPARTMENTS. Biochemistry; Microbiology and Immunology; Molecular and Cellular Biology.

GENERAL COMMITTEES. Black Studies; Business Administration; Gerontology; Humanities; Mexican American Studies; Religious Studies; Women's Studies.

EXTENDED UNIVERSITY AND THE SUMMER SESSION.

THE UNIVERSITY LIBRARIES.
The abbreviations listed below are used throughout this catalog to refer to the disciplines indicated:

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<tr>
<td>aed.</td>
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<tr>
<td>aen.</td>
<td>Agricultural Engineering</td>
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<tr>
<td>a.m.e.</td>
<td>Aerospace and Mechanical Engineering</td>
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<td>a.ph.</td>
<td>Animal Physiology</td>
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<td>acct.</td>
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<td>agri.</td>
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<td>Animal Sciences</td>
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<td>Applied Mathematics</td>
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<td>Arid Lands Resource Sciences</td>
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<td>Atmospheric Sciences</td>
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<td>Business Administration</td>
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<td>Bl.s.</td>
<td>Black Studies</td>
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<td>Civil Engineering</td>
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<td>Child Development and Family Relations</td>
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<td>Chemical Engineering</td>
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<td>Chemistry</td>
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<td>Communication</td>
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<td>coun.</td>
<td>Counseling and Guidance</td>
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<tr>
<td>cp.l.t.</td>
<td>Comparative Literature and Literary Theory</td>
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<td>c.s.</td>
<td>Consumer Studies</td>
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<td>Computer Science</td>
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<td>c.t.</td>
<td>Critical Thinking</td>
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<td>History and Philosophy of Science</td>
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<td>Medicine (Interdepartmental)</td>
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<td>Microbiology and Immunology</td>
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<td>m.l.s.</td>
<td>Management Information Systems</td>
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<td>Materials Science and Engineering</td>
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<td>Music</td>
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<td>musi.</td>
<td>Music (Performance Studies)</td>
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<td>neur.</td>
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<td>Nuclear and Energy Engineering</td>
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<td>Nutrition and Food Science</td>
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<td>Natural Resource Recreation</td>
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<td>Obstetrics and Gynecology</td>
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<td>Ophthalmology</td>
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<td>Or.s.</td>
<td>Oriental Studies</td>
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<td>o.s.h.</td>
<td>Occupational Safety and Health</td>
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<td>Romance Languages</td>
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<td>Russian and Slavic Languages</td>
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<td>s.e.r.</td>
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<td>Soil and Water Science</td>
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<td>Wildlife and Fisheries Science</td>
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<td>Women's Studies</td>
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<tr>
<td>ws.m.</td>
<td>Watershed Management</td>
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- **Abbreviation Guide**
- **Abbreviations**
- **Disciplines**
- **Listed Uses**
### GRADUATE CALENDAR

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<td>Aug. 23, Su</td>
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<td>Registration</td>
<td>Aug. 24-26, M-W</td>
<td>Aug. 22-24, M-W</td>
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<td>Aug. 27, Th</td>
<td>Aug. 25, Th</td>
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<tr>
<td>Deadline for senior petitions for graduate credit</td>
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<tr>
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<td>Sept. 3, Th</td>
<td>Sept. 1, Th</td>
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<tr>
<td>Labor Day - no classes</td>
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<tr>
<td>Last day to file Master's Degree Study Program for completion in December</td>
<td>Sept. 8, Tu</td>
<td>Sept. 12, M</td>
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<tr>
<td>Last day to drop with deletion of course from record</td>
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<td>Sept. 21, W</td>
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<td>Last day for doctoral students to file Doctoral Degree Study Program for completion in May 1988; May 1989</td>
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<tr>
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<td>Nov. 11, W</td>
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<tr>
<td>Last day to submit approved, library-ready copies of dissertation for December completion</td>
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<tr>
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<tr>
<td>Classes begin</td>
<td>Jan. 14, Th</td>
<td>Jan. 12, Th</td>
</tr>
<tr>
<td>Last day for doctoral preliminary examination for May</td>
<td>Jan. 18, M</td>
<td>Jan. 16, M</td>
</tr>
<tr>
<td>completion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last day to file Application for Candidacy for May</td>
<td>Jan. 18, M</td>
<td>Jan. 16, M</td>
</tr>
<tr>
<td>completion of doctoral requirements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deadline for senior petitions for graduate credit</td>
<td>Jan. 21, Th</td>
<td>Jan. 19, Th</td>
</tr>
<tr>
<td>Last day to register for credit, to add courses, and to</td>
<td>Jan. 21, Th</td>
<td>Jan. 19, Th</td>
</tr>
<tr>
<td>change from credit to no credit</td>
<td></td>
<td></td>
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<tr>
<td>Last day to file Master's Degree Study Program for</td>
<td>Feb. 1, M</td>
<td>Jan. 30, M</td>
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<tr>
<td>completion in May</td>
<td></td>
<td></td>
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<tr>
<td>Last day to drop with deletion of course from record</td>
<td>Feb. 10, W</td>
<td>Feb. 8, W</td>
</tr>
<tr>
<td>Presidents' Day - no classes</td>
<td>Feb. 15, M</td>
<td>Feb. 20, M</td>
</tr>
<tr>
<td>Records close for midterm scholarship report</td>
<td>Mar. 2, W</td>
<td>Mar. 1, W</td>
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<tr>
<td>Spring recess</td>
<td>Mar. 12-20, Sa-Su</td>
<td>Mar. 11-19, Sa-Su</td>
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<tr>
<td>Last day to file Master's Degree Study Program for</td>
<td>Mar. 25, F</td>
<td>Mar. 24, F</td>
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<tr>
<td>summer completion</td>
<td></td>
<td></td>
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<tr>
<td>Last day to drop courses and to change</td>
<td>Mar. 30, W</td>
<td>Mar. 29, W</td>
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<tr>
<td>from credit to no credit</td>
<td></td>
<td></td>
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<tr>
<td>Last day to file Report on Master's Final Examination</td>
<td>Apr. 18, M</td>
<td>Apr. 17, M</td>
</tr>
<tr>
<td>for May completion (thesis, if any, must have preliminary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>approval by Graduate College after final examination)</td>
<td></td>
<td></td>
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<tr>
<td>Last day to take doctoral final oral examination for</td>
<td>Apr. 18, M</td>
<td>Apr. 17, M</td>
</tr>
<tr>
<td>May completion</td>
<td></td>
<td></td>
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<tr>
<td>Last day to pay fees for doctoral degree candidacy and</td>
<td>Apr. 21, Th</td>
<td>Apr. 20, Th</td>
</tr>
<tr>
<td>dissertation processing and microfilming</td>
<td></td>
<td></td>
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<tr>
<td>Last day to submit approved, library-ready copies of</td>
<td>Apr. 22, F</td>
<td>Apr. 21, F</td>
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<tr>
<td>dissertation for May completion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Last day to submit approved, library-ready copies of</td>
<td>May 2, M</td>
<td>May 1, M</td>
</tr>
<tr>
<td>thesis for May completion</td>
<td>May 4, W</td>
<td>May 3, W</td>
</tr>
<tr>
<td>Class and laboratory sessions end</td>
<td>May 6, F</td>
<td>May 5, F</td>
</tr>
<tr>
<td>Semester examinations begin</td>
<td>May 13, F</td>
<td>May 12, F</td>
</tr>
<tr>
<td>Semester examinations end</td>
<td>May 14, Sa</td>
<td>May 13, Sa</td>
</tr>
</tbody>
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### Summer Sessions

#### Presession

<table>
<thead>
<tr>
<th>Event</th>
<th>1988</th>
<th>1989</th>
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<tbody>
<tr>
<td>Registration</td>
<td>May 16-17, M-Tu</td>
<td>May 15-16, M-Tu</td>
</tr>
<tr>
<td>Presession classes begin</td>
<td>May 16, M</td>
<td>May 15, M</td>
</tr>
<tr>
<td>Holiday - no classes</td>
<td>May 30, M</td>
<td>May 29, M</td>
</tr>
<tr>
<td>Last day of classes and final examination day</td>
<td>June 4, Sa</td>
<td>June 3, Sa</td>
</tr>
</tbody>
</table>

#### First Summer Session

<table>
<thead>
<tr>
<th>Event</th>
<th>1988</th>
<th>1989</th>
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<tbody>
<tr>
<td>Registration</td>
<td>June 3, F</td>
<td>June 2, F</td>
</tr>
<tr>
<td>First summer session begins</td>
<td>June 6, M</td>
<td>June 5, M</td>
</tr>
<tr>
<td>Holiday - no classes</td>
<td>July 4, M</td>
<td>July 4, Tu</td>
</tr>
<tr>
<td>Last day of classes and final examination day</td>
<td>July 7, Th</td>
<td>July 6, Th</td>
</tr>
</tbody>
</table>

#### Second Summer Session

<table>
<thead>
<tr>
<th>Event</th>
<th>1988</th>
<th>1989</th>
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<tbody>
<tr>
<td>Registration</td>
<td>July 8, F</td>
<td>July 7, F</td>
</tr>
<tr>
<td>Second summer session begins</td>
<td>July 11, M</td>
<td>July 10, M</td>
</tr>
<tr>
<td>Last day to file Report on Master's Final Examination for August completion (thesis, if any, must have preliminary approval by Graduate College after final examination)</td>
<td>July 18, M</td>
<td>July 17, M</td>
</tr>
<tr>
<td>Last day to submit approved, library-ready copies of master's thesis for August completion</td>
<td>July 27, W</td>
<td>July 26, W</td>
</tr>
<tr>
<td>Last day to take doctoral final oral examination for August completion</td>
<td>Aug. 9, Tu</td>
<td>Aug. 8, Tu</td>
</tr>
<tr>
<td>Last day to submit approved, library-ready copies of dissertation for August completion</td>
<td>Aug. 10, W</td>
<td>Aug. 9, W</td>
</tr>
<tr>
<td>Last day to pay fees for degree candidacy, thesis and dissertation processing and dissertation microfilming</td>
<td>Aug. 10, W</td>
<td>Aug. 9, W</td>
</tr>
<tr>
<td>Last day of classes and final examination day</td>
<td>Aug. 10, W</td>
<td>Aug. 9, W</td>
</tr>
</tbody>
</table>
Arizona Board of Regents

EX OFFICIO

EVAN MECHAM .............................................................................. Governor of Arizona
C. DIANE BISHOP ........................................................................ State Superintendent of Public Instruction

APPOINTED

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HERMAN CHANEN, Secretary ........................................................ January, 1992
DONALD PITT, J.D. ......................................................................... January, 1994
ESTHER N. CAPIN, M.Ed. ................................................................. January, 1994
University Administration

(Year of first appointment to faculty follows each name.)

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Darryl L. Sabers (1990) .......................... Associate Professor of Educational Psychology
Donal M. Sacken (1987) .......................... Associate Professor of Educational Foundations and Administration
Amos P. Sales (1988) ............................... Professor of Rehabilitation
William R. Salzman (1990) ......................... Professor of Psychology
T. Frank Saunders (1988) .......................... Professor of Educational Foundations and Administration
Ken Z. Szymanski (1988) .......................... Associate Professor of Educational Psychology
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Norval A. Sinclair (1990) .......................... Associate Professor of Microbiology and Immunology
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Karen L. Smith (1990) ............................. Professor of Atmospheric Sciences
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Orestes N. Stavroudis (1988) .......................... Professor of Chemistry
Cornelius Steelink (1990) .......................... Associate Professor of Spanish and Portuguese
H. Reynolds Stone (1990) .......................... Assistant Professor of Secondary Education
Janice Streitmatter (1989) .......................... Professor of Electrical and Computer Engineering
Mike N. Szilagyi (1990) ............................ Assistant Professor of Portuguese
L. Irene Terry (1989) ............................... Associate Professor of Anthropology
Richard A. Thompson (1989) .......................... Associate Professor of Anthropology
Mark E. Tischler (1990) .............................. Associate Professor of Biochemistry
Gordon Tollin (1987) ............................... Professor of Biochemistry
Paul R. Turner (1988) ............................... Professor of Anthropology
David L. Venable (1988) ........................................ Assistant Professor of Ecology and Evolutionary Biology
Ying-Yuh (Rich) Wang (1990) .................................. Assistant Professor of Management Information Systems
Thomas Weaver (1988) ......................................... Professor of Anthropology
E. Sue Weber (1990) ............................................. Assistant Professor of Management Information Systems
Jost Wendt (1990) .................................................. Professor of Chemical Engineering
Charles W. West (1990) ......................................... Associate Professor of Music
Jean M. Williams (1989) ....................................... Associate Professor of Exercise and Sport Sciences
Clifton E. Wilson (1988) ....................................... Professor of Political Science
Bruce Wood (1989) ............................................. Associate Professor of Mathematics
A. Wayne Wymore (1989) .................................... Professor of Systems and Industrial Engineering
Elizabeth B. Yost (1990) ....................................... Associate Professor of Psychology
Teaching and Research Faculty

Aamodt, Agnes M., Professor of Nursing
Abrams, Herbert K., Professor Emeritus of Family and Community Medicine
Adamec, Ludwig W., Professor of Oriental Studies
Adams, William G., Associate Professor of Art
Ahmann, Frederick R., Assistant Professor of Internal Medicine
Aiken, Susan, Associate Professor of English
Albanese, Charles A., Professor of Architecture
Albers, David S., Professor of Pharmacology and of Internal Medicine
Aleamoni, Lawrence M., Professor of Educational Psychology
Alepa, F. Paul, Professor of Internal Medicine
Alexander, Mary A., Assistant Professor of Nursing
Allen, Adela, Associate Professor of Reading
Allen, Hugh D., Professor of Pediatrics
Allen, Paul M., Professor Emeritus of Secondary Education
Allen, R. Van, Professor Emeritus of Elementary Education
Alcorn, Stanley, Professor of Plant Pathology
Alepa, F. Paul, Professor of Internal Medicine
Altman, Ellen, Professor of Library Science
Ames, Wilbur S., Professor of Reading
Ampe, Neil M., Assistant Professor of Internal Medicine
Amy, Gary, Associate Professor of Civil Engineering and Engineering Mechanics
Anderson, Jon V., Associate Professor of English
Anderson, Karen S., Associate Professor of History
Anderson, Robert M., Associate Professor Emeritus of Surgery
Anderson, Roger A., Professor Emeritus of Aerospace and Mechanical Engineering
Anderson, Waldo K., Professor Emeritus of Higher Education
Andrews, Arthur W., Professor of Law
Andrews, Gregory R., Associate Professor of Computer Science
Angel, J. Roger P., Professor of Astronomy and of Optical Sciences
Angervilla, Jay B., Jr., Professor of Anatomy
Angus, Robert C., Professor of Agricultural Economics
Anness, Julia E., Professor of Philosophy
Anthony, James R., Professor of Music
Anthony, John W., Professor Emeritus of Geosciences
Antilla, Shinin D., Associate Professor of Special Education
Archangeli, Diana B., Assistant Professor of Linguistics
Ares, Charles E., Professor of Law
Atkinson, George H., Professor of Chemistry and of Optical Sciences
Attarian, Peter J., Associate Professor of Family and Community Medicine; Assistant Professor of Psychiatry
Atwater, Anne E., Professor of Exercise and Sport Sciences
Atwood, Barbara A., Professor of Law
Atwood, Harry, Associate Professor Emeritus of Radio and Television
Atwood, Janet R., Professor of Nursing
Austin, J. Norman, Professor of Classics
Babcock, Barbara A., Professor of English
Badger, Terry A., Assistant Professor of Nursing
Bagnara, Joseph T, Professor of Anatomy
Bahlil, Andrew T, Professor of Systems and Industrial Engineering
Bahr, Randall K., Assistant Professor of Electrical and Computer Engineering
Bailey, Daniel E., Professor of Computer Science  
Bailey, Don C., Professor of Oriental Studies  
Bailey, Douglas A., Assistant Professor of Plant Sciences  
Baker, Boyd B., Associate Professor of Exercise and Sport Sciences  
Baker, Gregory R., Professor of Mathematics and of Aerospace and Mechanical Engineering  
Baker, Robert L., Associate Professor of Systems and Industrial Engineering  
Baker, Victor R., Professor of Geosciences and of Planetary Sciences  
Bales, Roger C., Assistant Professor of Hydrology and Water Resources  
Balsa, Thomas R., Associate Professor of Aerospace and Mechanical Engineering  
Bamford, Colin R., Associate Professor of Neurology  
Banner, William, Jr., Assistant Professor of Pediatrics and of Pharmacology  
Bannister, Bryant, Professor of *Dendrochronology*  
Barbee, Robert A., Professor of Internal Medicine  
Barefield, Russell M., Professor of Accounting  
Barfield, Michael, Professor of Chemistry  
Barham, Terry J., Associate Professor of Music  
Barker, Adele M., Associate Professor of Russian and Slavic Languages  
Barlow, David L., Associate Professor of Agricultural Economics  
Barnes, William D., Professor Emeritus of Secondary Education  
Barrett, Bruce R., Professor of Physics  
Barrett, Harrison H., Professor of Optical Sciences and of Radiology  
Barrett, William B., Professor of Accounting  
Barrow, Leo L., Professor of Spanish and Portuguese  
Bartels, Paul G., Professor of Plant Sciences  
Bartels, Peter H., Professor of Optical Sciences and of Pathology  
Bartlett, Neil R., Professor Emeritus of Psychology  
Bashkin, Stanley, Professor of Physics  
Basso, Ellen B., Professor of Anthropology  
Bates, Robert B., Professor of Chemistry  
Bowers, Eleanore E., Professor of Nursing  
Bechtel, Robert B., Professor of Psychology  
Beck, Jean R., Professor Emeritus of German  
Beck, Jonathan, Associate Professor of French and Italian  
Becker, Stewart, Professor Emeritus of Electrical Engineering  
Bedrick, Alan D., Assistant Professor of Pediatrics  
Beekman, Ruth Ann, Associate Professor of Elementary Education  
Beigel, Allan, Professor of Psychiatry and of Psychology  
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Bennel, William P., Professor Emeritus of Plant Sciences  
Benson, Bryant, Assistant Professor of Surgery  
Benson, Bryant, Professor of Anatomy  
Benson, Clark T., Professor of Mathematics  
Bergan, John R., Professor of Educational Psychology  
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Bergsohn, Isaac P., Associate Professor of Dance  
Berkhout, Carl T., Associate Professor of English  
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Bernath, Peter F., Assistant Professor of Chemistry  
Bernhard, Victor M., Professor of Surgery  
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Bernstein, Gail L., Professor of History and of Oriental Studies  
Bernstein, Harris, Professor of Microbiology and Immunology  
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Bessley, Paul M., Associate Professor of Plant Sciences  
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Bier, Milan, Professor of Engineering and of Microbiology  
Bierwag, Gerald O., Professor of Finance and Real Estate  
Birnie, Dunbar P., III, Assistant Professor of Materials Science and Engineering  
Bishop, Jerold, Associate Professor of Art  
Bjelland, John C., Associate Professor of Radiology  
Bjornovde, Reidar, Professor of Civil Engineering and Engineering Mechanics  
Black, John H., Associate Professor of Astronomy  
Blanchard, James, Associate Professor of Pharmaceutical Sciences  
Blank, Jacqueline J., Assistant Professor of Nursing  
Blaik, David E., Associate Professor of Anatomy  
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Dunnington, Gary L., Assistant Professor of Surgery
Durie, Brian G. M., Professor of Internal Medicine
Dutt, Gordon R., Professor of Soil and Water Science
Dutton, Vivian F., Associate Professor Emerita of Elementary Education
Dvorak, Robert W., Associate Professor of Architecture
Dye, Frieda A., Associate Professor of English
<table>
<thead>
<tr>
<th>Name</th>
<th>Title and Department</th>
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<tbody>
<tr>
<td>Earley, Paul C.</td>
<td>Assistant Professor of Management and Policy</td>
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<tr>
<td>Earnest, David L.</td>
<td>Professor of Internal Medicine</td>
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<tr>
<td>Eastoe, Christopher J.</td>
<td>Assistant Professor of Geosciences</td>
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<td>Eaton, Richard M.</td>
<td>Associate Professor of History and of Oriental Studies</td>
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<tr>
<td>Edwards, Richard M.</td>
<td>Professor Emeritus of Chemical Engineering</td>
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<td>Esfahani, Mohammad R.</td>
<td>Assistant Professor of Civil Engineering and Engineering Mechanics</td>
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<td>Eisner, Sigmund</td>
<td>Professor of English</td>
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<td>Eldridge, Nancy M.</td>
<td>Assistant Professor of Rehabilitation</td>
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<td>Emrick, Roy M.</td>
<td>Professor of Physics</td>
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<td>Endrizzi, John E.</td>
<td>Professor Emeritus of Plant Sciences</td>
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<td>Enemark, John H.</td>
<td>Professor of Chemistry</td>
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<td>Enoka, Roger M.</td>
<td>Assistant Professor of Exercise and Sport Sciences</td>
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<td>Enstice, Wayne E.</td>
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<td>Epperson, Gordon</td>
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<td>Ercolani, Nicholas M.</td>
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<td>Erickson, Melvin C.</td>
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<td>Erickson, Richard L.</td>
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<td>Erlings, Billie R.</td>
<td>Professor of Music</td>
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<td>Ervin, A. Elizabeth</td>
<td>Associate Professor of Music</td>
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<td>Ervin, Thomas R.</td>
<td>Associate Professor of Music</td>
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<td>Escamilla, Manuel</td>
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<td>Evans, Daniel D.</td>
<td>Professor of Hydrology and Water Resources</td>
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<td>Evans, Lawrence J.</td>
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<td>Ebwrkbank, Henry L.</td>
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<td>Fagan, Timothy C.</td>
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<td>Fan, Chang-Yun</td>
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<td>Fazzolare, Rocco A.</td>
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<td>Feinberg, William M.</td>
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<td>Fernandez, Roberto M.</td>
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26 Teaching and Research Faculty

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Flint, Franklin S., Professor of Architecture
Flippo, Edwin A., Professor of Management and Policy
Flores, Carlos M., Assistant Professor of Pediatrics
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Keck, Louis J., Professor of Internal Medicine
Keyworth, Robert A., Professor Emeritus of Drama
Kibler, Ruthann, Assistant Professor of Microbiology and Immunology
Kidwell, Margaret G., Professor of Ecology and Evolutionary Biology
<table>
<thead>
<tr>
<th>Name</th>
<th>Department</th>
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<tbody>
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<td>Kidwell, Richard A.</td>
<td>Professor of Business and Career Education</td>
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<td>Kight, Mary Ann</td>
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<td>Kilsson, Rein</td>
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<td>Kim, Young C.</td>
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<td>Kirk, Walter K.</td>
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<td>Klein, Raymond L.</td>
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<td>Klemmedson, James O.</td>
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<td>Kneebone, William R.</td>
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<td>Knief, Lotus M.</td>
<td>Professor Emeritus of Educational Psychology</td>
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<td>Knorr, Amy J.</td>
<td>Professor Emeritus of Forestry</td>
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<td>Knudson, Ronald J.</td>
<td>Professor of Internal Medicine</td>
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<td>Kobriger, Janice M.</td>
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<td>Kodric-Brown, Astrid</td>
<td>Associate Professor of Ecology and Evolutionary Biology</td>
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<td>Koehler, Virginia</td>
<td>Associate Professor of Secondary Education</td>
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<td>Koff, Theodore H.</td>
<td>Professor of Management and Policy</td>
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<td>Kreulien, David L.</td>
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May, Kathleen M., Assistant Professor of Nursing
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McClure, Michael A., Professor of Plant Pathology
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McCormick, Floyd G., Professor of Agricultural Education
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Stevenson, Frederick W., Associate Professor of Mathematics
Stewart, Harry E., Professor Emeritus of Electrical Engineering
Stine, William A., Professor of Anthropology and of Family and Community Medicine
Stitt, Lee S., Professor Emeritus of Plant Sciences
Stevelman, John C., Assistant Professor of Internal Medicine
Stockton, Charles W., Professor of Dendrochronology
Stokes, Mansden B., Professor Emeritus of Educational Foundations and Administration
Stokes, Marvin A., Professor Emeritus of Dendrochronology
Stone, H. Reynolds, Associate Professor of Spanish and Portuguese
Stone, John O., Jr., Professor of Physics
Stott, Gerald H., Professor Emeritus of Animal Science
Strack, David H., Professor of Exercise and Sport Sciences
Strauss, Richard E., Assistant Professor of Ecology and Evolutionary Biology
Streitmatter, Janice L., Assistant Professor of Secondary Education
Strickland, Robin N., Assistant Professor of Electrical and Computer Engineering
Strittmatter, Peter A., Professor of Astronomy
Strohlein, Jack L., Professor of Soil and Water Science
Strom, Robert G., Professor of Planetary Sciences
Strong, John W., Rosenstiel Distinguished Professor of Law
Stuart, Douglas G., Professor of Physiology
Stubblefield, Thomas M., Professor Emeritus of Agricultural Economics
Stull, John W., Professor Emeritus of Nutrition and Food Science
Suchanek, Gerry L., Assistant Professor of Finance and Real Estate
Sullivan, John B., Jr., Associate Professor of Surgery
Sullivan, Michael P., Professor of Political Science
Sullivan, Roger D., Associate Professor of Music
Summers, George W., Professor of Management and Policy
Sumner, John S., Professor Emeritus of Geosciences
Sundaresan, Malur K., Professor of Electrical and Computer Engineering
Sunde, Roger A., Assistant Professor of Nutrition and Food Science
Sutherland, R. Warren, Professor of Music
Swain, Richard A., Professor of Materials Science and Engineering and Technology Development
Swanson, Gerold, Associate Professor of Economics
Swenson, Charles W., Assistant Professor of Accounting
Swetschinski, Daniel M., Associate Professor of History and of Oriental Studies
Swihart, Thomas L., Professor of Astronomy
Swingle, Roy S., Associate Professor of Animal Science
Swisher, Linda, Associate Professor of Speech and Hearing Sciences and of Psychology
Szilagyi, Mike N., Professor of Electrical and Computer Engineering
Tanner, Clara L, Professor Emerita of Anthropology
Tannek, David A., Associate Professor of Management and Policy
Tao, Jing-shen, Professor of History and of Oriental Studies
Tatum, Roy A., Assistant Professor of Exercise and Sport Sciences
Tausig, Lynn M., Professor of Pediatrics
Taylor, B. Brooks, Professor Emeritus of Animal Science
Taylor, Bruce R., Professor Emeritus of Animal Science
Taylor, Lester D., Professor of Economics
Telewski, Frank W., Assistant Professor of Dendrochronology
Ter Merriët, Robert, Professor of Spanish and Portuguese
Terpening, Ronnie H., Associate Professor of French and Italian
Terry, L. Irene, Assistant Professor of Entomology
Thames, John L., Professor of Watershed Management
Theurer, C. Brent, Professor of Animal Science
Theus, Robert L., Professor of Physics
Thomas, Robert K., Professor of American Indian Studies
Thomas, Violet S., Associate Professor Emerita of Business and Career Education
Thompson, Charlotte B., Assistant Professor of English
Thompson, Ethel M., Professor Emerita of Home Economics
Thompson, Gary, Assistant Professor of Agricultural Economics
Thompson, Raymond H., Fred A. Riecker Distinguished Professor of Anthropology
Thompson, Richard A., Associate Professor of Anthropology
Thompson, Richard B., Associate Professor of Mathematics
Thompson, Roger I., Professor of Astronomy
Thomson, Donald A., Professor of Ecology and Evolutionary Biology
Thomson, Quentin R., Professor Emeritus of Aerospace and Mechanical Engineering
Thwatt, William H., Associate Professor of Psychology
Tifft, William G., Professor of Astronomy
Tindall, Robert E., Jr., Associate Professor of Management and Policy
Tinsley, Ann M., Associate Professor of Nutrition and Food Science
Tipton, Charles M., Professor of Exercise and Sport Sciences
Tischler, Marc E., Associate Professor of Biochemistry and of Physiology
Titey, Spencer R., Professor of Geosciences
Tobias, Robert P., Associate Professor of Art
Tobin, Thomas R., Assistant Professor in the Neurobiology Division of the Arizona Research Laboratory
Toland, Florence W., Assistant Professor Emerita of Office Administration and Business Education
Tollin, Gordon, Professor of Biochemistry
Toma, Peter A., Professor of Political Science
Tomizuka, Carl T., Professor of Physics
Tong, Theodore G., Professor of Pharmacy Practice
Tormey, Thomas J., Professor Emeritus of Law
Torres, David L., Assistant Professor of Management and Policy
Tothas, Elias, Professor of Mathematics
Traver, Gayle A., Associate Professor of Nursing; Assistant Professor of Internal Medicine
Treat, Jay E., Associate Professor Emeritus of Physics
Trejo, Arnulfo D., Professor Emeritus of Library Science
Trent, Jeffrey M., Associate Professor of Radiation Oncology
Trifar, Deonisie, Professor Emeritus of Mathematics
Triffet, Terry, Professor of Civil Engineering and Engineering Mechanics
Trosset, Michael W., Assistant Professor of Statistics
Tuchi, Ben J., Professor of Finance and Real Estate
Tucker, Thomas C., Professor of Soil and Water Science
Tumer, Paul R., Professor of Anthropology
Tuttle, Donald M., Professor Emeritus of Entomology
Twomey, Sean A., Professor of Atmospheric Sciences
Udall, John N., Associate Professor of Pediatrics
Uhlmann, Donald R., Professor of Materials Science and Engineering
Urech, John C., Professor of English
Umbreit, John, Associate Professor of Special Education
Underwood, Jane H., Professor of Anthropology
Upchurch, Robert P., Professor of Agronomy
Valentini, Robert C., Assistant Professor of Mathematics
Valmont, William J., Professor of Reading
Van Asdall, Willard, Associate Professor of Arid Lands
Van de Voorde, Ronald A., Associate Professor of Library Science
Van Metre, Patricia, Associate Professor of Drama
Van Ort, Emily S., Associate Professor of Nursing
Van Reusen, Anthony K., Assistant Professor of Special Education
Van Slyck, Willard N., Jr., Professor Emeritus of Law
Van Wyck, David B., Assistant Professor of Internal Medicine and of Surgery
Vavich, Mitchell G., Professor Emeritus of Nutrition and Food Science
Vaz, William Y., Associate Professor of Mathematics
Velez-Ibanez, Carlos G., Professor of Anthropology
Vemulapalli, G. Krishna, Associate Professor of Chemistry
Venable, David L., Assistant Professor of Ecology and Evolutionary Biology
Verran, Joyce A., Assistant Professor of Nursing
Vierling, Elizabeth, Assistant Professor of Biochemistry and of Molecular and Cellular Biology
Vignery, J. Robert, Professor of History
Villar, Hugo F., Professor of Surgery and of Radiation Oncology
Vincent, Thomas L., Professor of Aerospace and Mechanical Engineering
Vogel, Douglas R., Assistant Professor of Management Information Systems
Voight, Ronald J., Associate Professor of Management and Policy and of Economics
Vuillemin, Joseph J., Professor of Physics
Vuolo, Anthony F., Professor of Family and Community Medicine
Wacks, Morton E., Professor of Nuclear and Energy Engineering
Wade, James C., Associate Professor of Agricultural Economics
Walpe, Robert F., Professor Emeritus of Watershed Management
Wagner, Willard M. G., Assistant Professor of Management and Policy
Wakile, John C., Professor of Political Science
Walt, James R., Professor of Electrical and Computer Engineering and of Geosciences
Walsh, Stephen L., Professor of Surgery
Wallendorf, Melanie R., Associate Professor of Marketing
Wallace, Terry C., Associate Professor of Accounting
Wallraf, Charles F., Professor Emeritus of Philosophy
Walsh, J. Bruce, Assistant Professor of Ecology and Evolutionary Biology
Wang, Ying-yuh R., Assistant Professor of Management Information Systems
Wangensteen, Stephen L., Professor of Surgery
Wang, Naq K., Professor of Physics
Ward, Oscar G., Professor of Ecology and Evolutionary Biology
Ware, George W., Professor of Entomology
Warwick, Arthur W., Professor of Soil and Water Science
Watson, Theo F., Professor of Entomology
Watts, Raymond E., Professor Emeritus of Veterinary Science
Wearing, J. Peter, Professor of English
Weaver, Albert B., Professor Emeritus of Physics
Weaver, Thomas, Professor of Anthropology
Weber, Charles W., Professor of Nutrition and Food Science
Weber, E. Sue, Assistant Professor of Management Information Systems
Weber, Jean, Professor of Statistics and of Management and Policy
Weinstein, Donald, Professor of History
Weinstein, Louis, Associate Professor of Obstetrics and Gynecology
Weiss, Barry D., Assistant Professor of Family and Community Medicine
Weiss, Lawrence B., Assistant Professor of Anesthesiology
Welldon, Roger J., Professor Emeritus of Systems and Industrial Engineering
Welch, Donald A., Professor of Economics
Welsh, Michael A., Professor of Biochemistry
Welty, Mary J., Associate Professor of Nursing
Wendt, Jost O. L., Professor of Chemical Engineering
Werner, Floyd G., Professor of Entomology
West, Charles W., Associate Professor of Music
Westbrook, Robert A., Professor of Marketing
Westerman, Bryan R., Associate Professor of Radiology
Wetzel, Mary C., Professor of Psychology
Wexler, David B., Professor of Law and of Psychology
Wheeler, Lawrence, Professor Emeritus of Psychology
White, Donald H., Professor Emeritus of Chemical Engineering
White, Harrison C., Professor of Sociology and of Management and Policy
White, Raymond E., Associate Professor of Astronomy
White, Simon D. M., Associate Professor of Astronomy
Whiting, Allen S., Professor of Political Science
Whiting, Frank M., Professor of Animal Science
Wholey, Douglas R., Assistant Professor of Management and Policy
Wieland, John H., Professor Emeritus of Marketing
Wiersma, Frank, Professor of Agricultural Engineering
Wigley, David E., Assistant Professor of Chemistry
Wild, Peter T., Professor of English
Wildner-Bassett, Mary E., Assistant Professor of German
Wilhelm, Mari S., Assistant Professor of Family and Consumer Resources
Wilkening, Laurel, Professor of Planetary Sciences
Wilkin, Donovan, Associate Professor of Renewable Natural Resources
Willard, Thomas S., Assistant Professor of English
Williams, David A., Associate Professor of Communication
Williams, Edward J., Professor of Political Science
Williams, Jean M., Associate Professor of Exercise and Sport Sciences
Williams, Rickey L., Assistant Professor of Pediatrics
Williams, Theodore L., Associate Professor of Electrical and Computer Engineering
Williamson, Jeffrey F., Assistant Professor of Radiation Oncology
Witska, Alvar P., Professor of Physics
Wilson, Andrew W., Professor Emeritus of Geography, Regional Development and Urban Planning
Wilson, Clifton E., Professor of Political Science
Wilson, George S., Professor of Chemistry
Wilson, Herbert B., Professor Emeritus of Educational Foundations and Administration
Wilson, John M., Professor of Dance
Wilson, Paul N., Assistant Professor of Agricultural Economics
Wilson, William J., Associate Professor of Oriental Studies
Wimmer, Gayle E., Associate Professor of Art
Wing, William H., Professor of Physics and of Optical Sciences
Winstlow, Dianne J., Assistant Professor of Drama
Wirsching, Paul H., Professor of Aerospace and Mechanical Engineering
Wis, Edward N., Professor Emeritus of Chemistry
Wise, Mark E., Assistant Professor of Animal Science
Witkowski, James M., Assistant Professor of Civil Engineering and Engineering Mechanics
Witte, Charles L., Professor of Surgery
Witte, Marys H., Professor of Surgery
Wojtkowski, Macej, Assistant Professor of Mathematics
Wolfe, William L., Jr., Professor of Optical Sciences and of Radiology
Wolosin, David J. Professor Emeritus of German
Wood, Bruce, Associate Professor of Mathematics
Wood, Elwin G., Professor Emeritus of Marketing
Wood, Jeryldene M., Assistant Professor of Art
Wood, Mary A., Professor Emeritus of Home Economics
Woods, Alexander H., Associate Professor Emeritus of Internal Medicine
Woods, David G., Professor of Music
Woods, Winton D., Professor of Law
Woodti, Margaret A., Assistant Professor of Nursing
Woolf, Neville J., Professor of Astronomy
Woolfenden, James M., Professor of Radiology
Worthen, Thomas D., Associate Professor of Classics
Wortman, Robert H., Associate Professor of Civil Engineering and Engineering Mechanics
Wrenn, Robert L., Professor of Psychology
Wright, A. Larry, Associate Professor of Mathematics
Wright, Stephehn H., Assistant Professor of Physiology
Wyang, James C., Professor of Optical Sciences
Wygnanski, Israel J., Professor of Aerospace and Mechanical Engineering
Wymore, A. Wayne, Professor of Systems and Industrial Engineering
Wynn, Ruth E., Assistant Professor Emerita of Exercise and Sport Sciences
Yakowitz, Sidney J., Professor of Systems and Industrial Engineering
Yalkowsky, Samuel H., Professor of Pharmaceutical Sciences
Yall, Irving, Professor Emeritus of Microbiology
Yamamura, Henry I., Professor of Biochemistry and of Pharmacology; Associate Professor of Psychiatry
Yang, Peter J., Assistant Professor of Radiology
Yappel, Ralph, Professor Emeritus of Aerospace and Mechanical Engineering
Yates, Aalyne, Professor of Psychiatry; Associate Professor of Pediatrics
Yeh, Tian-Chyi J., Assistant Professor of Hydrology and Water Resources
Yin, Yong-Quan, Assistant Professor of Mathematics
Yitayew, Muluneh, Assistant Professor of Agricultural Engineering
Yocum, David E., Assistant Professor of Internal Medicine
Yohee, Norman, Associate Professor of Anthropology
Yoheino, I. Roger, Professor Emeritus of Sociology
Yost, Elizabeth B., Associate Professor of Psychology
Youmans, Robert L., Assistant Professor of Military Aerospace Studies
Young, Kenneth C., Associate Professor of Atmospheric Sciences
Young, Lai-Sang, Associate Professor of Mathematics
Young, S. Mark, Assistant Professor of Accounting
Younggren, Newell A., Professor Emeritus of Ecology and Evolutionary Biology
Zagona, Salvatore V., Professor Emeritus of Psychology
Zajac, Edward E., Professor of Economics
Zapotocky, Joseph A., Professor Emeritus of Pharmaceutical Sciences
Zegura, Stephen L., Associate Professor of Anthropology
Zeigler, Bernard P., Professor of Electrical and Computer Engineering
Zube, Ervin H., Professor of Renewable Natural Resources
Zukoski, Charles F., Professor of Surgery
Zumbro, Nicholas, Professor of Music
Zurbrick, Phillip R., Professor of Agricultural Education
Zwinger, Lynda M., Assistant Professor of English
Zwolinski, Malcolm J., Professor of Watershed Management
General Information

The pursuit of truth and the extension of knowledge are well-recognized goals of most American universities. At the University of Arizona, the Graduate College is the major administrative unit through which these dual purposes are achieved. Building on a well-balanced undergraduate education, graduate students are expected to develop a thorough understanding of a specific academic discipline. The fundamental purpose of the Graduate College is to encourage each graduate student to demonstrate excellent standards of scholarship and to produce high quality, original research.

Graduate studies, in progress continuously since the academic year 1898-1899, were organized independently in 1934 with the founding of the Graduate College. Initially, direction was provided by a dean and a committee composed of faculty members from graduate level disciplines. Administration of the Graduate College is now provided by the Dean of the Graduate College and the Graduate Council, whose membership is broadly representative of the academic areas in which graduate programs are pursued. In addition, a Committee on Graduate Study is primarily responsible for maintaining proper standards and developing graduate programs.

The status of graduate students is different from that of undergraduates. Satisfying degree requirements should not be the primary aim of graduate students. Graduate education is an opportunity to increase knowledge, to broaden understanding and to develop research capabilities. Consequently, the student's academic achievements should reflect a personal commitment to the discipline and to scholarly standards.

ACCOMMODATION OF RELIGIOUS OBSERVANCE AND PRACTICE

In accord with Board of Regents policy, no employee, agent, or policy of the University of Arizona shall discriminate against any student, employee, or other individual because of that individual's religious belief or practice or any absence thereof. Administrators and faculty members are responsible for reasonable accommodation of individual religious practices. A refusal to accommodate is justified only when undue hardship would result from each available alternative of reasonable accommodation. Further, no administrator or faculty member shall retaliate or otherwise discriminate against any student, employee, or prospective employee because that individual has sought a religious accommodation pursuant to this policy.

Persons wishing clarification of the nature or proper application of this policy should consult the Office of the Dean of Students or the Affirmative Action Office, as appropriate.

FACILITIES AND SERVICES

The University of Arizona offers graduate programs in more than 100 departments and fields, each supported by well-trained faculty and well-equipped physical resources. Departments offering advanced degree programs have excellent teaching and research facilities. Additionally, certain facilities and services of exceptional importance are available to advanced students. Some State of Arizona research and service agencies have been affiliated with the University of Arizona since their inception. Many facilities are interdepartmental and may be significant to graduate students from several fields.

AGRICULTURAL EXPERIMENT STATION — One of the divisions of the College of Agriculture, the Arizona Agricultural Experiment Station is responsible for the research program in agriculture, renewable natural resources, and family and consumer resources. The research activities
within the college are administered by the Director of the Experiment Station. Broad in scope, the program includes both basic and applied research in nearly every department. Modern facilities for both laboratory and field research are available on the University campus as well as at agricultural centers throughout the state of Arizona. Research is also conducted on farms, orchards, ranches, rangelands, and forests in cooperation with farmers, ranchers, and officials of various state and federal agencies.

The Experiment Station maintains close cooperative relationships with research agencies such as the Agricultural Research Service and the Forest Service of the United States Department of Agriculture.

Research assistantships are available in most of the departments in the Experiment Station. The graduate student is frequently an important member of an Experiment Station research project, sharing in the use of laboratory and field facilities as well as having the opportunity to work under the guidance of senior scientists of national and international reputation.

ARIZONA CENTER FOR EDUCATIONAL EVALUATION AND MEASUREMENT (1980) initiates and conducts multidisciplinary research on such topics as nondiscriminatory psychological assessment; assessment of developmental competencies, sequencing of instruction, cognitive skills in children; and evaluation of school effectiveness. The center maintains state-of-the-art research technology, prepares graduate students in research methodology; and provides technical assistance to public and private agencies regarding testing, student services, curriculum development and systems for program evaluation.

ARIZONA CENTER FOR EDUCATIONAL RESEARCH AND DEVELOPMENT (1971) initiates and conducts research and development programs in such areas as early childhood education, teaching and learning, language and literacy, cultural diversity and learning, and education of exceptional children.

ARIZONA COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT engages in graduate education, research, and extension. The unit is supported by the University of Arizona, the Arizona Game and Fish Department, the U.S. Fish and Wildlife Service, and the Wildlife Management Institute. The facilities and personnel of the unit are available to graduate students who wish to pursue both class work and research programs leading to advanced degrees in fisheries science and wildlife biology. The unit is included in the School of Renewable Natural Resources.

The ARIZONA COOPERATIVE NATIONAL PARK RESOURCES STUDY UNIT, located in the School of Renewable Natural Resources, is engaged in research to support the natural science program of the National Park Service. In cooperation with the University of Arizona, the unit provides graduate research opportunities and instructional support in a broad array of natural resource problem areas.

The ARIZONA HEART CENTER (1986) is an interdisciplinary organization intended to further research into cardiovascular biology and disease. The center's major objectives include conduct of basic and clinical research, provision of medical and surgical care to individuals, and provision of graduate, post-graduate, and continuing educational programs, both regionally and nationally. Coordination of cardiovascular research in the state and region is a major aim; close ties with investigators will be fostered. Research will include transplant immunology, echocardiography, clinical electrophysiology, molecular biology, experimental pharmacology and cell physiology, all applicable to cardiovascular problems.

The Arizona Heart Center operates as a division of the College of Medicine, reporting to the dean of the college. Its programs are linked to faculty and staff in the college, in the University Medical Center, and in other colleges and units in the University.

The ARIZONA POISON AND DRUG INFORMATION CENTER (1980) is operated by the College of Pharmacy and is located in the Arizona Health Sciences Center library. The center provides comprehensive poison information and advice on treatment of poisoning to anyone in the state. It also offers drug information and therapeutic consultations to health professionals. The center has a toll-free telephone number (listed on the inside cover of Arizona telephone directories) and can be reached 24 hours a day, seven days a week. Full-time clinical pharmacists staff the center and serve as poison and drug information specialists. Serving as consultants are medical
toxicologists and specialists in plant and animal poisons, drugs, and environmental and industrial poisons. The Arizona Poison and Drug Information Center also provides for clinical training of pharmacy students in the areas of drug and poison information. The Arizona Poison and Drug Information Center is a component of the Arizona Poison Control System which was established at the University of Arizona by the Arizona State Legislature in 1980. The system is certified as a regional poison control program by the American Association of Poison Control Centers.

The Arizona Poison and Drug Information Center (1972) is the focus of remote sensing research in the College of Agriculture. The staff of the Center is involved in interdisciplinary remote sensing and computer mapping projects related to agriculture and natural resource management. The Center contains equipment for manual analysis of satellite and aircraft imagery and a computer system for digital processing and display of images and maps. These facilities are available to faculty, students and cooperators from outside the University.

The ARIZONA REMOTE SENSING CENTER (1972) is the focus of remote sensing research in the College of Agriculture. The staff of the Center is involved in interdisciplinary remote sensing and computer mapping projects related to agriculture and natural resource management. The Center contains equipment for manual analysis of satellite and aircraft imagery and a computer system for digital processing and display of images and maps. These facilities are available to faculty, students and cooperators from outside the University.

The ARIZONA RESEARCH LABORATORIES (1979) is an interdisciplinary research unit established to provide a mechanism for administering and fostering research which bridges disciplines embraced by departments from more than one collegiate unit. A major thrust of the organization is to form research groups to initiate new programs of high priority to the development of the educational and research mission of the University. The organization of the Laboratories also provides a mechanism for serving as an organized research component for those teaching and research units that do not have such a capability.

The ARIZONA STATE MUSEUM, founded as a territorial museum in 1893, is an educational, research, and service division of the University. Prehistoric and recent Indian cultures of Arizona and the Southwest are interpreted through permanent exhibitions. Collections number more than 150,000 specimens, including those of the Gila Pueblo Archaeological Foundation. The close association of the Museum with the Department of Anthropology makes it possible for qualified graduate students to use the collections in research and to participate in the Museum's field projects. Museum personnel teach in the Department of Anthropology, especially in the museology and cultural resource management specialties. The State Museum is open daily to the public; it is closed on major holidays.

The ARIZONA VETERINARY DIAGNOSTIC LABORATORY was initiated by the Department of Veterinary Science in 1934 and has provided continuous service to the animal owners of Arizona since its establishment. Increased funding from the Arizona Legislature in 1983 has permitted an increased number and variety of diagnostic services in toxicology, microbiology, histopathology, serology and field investigations for companion animal and livestock owners referred through veterinary practitioners.

The BOYCE THOMPSON SOUTHWESTERN ARBORETUM is operated cooperatively by the University of Arizona College of Agriculture, Arizona State Parks Board, and the Boyce Thompson Southwestern Arboretum, Inc. This public botanic garden has facilities for teaching and research. Situated on the edge of the low desert near Superior, Arizona, the Arboretum is a two-hour drive from the campus. Thirty acres of native and introduced plants from arid and semi-arid regions, together with about 1,000 additional acres of undisturbed fauna and flora, are under Arboretum control. Additionally, large tracts of relatively undisturbed habitats in a variety of biomes lie in the surrounding Tonto National Forest. Laboratory facilities and housing are available. The Arboretum is open daily except for Christmas Day.

The BUREAU OF APPLIED RESEARCH IN ANTHROPOLOGY, a division of the Department of Anthropology, is a regional and international center for basic and applied research relating to culture change, urban and rural living, technological innovation, demography, cross-cultural management, agricultural and institutional development, educational innovation, and research methods.

The BUREAU OF GEOLOGY AND MINERAL TECHNOLOGY is charged with developing, maintaining, and disseminating to the people of Arizona information relating to mining, metallurgy, and earth sciences generally. Its scientific investigation and public service activities are comparable to those conducted by geological agencies and mineral experiment stations in other states.

The close union of the bureau with the programs of the College of Engineering and Mines
and the Department of Geosciences has been exceptionally productive in the development and dissemination of knowledge about the mineral resources of Arizona.

The bureau is a member of the Association of American State Geologists, the national affiliation of geological surveys of individual states.

The CENTER FOR COMPUTING AND INFORMATION TECHNOLOGY (CCIT) provides campus-wide services and facilities in support of the instructional, research, and administrative computing needs of the University. The University's network of shared computers consists of a Control Data Corporation CYBER 175 computer, Digital Equipment Corporation DECsystem-10, three VAX 11/780s, a VAX 8600 computer system in a cluster environment, two IBM 4381 computers, five Prime computer systems, and a Scientific Computer Systems SCS-40 minicomputer. These computers are interconnected to allow data transfer between systems. The CCIT provides a campus-wide data communications network supporting both central and distributed processors. Access to facilities is available 24 hours a day. Additionally CCIT provides access to outside networks such as Bitnet and Telenet, and to major national supercomputer networks. The CCIT provides terminal access centers at various locations on campus and dial-up access to the university systems.

The CCIT offers many services to assist users in taking advantage of available computing resources. Services include consulting on the use of the University's computers and various microcomputers; assistance in user acquisition of computing facilities; communications and networking between user-owned equipment and the University's systems; computer facility planning and preparation; selection, acquisition, and installation of microcomputer hardware and software; mainframe and microcomputer training facilities; programming and applications services; and dissemination of information through user publications, manuals, and program library documentation.

The CENTER FOR CREATIVE PHOTOGRAPHY (1975), a division of the University Library, is a growing research library and archive containing material on all aspects of photography. The collection includes rare photographic books, periodicals, photographs, and manuscript collections, as well as the archives of major American photographers and a large collection representing over 1500 photographers. In addition, the Center sponsors a lecture series and frequent exhibitions and publishes a journal entitled The Archive. Photographs not on exhibition may be viewed by appointment.

The CENTER FOR THE STUDY OF HIGHER EDUCATION (1978) in the College of Education conducts research studies and provides related service activities to meet state and institutional needs, as well as those of national, international and regional governmental units and other organizations. It develops and disseminates information about higher education policy and operation, and facilitates the research of faculty members and students. Special research and service projects are provided through University funds and outside support.

The COOPERATIVE EXTENSION SERVICE (1914) brings information to interested people of Arizona. One of the three divisions of the College of Agriculture, it emphasizes agricultural production and natural resources, family and consumer sciences, youth development (4-H), and rural development. The Service is financed from federal, state, and county appropriations. It operates through the county extension agent, state and area specialist system with faculty trained in their specialty, and in the practical application of scientific information on farms, ranches and in rural and urban homes. Assistance is provided to target audiences in problem solving, information dissemination and educational programs.

The DIVISION OF EXTENDED UNIVERSITY AND THE SUMMER SESSION, as an academic division of the University, provides off-campus daytime and on- and off-campus evening credit courses as well as presession, summer session and winter session courses. Students desiring graduate credit for off-campus graduate-level courses offered through the division must first be admitted to the Graduate College on regular graduate status. Also, students desiring graduate credit should be certain that the particular section of the course for which the student intends to register has been authorized as available for graduate credit. Off-campus graduate courses carry university credit, which may be applied toward graduate degree programs where appropriate, but no student may later apply toward an advanced degree more than six units earned as a graduate nondegree student. (Please see the "Graduate Nondegree Status" section of this
catalog.) Graduate students should confer with their advisers and the Graduate College regarding the applicability of extended university courses to their programs. Please see "Graduate Study in Summer Sessions" for information regarding summer study.

The DIVISION OF ECONOMIC AND BUSINESS RESEARCH is a research and service organization within the College of Business and Public Administration. Its broad objectives are to conduct research relating to business, economics, planning, and public policy; to complement the formal education of students with research experience; and to disseminate information. To achieve its objectives, the Division builds and maintains regional economic models for applications in forecasting and impact simulation, conducts research on state and local market conditions, analyzes the effects of public policy alternatives, and provides technical assistance for computerized corporate and government planning applications. It publishes the semiannual Arizona Review, the monthly Arizona's Economy, and the chart book Arizona Economic Indicators, and conducts both forums and seminars for the public. In addition, the Division answers requests from business, government, and the general public for tabular information and, as a member of the State Data Center, for computerized census information.

The DIVISION OF MEDIA AND INSTRUCTIONAL SERVICES (1939) provides a wide range of instructional media, production, research, and public broadcasting services to the University, community, and state. The division operates three maximum-power public broadcasting stations: KUAT-TV (Channel 6 and Translator Channel 71), KUAT-AM (1550 kHz), and KUAT-FM (90.5 MHz and Translator Frequency, 89.7 MHz in Northwest Tucson and Sierra Vista and 105.5 in Phoenix). Professional production facilities are maintained in the Modern Languages Building, the Audiovisual Building, and the Harvill Building. Production capability includes color studio and mobile television, and 16mm motion picture equipment. The stations are affiliated with the Public Broadcasting Service (PBS), National Public Radio (NPR) and American Public Radio (APR).

The Microcampus produces and distributes university courses to business and industry in the Tucson area through a two-channel Interactive Educational Television System (IETS) and throughout the nation by videotape and live satellite transmission.

Instructional Production and Engineering provides high technology educational support including: (1) Preproduction and instructional design for video and audio. Production and postproduction and distribution via nationwide Ku Band up-link facilities, ITFS and Microwave Transmission to Tucson and Fort Huachuca, satellite reception facilities, large screen viewing facilities and teleconference facilities. (2) Videotaping for teaching assistant evaluations, meetings, conferences and seminars is available as well as satellite reception of Soviet and French television programs for use in foreign language classes, big screen television playback facilities for large class viewing and multi-image slide presentations for promotional and fund-raising events. (3) Equipment maintenance and repair for departments is an additional service. The Graphics Center provides outstanding graphic and photography services to the University.

Film Library and Equipment Services provide media and audiovisual materials to both the University and other educational institutions.

The ENGINEERING EXPERIMENT STATION — As a part of the College of Engineering and Mines, the Experiment Station pursues a research program in a variety of areas of engineering, including solar energy, microelectronics, interactive computational mechanics, biophysics technology, digital image analysis, and nuclear fuel cycles. Through research assistantships, the station provides support and research opportunities for qualified graduate students. Also, the station provides research management services for investigators and promotes interdisciplinary programs.

The ENVIRONMENTAL RESEARCH LABORATORY (1967) conducts research in controlled-environment agriculture (CEA) for intensive food production, in seawater crop irrigation, and in solar heating and cooling. ERL has designed CES vegetable systems which produce crops in the desert sands of the United States, Mexico and Middle East, and it has developed CEA for the intensive culture of marine shrimp. ERL is developing halophytic crops for livestock feeds and other uses — plants which are irrigated solely with seawater or other highly saline water. ERL consults on such special projects as the portrayal of agriculture of the future at the EPCOT Center at Walt Disney World in Florida. ERL has also developed a series of demonstration solar homes at Tucson International Airport, where the laboratory is located.
The **Grace H. Flandrau Planetarium** (1975), a part of the College of Arts and Sciences, was built as a result of a gift to the University by Grace H. Flandrau. It houses a 50-foot projection dome, a Minolta Series IV planetarium projector, and a hemispheric 35mm motion picture projector. It is used as a teaching facility for University classes in astronomy, and 25,000 Tucson public school children attend its special educational programs each year. The Planetarium presents dramatic public programs on astronomy and planetary science that take audiences on cosmic journeys through time and space. The science exhibit halls and 16-inch telescope are open free to the public. Open daily; theatre dark Mondays.

The **Human Development Laboratory** (1979) is an interdisciplinary research and training center within the Division of Child Development and Family Relations in the School of Family and Consumer Resources. The laboratory is charged with promoting and conducting applied research to enhance the welfare of families and individuals. The laboratory supports and conducts funded and nonfunded research on issues relating to all stages of human life. Priority is given to research that is interdisciplinary, preventive, and issue-oriented. The facility is equipped for audio and video taping and sponsors colloquia and a semiannual newsletter.

The **Institute of Atmospheric Physics** is a research organization that places particular emphasis on the study of radiative transfer, remote sensing, atmospheric aerosols, atmospheric chemistry, cloud and precipitation physics, lightning and atmospheric electricity, atmospheric dynamics, mesoscale meteorology, and the mathematical modeling of global climate.

Undergraduate and graduate student instruction is offered by the Department of Atmospheric Sciences.

The **Jeffrey M. Golding Clinical Research Unit** (1984) is a specially equipped facility located in the College of Pharmacy. Its primary objective is to provide clinical scientists at the University of Arizona with the opportunity to study the action of drugs in humans with the ultimate goal of developing improved methods of treatment. The unit has three rooms: a patient waiting room, a private office for conducting patient interviews or preliminary examinations, and the main room which houses two hospital beds and is equipped with specialized medical equipment.

The **Karl Eller Center for the Study of the Private Market Economy** (1983) is a research and education organization within the College of Business and Public Administration. It has three broad objectives: (1) to promote research in basic market processes, (2) to sponsor an Entrepreneurial Studies Program, and (3) to provide for business/academic exchange. Research is supported through the recruitment of Karl Eller Chair holders in the disciplines represented in the College. Faculty research fellowships are also available. The Entrepreneurial Studies Program offers both academic courses for students interested in entrepreneurship and practical courses on the development of business plans. Approximately 35 students are included in the program annually. Business/academic exchange occurs through an annual dialogue on significant national economic issues and through semiannual new venture forums where entrepreneurs present business plans.

The **Laboratory of Tree-Ring Research** was organized in 1937 as an outgrowth of the pioneering tree-ring studies initiated by Andrew Ellicott Douglass at the University of Arizona in 1906. A division of the College of Arts and Sciences, the Laboratory conducts a unique program of teaching and research in all aspects of dendrochronology. Graduate-level instruction is offered through cooperating academic departments, and a limited number of graduate research assistantships are available to qualified students. Current research efforts are directed toward the quantification of tree-ring parameters, the establishment of new tree-ring chronologies throughout the world, the understanding of basic treegrowth and environmental relationships, the reconstruction of paleohydrologic and paleoclimatic variables, and the documentation and development of prehistoric chronological controls. Along with the world's largest collection of tree-ring specimens from living trees and ancient timbers, the Laboratory maintains a variety of specialized equipment and data files containing processed tree-ring chronologies, relevant climatic and hydrologic records, and archaeological tree-ring dates and site information.

The **Lunar and Planetary Laboratory** is the research institute allied with the Planetary Sciences Department. The Laboratory research staff includes members of the department as
well as those holding research appointments in the Lunar and Planetary Laboratory. The Laboratory is housed in the Gerard P. Kuiper Space Sciences Building, in close proximity to the Optical Sciences Center and the Kitt Peak National Observatory, as well as the Steward Observatory and Astronomy Department, with which close working relationships are maintained.

Laboratory staff engage in research and graduate instruction over a wide range of planetary, space, and terrestrial science. Some of the areas of present scientific activity are experimental and theoretical geochemistry, geophysics, lunar and planetary geology, spacecraft imaging of planetary surfaces and rings, the physics of planetary interiors; cosmic rays, the solar wind, comsical plasmas and magnetohydrodynamics, polarimetry, infrared Fourier spectroscopy, planetary atmospheres, solar physics, asteroid and comet research, ultraviolet space astronomy, optical astronomy, and studies of the origin of the solar system. Much of the research at the Lunar and Planetary Laboratory is closely associated with the NASA space science program, including numerous lunar, planetary, and Earth-orbital missions. Several faculty of the Department and the Laboratory have been principal or co-investigators on space experiments including Apollo, Mariner, Voyager, Space Telescope and Pioneer spacecraft, as well as several international spacecraft missions.

Major ground-based research facilities include the University of Arizona telescopes (150 cm, 100 cm, 70 cm aperture reflectors on Mt. Lemmon; 154 cm aperture reflector and 46/71 cm Schmidt camera near Mt. Bigelow; 53 cm reflector on Tumamoc Hill; 220 cm Cassegrain reflector in Kitt Peak; and the multiple-mirror telescope in Mt. Hopkins); a scanning electron microscope laboratory, a neutron activation analysis laboratory, and the Space Imagery Center. In addition, the Laboratory conducts high-altitude observational programs for solar, planetary, and stellar infrared spectroscopy using NASA jet aircraft. A full complement of computational facilities, and other technical support, is available to the research programs; the University has access, through a national consortium, to a large super-computer.

The Laboratory sponsors a regular series of scientific colloquia and seminars, and frequently is host to visitors from other scientific institutions around the world. Graduate research assistantships are available on a selected basis to students planning to study toward the Ph.D. degree with a major in planetary sciences.

MICROCAMPUS (1972) is an education delivery system which uses video cassettes, live interactive microwave and satellite transmission to make University of Arizona classes available to students throughout the U.S. Students in remote locations who want University credit must be admitted to the University and register for classes in absentia. Successful completion of a course results in a University credit transcript entry. In addition to regular courses, videotaped short courses provide up-to-date information on diverse subjects, but are not available for University credit. Developed in the College of Engineering, Microcampus has grown to include courses from many other colleges and is now part of the Division of Media and Instructional Services.

The MINERAL MUSEUM (1919) emphasizes Arizona's unique mineral heritage in a spectacular collection of minerals, fossils, and gems. The Museum, a part of the collections of the Department of Geosciences since its establishment, is open to students and the general public.

NUCLEAR REACTOR — The TRIGA reactor in the Department of Nuclear and Energy Engineering is both a training and a research facility. The uranium-zirconium hydride-fueled, pool-type reactor is conveniently designed for the study of many research problems in reactor engineering, including those of variation in core geometry, shielding, neutron behavior, transient characteristics, and control.

The reactor operates at an average power level of 100 kilowatts with a thermal neutron flux of approximately $2 \times 10^{12}$ neutrons per square centimeter per second. Operation in the pulse mode with peak power levels up to 680 Mw and pulse widths of about 17 milliseconds is also available.

The reactor is available for research to all departments of the University for neutron irradiation services. Objects of large size may be encased and lowered to the top of the reactor core for exposure to neutrons. Smaller samples may be placed directly in a fast neutron irradiation facility or in one of the forty thermal neutron exposure positions available.

A pneumatic sample irradiation facility is available for research with short-lived radioactive materials, and external neutron beams may be used for neutron radiography. A variety of gamma ray spectroscopy equipment is available to allow full use of the activation analysis capabilities of the reactor.
The **OFFICE OF ARID LANDS STUDIES**, administratively located in the College of Agriculture, is active in international studies, natural resources development and management, environmental studies, economic botany, new crop development, water and energy conservation, information services, Indian programs, remote sensing, geographic information systems, publications and education. Activities are conducted within the framework of the arid environment. The Office provides interdisciplinary project management and works closely with local and campus communities as well as with local, state, federal, and international government agencies. The office administers the interdisciplinary Doctor of Philosophy degree with a major in arid lands resource sciences. This degree program offers an opportunity for the qualified, mature student to make an outstanding contribution toward understanding and solving the worldwide problems of the arid zones.

Additionally, the Office of Arid Lands Studies undertakes special studies under grants and contracts, issues bibliographical and scientific publications, and, as a clearinghouse for the exchange of world arid lands information, maintains liaison with all international bodies and foreign institutions concerned with arid zone problems.

The **OPTICAL SCIENCES CENTER** is a graduate center for research in applied and theoretical optical physics, and students may undertake graduate programs leading to the M.S. and Ph.D. degrees. Areas in which research is currently being conducted include atmospheric optics, coherent optics, holography, image processing, infrared techniques, integrated optics, laser physics, medical optics, modulation spectroscopy, optical design, optical fabrication and testing, optical properties of materials, quantum optics, remote sensing, solar energy, and thin-film technology. In addition, interdisciplinary research programs involving the Departments of Astronomy, Civil Engineering and Engineering Mechanics, Electrical and Computer Engineering, Mathematics, Physics, Physiology, Planetary Sciences, and Radiology are in progress.

Special facilities of the Optical Sciences Center include an electronics shop, faculty/student machine shop, instrument shop, massive-optics shop, small-optics shop, photographic dark rooms, PDS microdensitometer, eclipse minicomputer, remote computer terminal, reading room, teaching laboratory, and thin-film facility. These facilities are often used by graduate students in their research programs.

The **RUTH E. GOLDING CLINICAL PHARMACOKINETICS LABORATORY** (1977) in the College of Pharmacy is primarily an analytical laboratory where new assays are developed to quantify drugs and their metabolites from biological fluids. These assays are used in conjunction with animal and clinical research projects to better define the disposition of and response to drugs. The results of these studies along with the monitoring of drug plasma concentrations in patients are used to optimize therapy by individualizing drug administration.

The **SOCIAL AND BEHAVIORAL SCIENCES RESEARCH INSTITUTE** (1984) promotes fundamental and applied research focusing on both individuals and social groups. The areas of fundamental research encompass individual behavior, including behavior, including its linguistic and psychological expression, social organization, theory and values, and public and private policy. Knowledge gained through this social and behavioral research is applied to the practical problems confronting society and the individual. This mission is achieved by stimulating and supporting the varied substantive research of faculty in the broad range of disciplines and interdisciplinary programs represented by the Faculty of the Social and Behavioral Sciences. Major departments and organized research units cooperate in establishing, maintaining, and operating the centralized research facilities of the Institute. Primary among these is the SBSRI Data and Software Library, which supplies technical support in computer software, and maintains an extensive data library.

The **SOUTHWEST CENTER** (1982) is a University unit which seeks to encourage and facilitate teaching, research, and the dissemination of information related to the history, culture, and ecology of the Mexican Northwest and U.S. Southwest. The Center is affiliated with the Universidad Nacional Autonoma de Mexico, U.N.A.M. Courses on the Southwest are taught through many University departments and programs, including American Indian studies, anthropology, English, geography, history, Latin American studies, linguistics, Mexican American studies, political science, sociology, Spanish and Portuguese, and women's studies. For more information contact the Director, Southwest Center, Social Sciences Building, Room 216.
The SOUTHWEST INSTITUTE FOR RESEARCH ON WOMEN (SIROW) (1979) is a regional research and resource center within the Committee on Women's Studies. The Institute develops and conducts research on women in the Southwest (Arizona, Colorado, New Mexico, and Utah) or of interest to scholars in the region. SIROW publishes a newsletter and a working paper series, links researchers with community organizations and policy makers through a research clearinghouse, and provides professional development and training for people in education, research, business, and government.

The STEWARD OBSERVATORY was established in 1916 by the generous gift of Lavinia Steward in honor of her husband, George Steward. For many years, the Observatory's principal telescope was its 36-inch (91-cm.) reflector, constructed with the aid of the Steward bequest.

The primary research telescopes of the Observatory now include the Multiple Mirror Telescope (MMT), located on the Mt. Hopkins summit in the Santa Rita Mountains, the 90-inch (2.3-m.) Ritchey-Chretien reflector at the Kitt Peak site, and the 61-inch (1.55-m.) Cassegrain reflector at the Mt. Bigelow station in the Santa Catalina Mountains. The MMT, operated jointly with the Smithsonian Astrophysical Observatory, represents an innovative and successful concept for construction of large optical telescopes; it may thus become the prototype for future large-aperture telescopes. The major telescopes are used with a wide variety of instrumentation and detectors and are supported by several smaller instruments used for teaching or special research projects.

The Steward Observatory offices and laboratories are located on the University campus adjacent to the original 36-inch dome, which now houses a 21-inch instructional telescope. The main areas of research at the Observatory include extragalactic and galactic astronomy, with specializations in the areas of quasars, star formation, interstellar medium, degenerate stars, infrared sources, novae, and radio galaxies. Observational work is concentrated in the optical and infrared but includes work at radio, ultraviolet, and x-ray wavelengths using other facilities. The Observatory is developing a 10-meter class telescope for work at mm and sub-mm wavelengths in collaboration with the Max Planck Institute for Radioastronomy in Bonn, West Germany. The Observatory's Large Mirror Lab is collaborating in the development of optics for the next generation of giant optical/infrared telescopes. The research programs also include a new initiative in Theoretical Astrophysics, and an active involvement in astronomy in space, such as the infrared Astronomy Satellite (IRAS), Space Infrared Telescope Facility (SIRTF) and Space Telescope.

The administrative offices and laboratories of the Kitt Peak National Observatory are across the street from the Steward Observatory and the offices of the National Radio Astronomy Observatory are located within the Steward Observatory. The observatories co-sponsor a series of weekly professional colloquiums. Steward Observatory also maintains close working ties with the University's Lunar and Planetary Laboratory, the Department of Planetary Sciences, the Optical Sciences Center, the Physics Department, and the Grace M. Flandrau Planetarium.

The UNIVERSITY ANALYTICAL CENTER was established in response to the increasing need for various segments of the academic community to have access to modern chemical analysis methodology. The Analytical Center provides the University with a centralized system analysis. The facility is available to all University disciplines requiring or desiring to use the University community by providing analytical equipment, analytical advice, methods development, sample analysis, and the training of both technical and nontechnical personnel in various aspects of analytical measurements. In addition, the Analytical Center maintains an active program of both basic and applied analytical research. The research activities provide a means of continuously expanding the Analytical Center capabilities and ensuring that equipment and personnel are kept at state-of-the-art levels in various analytical areas.

UNIVERSITY LIBRARIES — The University Library system contains more than 5,000,000 items, including books, periodicals, microforms, maps, government publications, manuscripts, and non-book media. Basic holdings cover all fields of instruction, and there are especially strong collections in anthropology, geology, arid lands, Spanish and Latin American language and literature, American agriculture, Southwestern Americana, Arizoniana, 20th century photography, history of science, science fiction, and 18th- and 19th-century British and American literature. Through the library the University is a member of the Center for Research Libraries and the Association
of Research Libraries. The library is also a member of the AMIGOS Bibliographic Network and through that and other agencies can borrow materials for student and faculty research on interlibrary loan. The Library offers reference service, online searching of computerized data bases, and bibliographic course-related instruction.

The University Library system consists of the Main Library which houses the Central Reference Department, Government Documents, the Media Center, the Map Collection, and the Current Periodicals, Newspapers, and Microforms Room; the Science-Engineering Library; and the following Branch Collections: the Oriental Studies Collection, the Music Collection, the Center for Creative Photography, the Southwest Folklife Center, Special Collections, and the Library Science Library. Four large but separate library facilities are the College of Law Library, the Architecture Library, the Arizona Health Sciences Center Library, and the Arizona State Museum Library. In addition, several other departmental libraries such as the Division of Economic and Business Research Library, the Steward Observatory Library, the Herbarium, and the Lunar and Planetary Sciences Library have been established to serve special research needs.

CENTRAL REFERENCE — Houses the library's main card catalog and reference materials for the social sciences, fine arts and humanities.

GOVERNMENT DOCUMENTS — A regional depository for U.S. government documents; houses almost a million items.

MEDIA CENTER — Houses all the library's non-book materials except microforms and music tapes and records.

MAP COLLECTION — A depository for USGS maps, houses a fully cataloged collection of almost 200,000 maps on every subject.

CURRENT PERIODICALS, NEWSPAPERS, AND MICROFORMS — Displays current issues of the 5200-plus periodicals received in the Main Library, subscribes to over 150 newspapers and has a collection of microforms which numbers nearly 2 million.

SCIENCE-ENGINEERING LIBRARY — Houses all materials on science and technology; has over 360,000 volumes, over a million microforms, and displays current issues of its 4500-plus periodicals.

MUSIC COLLECTION — Houses the library's collection of 50,000 scores, 28,000 pieces of sheet music and 25,000 recordings. Facilities for listening are provided.

CENTER FOR CREATIVE PHOTOGRAPHY — Houses the library's archive of over 100 famous 20th century photographers. The Center's collections are internationally known.

SOUTHWEST FOLKLORE CENTER — Houses musical tapes and manuscript archives of Southwest music and folklore.

LIBRARY SCIENCE LIBRARY — Houses the library's collection of professional library literature in support of the Graduate School of Library Science.

SPECIAL COLLECTIONS — Houses the library's collections of Arizoniana and Southwest Americana, special subject collections, rare books, fine printing, manuscripts, and the University of Arizona archives.

ORIENTAL STUDIES COLLECTION — Houses books, periodicals and newspapers in the Chinese, Japanese, Arabic, Persian, Hindi, Urdu, Turkish, and other Oriental languages; has over 160,000 items.

LAW LIBRARY — This library now contains over 175,000 volumes, including the reported cases of all the jurisdictions in the United States and substantially all the English reported cases; American and English statutory law; decisions of federal administrative agencies; complete sets of leading legal periodicals; a carefully selected collection of legal encyclopedias, digests, treatises, and textbooks; and a developing collection of civil law with emphasis on Latin America.

HEALTH SCIENCES CENTER LIBRARY — This specialized library, which serves the University Hospital as well as the Colleges of Medicine, Nursing, and Pharmacy, contains almost 150,000 cataloged volumes and receives approximately 3,100 serial titles. The collection includes books, journals, and nonprint materials in the health sciences.
ARCHITECTURE LIBRARY — This specialized library houses a collection with emphasis on the topics of design, architectural history and theory, graphic communication, and building technology including over 10,000 cataloged volumes, 120 periodicals and over 24,000 slides for architecture faculty use. This library is open to the University community and general public on a reference basis.

UNIVERSITY OF ARIZONA MUSEUM OF ART — The University of Arizona is exceptionally fortunate to possess several outstanding art collections. Housed in the Museum are the masterpieces of the Samueh H. Kress Collection, which include the surviving panels of the Retablo of Ciudad Rodrigo by Fernando Gallego, and one of the finest university collections of Renaissance 16th- and 17th-century art in the United States. Contemporary international painting and sculpture are well represented in the Edward Joseph Gallagher III Memorial Collection; in the Jacques Lipchitz sketches and models; and in the C. Leonard Pfeiffer Collection, which was the first collection donated to the University. Temporary exhibitions are presented throughout the year, and the Museum conducts a very active education outreach program. The Museum of Art is open to the public on weekdays from 9 to 5, and on Sunday from 12 to 4. There is no admission fee.

JOSEPH GROSS GALLERY and ART DEPARTMENT PRINT COLLECTION — The Joseph Gross Gallery of the Department of Art, created by a generous gift to the University from Professor Joseph F. Gross in memory of his father, Mr. Joseph Gross, is a professional art gallery featuring exhibitions of works by artists throughout the United States and occasionally foreign countries. Occasionally, the work of graduate students and faculty members is exhibited as well. The gallery's exhibitions include works of fiber, graphic design, painting, sculpture, photography, ceramic and metal crafts.

The Department of Art maintains and displays its own collection of original graphic prints, ranging from the 15th to the 20th century. It presents a cross-section of authentic prints throughout the history of this art form, including early engraving, etching, wood-cut and lithography. Important donations by Mr. and Mrs. H. Kelley Rollings and Mrs. Helen Murphey have given this collection a public importance which augments its original intent, that of a teaching collection for university art students.

The UNIVERSITY OF ARIZONA POETRY CENTER — A 1960 gift of Ruth Stephan, the rapidly growing poetry collection numbers more than 15,000 volumes of poetry; has an extensive collection of literary magazines and poetry readings on tape; and is available daily for use by students, faculty and the community. The collection includes poetry of all ages and various nations, with emphasis on American and British poets. It also includes books about poetry and poets. The center regularly sponsors campus readings by nationally known poets and writers throughout the year.

The UNIVERSITY OF ARIZONA PRESS, founded in 1959 as a department of the University of Arizona, is a nonprofit publisher of regional and scholarly books. As a delegate of the University of Arizona to the larger world, the Press publishes the work of scholars wherever they may be, concentrating upon scholarship that reflects the special strengths of the University of Arizona, Arizona State University, and Northern Arizona University.

The Press publishes scholarly books in anthropology and archaeology, space sciences, arid lands studies, biology, Latin American studies, Asian studies, American Indian studies, and other fields. Also on the UA Press list are trade books on the Southwest borderlands, including accounts by scholars and professional writers of the natural history, geography, history, folklore, and lifeways of the region. The UA Press does not publish children's books or volumes of original fiction or verse.

The University of Arizona Press invites inquiries from the authors of works — whether scholarly books or works of general interest — that are appropriate to its list.

Twenty-two people are on the staff of the University of Arizona Press. In addition, sales representatives market UA Press books throughout the United States, Canada, Europe, and parts of Asia. The manufacture of books is by contract, and the UA Press has no direct affiliation with the printing services of the University of Arizona.

Also appearing under the Press imprint is the historical quarterly Arizona and the West, whose separate editorial and subscription office is in the UA Main Library.
The WATER RESOURCES RESEARCH CENTER, an interdisciplinary organization formed in response to the U.S. Congress's Water Resources Act of 1964, is primarily devoted to assistance to water-related research activities at the three state universities. In addition, the Center conducts certain special research investigations within its organization. This work includes the harvesting of additional water from arid and semi-arid watersheds; artificially recharging the groundwater aquifers; evaporation suppression; seepage control; urban hydrology; and operation and maintenance of the research facility on the Casa Grande Highway, and one undeveloped and three urbanized watersheds, all in or near Tucson. Lastly, the Center, together with the Office of Arid Lands Studies, manages a Water Information Center for disseminating the results of water-related research in the state.

COOPERATING ORGANIZATIONS

Certain other independent agencies, not administratively a part of the University of Arizona, cooperate closely with the University and provide opportunity for study and research for faculty and qualified graduate students. Several of these are actually located on the University campus, and certain staff members of some also hold University staff appointments.

The ARIZONA-SONORA DESERT MUSEUM is a self-supporting, nonprofit institution situated 14 miles west of Tucson in a saguaro and palo verde landscape of the Sonoran desert. This living indoor and outdoor museum of natural history enables one to gain in a few hours a knowledge of the flora and fauna of the Southwest that would otherwise require many years. Unique habitat groups and other displays of desert animals and plants have been developed at this unusual museum. The Museum cooperates with educational institutions at all levels as an outdoor education center and provides laboratory and field space for research in the natural history of Arizona and Sonora, Mexico, with special emphasis on the Sonoran desert common to both states.

ARIZONA HISTORICAL SOCIETY — Organized in 1884 for “the collection and preservation of materials illustrative of the history of Arizona in particular and of the West generally,” the Society receives support from the state, and maintains both a historical museum and a research library. The museum and library are located adjoining the University campus and contain 50,000 books, 2,000 manuscript collections, and 250,000 photographs. The manuscript collections are especially rich, with letters, diaries, journals, business records and other documents, many of which are still partially or completely unpublished. One of its most valuable research resources is its file of over 2,000 bound volumes of Arizona newspapers beginning with the first issue of the first weekly in 1859. State and federal historical records are on microfilm, as are records from Spanish colonial archives. Membership is open to everyone.

The MUSEUM OF NORTHERN ARIZONA and its Research Center, located at Flagstaff, Arizona, provide unusually fine training and research facilities in many areas of anthropology, art, biological sciences, and geology. A close association is maintained between the Museum and Research Center and certain departments of the University of Arizona. Field work and independent research for a limited number of graduate students can be undertaken at the Museum's Research Center with the approval of the departments concerned, the Director of the Museum, and the Dean of the Graduate College. Registration may be arranged by the procedure used for work done in absentia for credit in 900 Research to apply toward requirements for an advanced degree, for 910 Thesis, and for 920 Dissertation.

The SOUTHWESTERN RESEARCH STATION of the American Museum of Natural History, New York, is located within a few hours of the University campus in the Chiricahua Mountains of southeastern Arizona. The Station proper is located at an elevation of 5,400 feet in a moderate evergreen woodland climate, midway between the desert below and the coniferous forest above. A wide variety of life zones is represented within a few miles of the Station between the desert floor and the fir-covered peaks at 9,800 feet. This unspoiled area within the Coronado National Forest includes many protected wilderness areas accessible only on foot or horseback.

Station living facilities are excellent, and the laboratory is well equipped for modern field and laboratory research in ecology and physiology. The station is an excellent field base for work in biology, geology, paleontology, resource management, and wildlife management. Though it is primarily a field research station for professional biologists, biology classes and graduate students are encouraged to make use of facilities.
UNIVERSITY OF ARIZONA

GENERAL INFORMATION

UNITED STATES GOVERNMENT AGENCIES — A number of agencies of the United States Government, including several divisions of the Agricultural Research Service and the Soil Conservation Service of the United States Department of Agriculture, the United States Bureau of Mines, and the United States Geological Survey, are located on or near the campus of the University. These research organizations work closely with the University, and a number of their personnel also hold University staff appointments.

FEES — 1987-1988

The Board of Regents reserves the right to change all fees and charges without notice.

LEGAL RESIDENTS OF ARIZONA:

- Registration fee* ........................................... $1,196.00
  ($598.00 per semester)
- Residence halls, average rate** ......................... $1,116.00
- Meals in university cafeteria ............................. $1,596.00
- Books and supplies ........................................ $433.00
  Total minimum annual expense .......................... $4,341.00

NONRESIDENTS OF ARIZONA:

- Registration fee* ........................................... $1,196.00
  ($598.00 per semester)
- Nonresident tuition fee*** ............................... $3,432.00
  ($1,716.00 per semester)
- Residence halls, average rate** ......................... $1,116.00
- Meals in university cafeteria ............................. $1,596.00
- Books and supplies ........................................ $433.00
  Total minimum annual expense .......................... $7,773.00

MISCELLANEOUS EXPENSES

- Music fee for private lessons, per semester**** (½ hr. per week - $40, 1 hr. per week - $60). See General Catalog for details.
  Late registration fee (any time after the scheduled 2-day period) $10.00
  Change-of-schedule fee ................................ $2.00
  Foreign student language examination fee (any one examination) $10.00
  Application for degree candidacy fee ........................ $15.00
  Late application for degree candidacy fee
    (see Graduate Calendar for deadlines) ................... $2.00
  Processing fee (thesis or dissertation) .................. $15.00
  Dissertation microfilm fee ............................... $25.00
  Caps and gowns are purchased for $16.54 or $19.43,
    depending upon degree.
    Hoods are purchased for $13.65 or
    $16.28, depending upon degree.
  Transcript fee, after one free transcript
    (Instantaneous service is $3.00) ...................... $1.00

* The registration fee for seven or more units includes services and facilities of student activities, Student Union, Health Service, Parking, Alumni Association and Artist Series. Students taking fewer than seven units pay $63.00 per unit per semester.

** Average residence hall rates range from $767.00 to $1,680.00 per student per year and are subject to increase for the 1987-88 and 1988-89 academic years.

*** For seven through 11 units of course work, the nonresident tuition per semester is: $1,001.00 for 7 units; $1,144.00 for 8 units; $1,287.00 for 9 units; $1,430.50 for 10 units; $1,573.00 for 11 units. $1,716 for 12 units or more. The nonresident tuition is waived for graduate assistants currently on appointment and for students taking fewer than seven units.

**** Graduate assistants currently on appointment are exempt from music fees in the major field if the student is a music major.
HOUSING

SINGLE GRADUATE STUDENTS — One residence hall is reserved for graduate students. This hall is modern and fully air-conditioned. A request for Graduate Student Housing form is included in the admissions packet. Additional information may be obtained by writing to the Department of Residence Life.

MARRIED STUDENTS AND SINGLE-PARENT FAMILIES — The University has 420 apartments, located about six miles from the campus, available for qualified married students and single-parent families. Interested students should write directly to the Department of Residence Life; 3401 North Columbus Boulevard; Tucson, Arizona 85712 for additional information.

UNIVERSITY DINING SERVICE

The University offers a variety of dining services operated in the Student Union and in the Garden Court Restaurant at the Park Student Center. The range includes specialty snack bars, cafeterias, and a complete table-service restaurant. Campus vending locations are also offered. All Aboard is the university meal plan that is available to all students. For additional information, write: All Aboard, S.U.P.O. 10,000, Tucson, AZ 85720. Approximate monthly food cost for the average student is $210.00.

STUDENT SERVICES

Counseling, testing, job and learning skill services are available to students through the Student Resource Center in the Old Main Building; the Student Health Service (Infirmary); the Speech and Hearing Clinic; the Disabled Student Services Program (individualized support group services); the Foreign Student Adviser; the American Indian Student Adviser; and the Veterans’ office. For full information concerning each of these, the student should consult the Dean of Students Office or the General Catalog.
General Regulations

THE NATURE OF GRADUATE WORK — The status of graduate students is different from that of undergraduates. Satisfying degree requirements should not be the primary aim of graduate students. Graduate education provides an opportunity to increase knowledge, to broaden understanding and to develop research capabilities. Consequently, the student's academic achievements should reflect a personal commitment to the discipline and to scholarly standards.

ADMISSION — Admission to the Graduate College is open to qualified applicants who hold the bachelor's degree from the University of Arizona or from a college or university which grants degrees recognized by the University of Arizona. Degrees that are recognized should be based on programs of study that meet or exceed the general education requirements for comparable degree majors at the University of Arizona. A degree cannot ordinarily be recognized if it is based on any of the following types of credits:

1. Credits awarded by postsecondary institutions in the United States that lack candidate status or accreditation by a regional accreditation association.
2. Credits awarded by postsecondary institutions for life experience unless validated by the institution awarding the credits through the use of standardized (such as CLEP) or comprehensive examinations.
3. Credits awarded by postsecondary institutions for courses taken at noncollegiate institutions (e.g., governmental agencies, corporations, industrial firms, etc.).
4. Credits awarded by postsecondary institutions for noncredit courses, workshops, and seminars offered by other postsecondary institutions as part of continuing education programs.

In general, degrees that are recognized should be based on a unit of credit comparable to that defined by the Arizona Board of Regents (26 May 1979) for institutions under its jurisdiction. A minimum of 45 hours of work by each student is required for each unit of credit. An hour of work is the equivalent of 50 minutes of class time (often called a “contact hour”) or 60 minutes of independent study work. For lecture-discussion courses, this requirement equates to at least 15 contact hours and a minimum of 30 hours of work outside of the classroom for each unit of credit. Even though the values of 15 and 30 may vary for different modes of instruction, the minimum total of 45 hours of work for each unit of credit is a constant. Each applicant with an undergraduate academic record containing “pass,” “satisfactory,” “credit,” or similar entries for courses which have a substantial bearing on the field of specialization must also submit (i) a written evaluation by the instructor of each such course, or a letter grade, and (ii) scores on the aptitude test of the Graduate Record Examinations. Admission is granted only after approval of the applicant's previous academic record by the Dean of the Graduate College and the head of the academic unit in which the greater portion of major academic work will be completed.

GRADE-POINT AVERAGE — Applicants who apply for admission to the Graduate College are evaluated on the individual merits of their academic achievements and individual scholarly potential to complete graduate level course work and curriculum requirements. Ordinarily, a minimum cumulative grade-point average of 3.0 over the last 60 units of course work is required for admission to the Graduate College. Applicants should consult the academic unit to which they are applying regarding that unit's grade-point average expectations. Prospective students who do not meet this standard may enroll as nondegree students and complete 12 consecutive units of 500-level (or higher) course work with a grade-point average of at least 3.25 in order to establish eligibility for seeking admission to the graduate degree program of their choice.

GRADUATE RECORD EXAMINATIONS (GRE) — Normally applicants must submit scores on the Graduate Record Examination in order to complete the admission process. Scores on the aptitude test of the Graduate Record Examinations are used to supplement other evidence of preparation for graduate work. Such scores are only one component of the credentials used to make admission decisions, and they are evaluated in the context of the complete record in the application folder of each applicant. No formal minimum scores on standardized examinations
are required for admission to the Graduate College. A number of departments, however, have specific requirements with regard to the Graduate Record Examination, the Graduate Management Admissions Test, or other examinations. Some may require applicants to take the advanced GRE in the appropriate discipline. Academic departments and departmental headnotes in the Departments and Courses of Instruction section of this catalog should be consulted for further information. It is important that the examination be taken as early as possible in the academic year. Applications for the examinations, which are administered locally as well as in other centers, should be sent, together with the examination fee, to Graduate Record Examinations, Educational Testing Service; Box 1502; Berkeley, California 94701; or Box 955; Princeton, New Jersey 08541.

REGULAR GRADUATE STATUS — Students who meet the admission requirements outlined above may be admitted to Regular Graduate Status to undertake work leading to an advanced degree.

ADMISSION WITH DEFICIENCIES — An additional number of undergraduate courses may be required when previous work has not approximated the general requirements for the corresponding bachelor's degree at the University of Arizona or the special requirements for the field in which the candidate proposes to specialize. With departmental approval, a limited number of course deficiencies may be satisfied after admission to a graduate program; however, this work will not receive graduate credit.

GRADUATE NONDEGREE STATUS — Individuals holding a bachelor's degree, or its equivalent, from a college or university which grants degrees recognized by the University of Arizona may attend graduate-level courses without being admitted to a graduate degree program. Such students may enroll in graduate-level course work as their qualifications and performance permit; however, no more than six units earned while in this status may later be requested to be applied toward an advanced degree awarded at the University.

ADMISSION OF FOREIGN STUDENTS — Nonimmigrants should request graduate application forms from the Graduate Student Admissions Office and departmental requirements and materials from the major department. All foreign student applications, with the required credentials, should reach the Graduate Student Admissions Office before March 1 for the summer and fall terms and September 1 for the spring term. Some graduates of foreign institutions may be admitted initially as International Special Students for a period of enrollment limited to two academic terms with the understanding that they may be required to undertake some work without graduate credit in order to make up deficiencies in preparation. In any event, no commitment can be made regarding the time required to complete a course of study.

The University requires all applicants whose native language is other than English to take the Test of English as a Foreign Language (TOEFL) unless they have completed at least two academic years of full-time study or received a bachelor's or higher degree at a postsecondary academic institution in which English is the spoken tongue and medium of instruction. Results of the TOEFL are valid for two years, and scores will be sent to the University of Arizona, when requested by the applicant, from TOEFL; Box 899-TR; Princeton, New Jersey 08540, U.S.A. The scores for this examination must be received before the student's application is complete. New students who are required to take the TOEFL test and whose scores are below 550 are required to take a locally administered English test and to enroll for any further English courses which may be recommended. Students whose native language is not English and who wish to be considered for a teaching assistantship should also submit scores on the Test of Spoken English (TSE) that is also administered by the Educational Testing Service of Princeton, New Jersey 08540.

For those prospective students who lack college-level English proficiency, the Center for English as a Second Language (CESL) offers full-time English language training on campus. The full semester or summer term sessions carry no college credit, but satisfactory completion of CESL training meets the University's English proficiency requirement for admission. Request further information from the Center for English as a Second Language, Room 104, CESL Building, University of Arizona, Tucson, AZ 85721.

Students on nonimmigrant visas must certify that they possess adequate financial resources to support themselves while in residence at the University of Arizona. If sponsorship is through an organization or government agency, the sponsor must inform the Graduate Student...
General Regulations

Admissions Office, in advance, what the terms of support will be. Financial guarantees must be dated and addressed to the University of Arizona. If the University is to bill for tuition and fees, billing must be through an embassy or an agent in the United States. In addition, students on nonimmigrant visas are required by the University to have student accident and sickness insurance coverage for each term of enrollment. The cost of this insurance is included in the amount of financial guarantee required. Students may be exempted from the University of Arizona insurance plan only when their government or sponsoring agency has submitted accident and insurance plans acceptable to the University of Arizona. Additional information and costs of this coverage will be sent to those foreign students who are accepted for admission.

Application for Admission — Application for admission to the Graduate College must be made on forms furnished by the Graduate College. Completed application forms must arrive before supporting transcripts come or processing will be seriously delayed. An applicant from another institution should request that two sets of complete official transcripts of all undergraduate and graduate work done and degrees received be sent directly by the institution at which the work was done to the Dean of the Graduate College of the University of Arizona. Both the application and the transcripts should be on file four to six months prior to registration. Applicants whose records are not in English are required to provide a certified translation of their records. Applicants should also contact the department of their intended major to obtain departmental application materials and requirements. Students who have been admitted to the Graduate College but who were not enrolled during the previous regular semester must reapply for admission.

Candidacy for an Advanced Degree — Admission to graduate study does not imply admission to candidacy for an advanced degree and gives no right or claim to be so admitted. Such candidacy is determined after the student has demonstrated, by work done at the University of Arizona, the ability to do work of graduate character with originality and independence. Until admitted to candidacy a student should not rely upon taking the final examination for a degree at any set time.

Graduate Credit for Seniors — A University of Arizona student of senior standing who is within 15 units of completing all requirements for graduation may register for graduate work if recommended by the head of the department and approved by the Dean of the Graduate College. For such registration a petition for graduate credit in excess of senior requirements must be filed with the Dean at the time of registration. This petition must be endorsed by the professor in charge of the course and the student's adviser. The Dean will not approve a petition unless the senior has a grade-point average of 3.0000 or better on all work already completed at the University, is proceeding toward graduation as directly as possible, and does not propose a total load to exceed sixteen units. The maximum number of units of graduate credit that may be earned by a senior in any semester is equal to the difference between sixteen and the number necessary to complete requirements for graduation.

General Prerequisites for Major Graduate Credit — The undergraduate major, or its equivalent, in any field of study is prerequisite to major graduate work in that field. In some cases, a field of concentration in undergraduate work different from but suitably related to the graduate major may be acceptable. Deficiencies in undergraduate preparation must be satisfied by the completion of prescribed courses, for undergraduate credit.

Regular Graduate Credit Courses — Regular courses numbered at the 500, 600, 700, and 900 levels are intended for graduate students, while approved 400-level courses, indicated by a GC in the course listing, may be taken for graduate credit by students admitted to graduate degree programs and by undergraduates who have received prior, written permission of the Dean of the Graduate College. (See the Departments and Courses of Instruction section for classification of regular courses by number.) With prior written permission of the Dean of the Graduate College, exceptionally well-qualified seniors may enroll in 500-level courses. Courses numbered at the 600, 700 and 900 levels are not open to undergraduates.

Other Courses for Graduate Credit — In addition to the regularly scheduled campus offerings, the University also offers a variety of special courses. Such courses are designated by
numbers of four digits. The first digit — 4, 5, or 6 — indicates the type of course instruction. The last three digits are the same as the number of the regular campus offering unless there is no such counterpart.

All courses given by television for credit are designated by four-digit numbers beginning with 5. As many as eighteen units of graduate credit may be applied toward meeting the requirements for the master’s degree, except that this limit is reduced by the number of units of transfer work offered. No course in the 5000 series may be used toward a graduate degree. Short courses are designated by a four-digit number beginning with 6. All graduate courses in the 6000 series may be applied toward the requirements of graduate degrees.

TRANSFER OF GRADUATE CREDIT — The University of Arizona accepts graduate credit by transfer from other accredited institutions; however, the whole number of transferred units offered toward a master’s degree may not exceed twenty percent of the minimum number of units required for the degree in question. Such transfer of credit may be applied toward an advanced degree only upon satisfactory completion of such additional courses as may be prescribed by the head of the corresponding department in the University. Furthermore, the application of transfer work toward meeting requirements for a master’s degree will reduce the number of units of work in the 5000 series acceptable for the same program (see “Other Courses for Graduate Credit” above).

In any case, transfer of credit toward an advanced degree will not be made unless approved by the head of the major department, unless the grade earned was A or B, and unless it was awarded graduate credit at the institution where the work was completed. Furthermore, transfer will be made of credit only; no account will be taken of the grades of transfer work in computing the student’s grade point average. Such transfer, which must be arranged by the student through the Graduate Degree Check Office, may be initiated at any time but will not become effective until the student has completed satisfactorily at least twelve units of graduate work at the University of Arizona.

Credit for extension work from other institutions will not be accepted.

CORRESPONDENCE COURSES — Correspondence courses will not be accepted for graduate credit.

GRADING SYSTEM — The grading system used by the University of Arizona follows:

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Excellent</td>
</tr>
<tr>
<td>B</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>Fair</td>
</tr>
<tr>
<td>D</td>
<td>Poor</td>
</tr>
<tr>
<td>E</td>
<td>Failure</td>
</tr>
<tr>
<td>F</td>
<td>Failure (see section on “Pass/Fail Option”)</td>
</tr>
<tr>
<td>P</td>
<td>Passing (see paragraph on “Special Grades” and section on “Pass-Fail”)</td>
</tr>
<tr>
<td>S</td>
<td>Superior (see paragraph on “Special Grades”)</td>
</tr>
<tr>
<td>I</td>
<td>Incomplete</td>
</tr>
<tr>
<td>K</td>
<td>Course in progress</td>
</tr>
<tr>
<td>W</td>
<td>Approved withdrawal</td>
</tr>
<tr>
<td>O</td>
<td>Audit</td>
</tr>
<tr>
<td>CR</td>
<td>Credit</td>
</tr>
</tbody>
</table>

EXAMINATIONS REQUIRED — All courses offered for credit shall include a final examination given at the regularly scheduled examination time, unless specific exceptions for certain courses have been granted prior approval by departmental action and have been reported to the appropriate academic dean.

WITHDRAWAL GRADES — Prior to the end of the fourth week of classes, withdrawal from a course cancels the registration for the course. Between the end of the fourth week and the end of the tenth week, a grade of W will be awarded to students who are passing at the time of withdrawal and a grade of E will be awarded to students who are failing at the time of withdrawal. The grade of W shall not be awarded to graduate students after the last day of the tenth calendar week in which classes are held except for cause approved by the Graduate Council. The grade for a nonofficial withdrawal, without the filing of withdrawal forms, is restricted to E.

SPECIAL GRADES — The grades S (superior) or P (passing) are used in place of grades A or B respectively for individual studies courses numbered 591, 593, 594, 599, 691, 693, 694, 699, 791,
793, 794, 799, 900, 908, 909, 910, 920, and 925. The only grades available in courses numbered 599, 699, and 799 are S, P, C, D, E, I, and W. For courses numbered 595, 596, 695, 696, 795 and 796, the instructor may use these special grades or the regular letter grades as departmental policy or the instructor's own policy dictates; but all registrants in a given instance are graded by the same system. Grades available for 900 are S, P, C, D, E, K, and W. The only grades available for 908, 909, 910, 920, and 925 are S, P, E, K, and W. The only grade available for 930 is K. Special grades (S, P) are not used in the computation of the grade point average.

**AVERAGING OF GRADES** — For the purpose of computing grade point averages, grade points are assigned to each grade as follows: A, 4 points for each unit; B, 3 points; C, 2 points; D, 1 point; and E, 0 points. To calculate the grade point average, the unit value for each course in which a student receives one of the above grades is multiplied by the number of grade points for that grade. The sum of these products is then divided by the sum of the units of A, B, C, D, and E. The grade point average is based only on work attempted in residence at the University.

**PASS-FAIL OPTION** — This option is not available to graduate students except for: (a) admission deficiencies which the student has specific, prior, written approval to take on a P-F basis from the head of an academic unit or the graduate advisor (this permission must be on file in the Graduate College office before registration); and (b) any nondeficiency course available for P-F grading and for which graduate credit is not available; and (c) any course offered by the College of Law.

**REMOVAL OF INCOMPLETE** — Graduate students have a maximum of one calendar year to remove a grade of I (incomplete). This calendar year begins at the end of the semester in which the student registered for the course which was graded I (incomplete). If not removed within one calendar year, a grade of I will be changed to an E on the student's record and will be counted as an E in the grade point average.

**SCHOLARSHIP REQUIREMENTS** — A high level of performance is expected of students enrolled in a graduate degree program. A student who does not appear to be making satisfactory progress in graduate work may be required to withdraw from the University. No student will be recommended for the award of an advanced degree unless he or she has achieved a grade point average of 3.00 or better (a) on all work taken for graduate credit and (b) on all work included specifically in the graduate study program. To meet condition (a) the grade point average will be computed on all University of Arizona course work for which the student has enrolled for graduate credit, whether or not it is offered in satisfaction of requirements for an advanced degree, except for courses in which grades of P or S have been awarded. To meet condition (b) the grade point average is computed in a like manner but only on courses included in an approved graduate study program in the major department. Students who do not meet condition (b) may take additional work. Such additional work may be included with the major work in the computation of the grade point average to meet condition (b), but only with the approval of the major department secured prior to taking the work in question.

**FULL-TIME STUDENT STATUS** — Full-time status for graduate students varies, depending upon assistantship and associateship duties and the constitution of the individual student's program. Students in doubt about their standing should check with the Graduate College.

**MAXIMUM ENROLLMENT** — The maximum enrollment (including graduate, undergraduate and audited courses) allowed per semester for students registered in the Graduate College is sixteen units.

**SUPPLEMENTARY REGISTRATION** — Each student admitted to a graduate degree program who, during any academic term, is associated with the University in any capacity that makes use of University facilities or faculty time must register. During the fall and spring semesters a minimum of three units of graduate credit will be required; during any summer term one unit of graduate credit will be required. The minimum course work registration requirement may be met by registering officially for any single course or combination of courses for which the total number of units meets or exceeds the specific minimum.

Each student completing requirements for an advanced degree must be registered during...
the semester or summer term during which requirements are completed, or the previous semester or term if requirements are completed during an intersession. Students who have previously enrolled for all the regular courses required for their degrees and who still must register should enroll for supplementary registration (course number 930). Supplementary registration may be used concurrently with other enrollments to meet these registration requirements.

**THESIS AND DISSERTATION WORK IN ABSENTIA** — Under conditions approved by the head of the major department, a portion of the student's thesis or dissertation work may be done in absentia. Approval to do work in absentia must be sought prior to undertaking the work.

**AUDITING OF COURSES BY GRADUATE STUDENTS** — With the consent of the Dean of the Graduate College and the instructors concerned, students enrolled in the Graduate College may unofficially audit courses not included in their regular programs. It is not necessary to register for such courses, but an auditor's permit must be obtained from the Dean. If courses are audited officially by registering as an auditor, the units are included in the student's unit load and the fees are the same as a registration for credit. For the purpose of reporting full- or part-time student status to outside agencies, however, only those courses taken for credit are counted. After the fourth week of classes, a change from credit to audit will be permitted only if the student is doing passing work in that course, and receives the approval of the course instructor and the Dean of the Graduate College.

**GRADUATE STUDY IN SUMMER SESSIONS**

Graduate study is available during the University of Arizona summer sessions. All courses numbered at the 500, 600, 700, or 900 levels are graduate courses. Approved 400-level courses which are identified by GC in the catalog are also available for graduate credit to students admitted to graduate degree programs.

In response to demand for graduate work during the summer, a number of departments of the University have provided for individual research in their special fields. Such courses are listed under their respective departments. Students who wish to pursue any of these courses must obtain the consent of the course instructors before registering.

Graduate credit earned at the University of Arizona Summer School at Guadalajara, Mexico, may be used directly in advanced degree programs where appropriate.

In certain departments provision is made for teachers in service and others who are unable to attend the University during the regular year to complete the requirements for the master's degree by attendance at summer sessions only.

**EXPENSES** — Tuition per unit of credit for the 1987-88 academic year is $63.00. There is no additional nonresident fee for out-of-state students. In addition to the per unit tuition fee, students are assessed a student fee of $20.00 per five-week term ($4.00 per week for those registering for short courses only). Since fees are subject to change, students should consult the current Summer Session Schedule of Classes for fees in effect for any given year.

**GRADUATE APPOINTMENTS, SCHOLARSHIPS AND FINANCIAL AIDS**

Financial assistance for graduate students is available from diverse sources, but the primary source of information and assistance is the Office of Student Financial Aid, 203 Administration Building. A catalog delineating the financial assistance available to students is published by that office and may be obtained by requesting a copy. Various types of financial aid are described below.

Students are also urged to explore various other possibilities at other locations such as the student's major department; the College of Education; the Advisor to Study Abroad; the Student Counseling Service; and the Social Science Reference Department of the Main Library.
Assistantships and Associateships

Teaching and research assistantships are available in many University departments. Approximately 2,000 of these positions exist and many of them are for first-year graduate students. Salaries vary, but students may expect to receive an academic year salary in the range of $2,517 to $4,038 for services not exceeding ten hours a week, or $5,034 to $8,086 for half-time assistantships. Except by permission of the Graduate College, a student may hold a graduate assistantship or associateship only in the department of the major subject.

TUITION AND FEES — Graduate assistants and associates are exempt from the nonresident tuition charge and from music fees applicable to courses in their major fields. Registration fees are not waived.

ACADEMIC REQUIREMENT — Graduate assistants and associates must maintain a University of Arizona graduate grade point average of 3.00 or better.

MINIMUM ENROLLMENT — Students employed as graduate assistants and associates are required to register for at least six units of graduate credit per semester as a condition of their appointments.

MAXIMUM ENROLLMENT — The maximum number of units per semester which students employed as graduate assistants and associates may take is dependent upon the total hours of employment.

ADDITIONAL INFORMATION — All communications regarding graduate assistantships and associateships should be addressed to the head of the department concerned.

Scholarships, Fellowships, Traineeships, Grants, Awards

A limited number of scholarships and College Work Study awards are available to qualified graduate students. Interested students should request financial aid applications from the Office of Student Financial Aid. The priority deadline for applications is April 1 for continuing students and May 1 for new admits.

Graduate Tuition Scholarships, which waive out-of-state tuition, are available for academically qualified graduate students. A limited number of awards are available. Scholarship recipients must be recommended by their major departments and approved by the Graduate College.

Graduate Academic Scholarships, which waive the registration fee, are available in limited numbers for academically qualified graduate students. As with the Graduate Tuition Scholarships, recipients must be recommended by their major departments and approved by the Graduate College.

Awards such as NSF Graduate Fellowships and Ford Foundation Fellowships for Minority Students are made by the sponsoring agency to individual students. Applications are submitted by students to the sponsor, usually in early fall.

Loans

Loan programs in which graduate students may participate include, but are not limited to, Perkins Loans (formerly National Direct Student Loans), Nursing Student Loans (NSL), Pharmacy Student Loans, Medical Student Loans, Dougherty Foundation Student Loans, and Guaranteed Student Loans.

Financial aid applications should be submitted to the Office of Student Financial Aid by the annual application deadline of the year the funds are required. The priority deadline for applications is usually May 1. Selection will be made on objective criteria with respect to the applicant's qualifications, and awards are limited by the availability of funds.

A separate application is required for the Guaranteed Student Loan Program. An applicant must be admitted to a degree program before submitting the application to the Office of Student Financial Aid. The total processing time at the University, bank and guaranty agency can take up to four months. Therefore, early application is advised.
Graduate Degrees

MAJOR FIELDS FOR MASTER'S DEGREES

Major work leading to a master's degree is offered in each of the following fields:

accounting
aerospace engineering
agricultural economics
agricultural education
agricultural engineering
agronomy &
plant genetics
American Indian studies
anatomy*
animal physiology
animal science
anthropology
applied mathematics
architecture
art
art education
art history
astronomy
atmospheric sciences
bilingual/bicultural education
biochemistry
botany
business administration
chemical engineering
chemistry
civil engineering
classics
communication
comparative literature &
literary theory
composition (music)
computer science
counseling & guidance
creative writing
dairy science
dietetics
drama
ecology &
evolutionary biology
economics
educational administration
educational media
educational psychology
electrical engineering
elementary education
engineering mechanics
English
English as a second language
entomology
exercise and sport sciences
family and consumer resources
finance
food science
foundations of education
French
general biology
geology
government
geological engineering
geosciences
German
health education
higher education
history
home economics education
horticulture
hydrology
industrial engineering
journalism
landscape architecture
Latin American studies
library science
linguistics
management and policy
management information systems
marketing
materials science &
electrical engineering
mathematics
mechanical engineering
microbiology
mineral economics
mining engineering
molecular & cellular biology
music education
musicology
music theory
nuclear engineering
nursing
nutritional sciences
optical sciences
Oriental studies
performance (music)
pharmaceutical sciences
pharmacology
pharmacy
philosophy
physics
physiology*
planetary sciences
planning
plant pathology
plant protection
political science
poultry science
psychology
public administration
range management
reading rehabilitation
reliability engineering
renewable natural resources studies
Romance languages
Russian
secondary education
sociology
soil & water science
Spanish
special education
speech & hearing sciences
statistics
systems engineering
toxicology
water resources administration
watershed management
wildlife and fisheries science

*Applicants are not admitted directly to this degree program. The degree is awarded only in rare instances when individuals admitted to Ph.D. programs are forced to terminate early.
MAJOR FIELDS FOR SPECIALIST DEGREES

Major work leading to a specialist degree is offered in the following fields:

- educational administration
- educational media
- educational psychology
- elementary education
- microbiology
- nursing
- reading
- secondary education
- special education

MAJOR FIELDS FOR DOCTORAL DEGREES

Major work and research leading to a doctoral degree are offered in the following fields. (Except as noted, the degree is the Doctor of Philosophy.)

- aerospace engineering
- agronomy & plant genetics
- anatomy
- animal physiology
- anthropology
- applied mathematics
- arid lands resource sciences
- astronomy
- atmospheric sciences
- biochemistry
- botany
- business administration
- chemical engineering
- chemistry
- civil engineering
- communication
- comparative literature & literary theory
- composition (music/A.Mus.D.)
- computer science
- conducting (music/A.Mus.D.)
- counseling & guidance**
- ecology & evolutionary biology
- economics
- educational administration*
- educational psychology*
- electrical engineering
- elementary education*
- engineering mechanics
- English
- English education
- entomology
- foundations of education*
- French
- general biology
- genetics
- geography
- geological engineering
- geosciences
- higher education*
- history
- horticulture
- hydrology
- irrigation engineering
- linguistics
- materials science & engineering
- mathematics
- mechanical engineering
- microbiology
- mineral economics
- mining engineering
- molecular & cellular biology
- music education (A.Mus.D.)
- music theory
- nuclear engineering
- nursing
- nutritional sciences
- optical sciences
- Oriental studies
- performance (music/A.Mus.D.)
- pharmaceutical sciences
- pharmacology and toxicology
- pharmacy
- philosophy
- physics
- physiology
- plant pathology
- political science
- psychology
- range management
- reading*
- rehabilitation*
- renewable natural resources studies
- secondary education*
- sociology
- soil & water science
- Spanish
- special education*
- speech & hearing sciences
- systems engineering
- water resources administration
- watershed management
- wildlife and fisheries science
- biology
- music education
- (A.Mus.D.)
- music theory
- nuclear engineering
- nursing
- nutritional sciences
- optical sciences
- Oriental studies
- performance
- (music/A.Mus.D.)
- pharmaceutical sciences
- pharmacology and toxicology
- pharmacy
- philosophy
- physics
- physiology
- plant pathology
- political science
- psychology
- range management
- reading*
- rehabilitation*
- renewable natural resources studies
- secondary education*
- sociology
- soil & water science
- Spanish
- special education*
- speech & hearing sciences
- systems engineering
- water resources administration
- watershed management
- wildlife and fisheries science

*Both Ph.D. and Ed.D. degrees are offered.
**At the time of catalog editing, the Doctor of Education and Doctor of Philosophy were under review. Consult the Graduate College for further information.
ADVANCED DEGREES OFFERED

Full descriptions of programs and requirements for each of the following degrees are found elsewhere in the *Graduate Catalog*.

<table>
<thead>
<tr>
<th>Degree</th>
<th>Degree</th>
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<tbody>
<tr>
<td>Master of Accounting (M.Ac.)</td>
<td>Master of Landscape Architecture (M.L.Arch.)</td>
</tr>
<tr>
<td>Master of Agricultural Education (M.Ag.Ed.)</td>
<td>Master of Library Science (M.L.S.)</td>
</tr>
<tr>
<td>Master of Architecture (M.Arch.)</td>
<td>Master of Music (M.M.)</td>
</tr>
<tr>
<td>Master of Arts (M.A.)</td>
<td>Master of Public Administration (M.P.A.)</td>
</tr>
<tr>
<td>Master of Business Administration (M.B.A.)</td>
<td>Master of Science (M.S.)</td>
</tr>
<tr>
<td>Master of Education (M.Ed.)</td>
<td>Master of Teaching (M.T.)</td>
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<tr>
<td>Master of Fine Arts (M.F.A.)</td>
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<tr>
<td>Master of Home Economics Education (M.H.E.Ed.)</td>
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</tr>
<tr>
<td>Educational Specialist (Ed.S.)</td>
<td>Nursing Specialist (N.S.)</td>
</tr>
<tr>
<td>Specialist in Microbiology (Sp.M.)</td>
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</tr>
<tr>
<td>Doctor of Philosophy (Ph.D.)</td>
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</tbody>
</table>

A number of departments offer work leading to more than one degree, and a great many specializations are available within the degrees listed. Details regarding degree programs and specializations are given in the informative text preceding the listings of course offerings for each department. While no specific graduate degree is required for junior college teaching, the normal minimum preparation includes a master's degree. For information on certification see "Certification for Community College Teaching" in the *College of Education* section, *General Catalog*. 
Requirements for Master's Degrees

GENERAL REQUIREMENTS

Master's degrees may be conferred for advanced work done by students who have received the bachelor's degree from this institution or one of similar standing. The master's degree implies advanced training gained through intensive study in a special field, supplemented, if advisable, by study in supporting subjects. The unit requirement varies somewhat among the various master's degrees, but all work must be completed within a six-year period. All master's degree programs must include a minimum of twelve units of work done on the University campus in Tucson. Except for a limited amount of transfer work from other approved institutions, the remaining credit requirements must be met by university-credit, graduate-level courses, including (a) on-campus courses, (b) courses offered away from the main campus, (c) approved thesis credit in absentia, and (d) a limited number of graduate-level television courses (5000 series). For restrictions on the applicability of transfer credit and television courses to degree programs, see General Regulations ("Other Courses for Graduate Credit"). With the prior approval of the head of the department, thesis work, where applicable, may be done in absentia under the direct supervision and guidance of a member of the faculty.

TIME LIMITATION — Graduate credit to be applicable with full value toward a master's degree shall have been earned not more than six years prior to the completion of the requirements for the degree. Graduate courses taken more than six years and not more than ten years prior to completion of degree requirements will be counted for half credit toward the degree. Work more than ten years old is not accepted toward meeting degree requirements.

MAJOR PROFESSOR — The head of the department in which the student's major work lies shall designate as the major professor (adviser) some member of the department and, where applicable, as the thesis director either this same person or some other member of the department. To be acceptable, the student's program of study and thesis (if required) must have the prior approval of the major professor and thesis director.

FOREIGN LANGUAGE OPTION — At the option of the head of the department in which the major work is done, a reading knowledge of German, French, Russian, Spanish, or other language, may be required to complete the requirements for the master's degree.

MASTER'S DEGREE STUDY PROGRAM — See the Graduate Calendar for deadline dates by which the Master's Degree Study Program must be submitted to the Graduate College. This notice, approved by the major advisor and the department head on forms provided by the Graduate College, shall set forth the student's program of study and other information required by the Graduate College. The program must conform to the requirements set forth in this catalog and those issued from time to time by the Graduate Council, including the general requirement that at least one half of the required units be offered in 500-level or above, university-credit courses, and that at least one half of the required units be offered in courses in which regular grades (A, B, C) have been earned. Approval of this notice by the Dean of the Graduate College will constitute approval of advancement to candidacy for a master's degree.

THESIS — A thesis is required in many master's programs. The appropriate departmental statement in this catalog will indicate thesis requirements for each degree. Where a thesis forms part of the program, a limited number of units may be earned for its preparation. Following the final examination, the candidate submits the thesis to the Graduate College for review a final copy of the completed thesis (approved and accepted by the major department), along with the Statement by Author and special abstract of 150 words or less. After making any required corrections, the candidate submits two complete and signed copies of the thesis to the Graduate College on or before the date specified in the Graduate Calendar for the candidate's desired degree award.
date. A third copy of the thesis may be required by the major department at its option. A manual of instructions relating to the form of the thesis may be obtained from the Associated Students' Bookstore. A thesis fee is paid to the University Cashier to cover the cost of processing.

**PUBLICATION OF THESIS** — Master's theses are published by University Microfilms, Ann Arbor, Michigan. Upon certification by the student's major professor, members of the committee for the final examination, and the Graduate College, a thesis copy and an abstract of 150 words or less are forwarded to University Microfilms. (This abstract is in addition to the two abstracts required for processing with the thesis and must be carefully prepared for microfilming according to specifications set forth in the Thesis Manual.) The manuscript is cataloged and microfilmed and the negative inspected and put in vault storage; the catalog information is sent to the Library of Congress for printing and distribution of cards for depository catalogs and libraries. The abstract is printed in *Microfilm Abstracts* and distributed to leading libraries in the United States and abroad, and to a selected list of journals and abstracting services. The copy is then returned to the University of Arizona Library.

Publication by microfilm does not preclude publication by other methods later, and successful candidates are urged to submit thesis material for publication in a scholarly or professional journal. Suitable acknowledgment must always indicate the publication to be a thesis, or portion of a thesis, submitted in partial fulfillment of the requirements for a master's degree at the University of Arizona.

**FINAL EXAMINATION** — A candidate for the master's degree must pass a final examination, oral or written or both, administered by a committee of at least three faculty members (including at least two from the major department) recommended by the major department for appointment by the Dean of the Graduate College. The result of the examination must be reported to the Graduate College within two weeks. Any candidate who fails the final examination may, upon recommendation of the major department and approval of the Graduate Council, be granted a second examination after a lapse of at least one semester. The second examination is final. The report of successful completion of all requirements must be made to the Graduate College at least 21 days before the date on which degrees are awarded.

**SECOND MASTER'S DEGREE** — Normally, students may earn only one master's degree at the University of Arizona. Occasionally, a student is permitted to enter a second master's degree program if the majors are sufficiently different to justify such an exception. No student will be permitted to undertake a third master's degree program at the University without the specific prior approval of the Graduate Council.

**MASTER OF ARTS AND MASTER OF SCIENCE**

A minimum of thirty units of graduate work, including the thesis where one is appropriate, is required. Not less than fifteen units must be in a major field. By prior approval of the Graduate Council, two or more closely allied subjects may be combined to form a major. Special departmental requirements, if any, are listed in departmental headnotes.

**MASTER OF ACCOUNTING**

The Master of Accounting degree program is a graduate professional program designed to provide advanced specialized training in accounting and related fields. Except as indicated below, the general regulations and requirements for the Master of Science degree apply. A score at the 60th percentile or above on the Graduate Management Admissions Test and an academic average of approximately "B" or better are required for admission consideration. Applicants must also have completed 6 hours of statistics and 24 hours of accounting including: accounting principles, 6 hours; intermediate accounting, 6 hours; cost accounting, 3 hours; federal income tax, 3 hours; advanced accounting, 3 hours; and auditing, 3 hours.

Of the 30 hours required for the Master of Accounting degree, no fewer than 15 must be in the field of accounting and at least 16 must be in course work open only to graduate students.
The required courses consist of a 15-hour core: Acct. 510, 526a, 526b, 528, 531, and 569. The balance of the 30 hours is to be completed with electives. Each candidate must pass a written comprehensive examination.

**MASTER OF AGRICULTURAL EDUCATION AND MASTER OF HOME ECONOMICS EDUCATION**

The general regulations and requirements for the Master of Arts and Master of Science degrees apply to these degrees, with the following exceptions. Candidates must have a bachelor's degree and a minimum of one year's successful classroom or extension teaching or similar education experience. Evidence of acceptability of the candidate's experience record shall be based upon at least two letters to either the Chairperson of the Division of Home Economics Education/Consumer Studies or the department head in Agricultural Education from persons who have had administrative authority over the candidate's professional work experience. These letters should attest the candidate's professional competence. A minimum of thirty-two units of course work is required. The major or field of study shall include a minimum of twenty units in home economics education, family and consumer resources and/or education; or, agriculture and agricultural education. All candidates shall complete a professional report of approved investigative work.

**MASTER OF ARCHITECTURE**

The College of Architecture offers a graduate program leading to the second professional degree, the Master of Architecture. The program is designed to accommodate graduates of accredited schools of architecture and is flexible in concept in order to meet the needs and interests of students who desire advanced, specialized training in architecture and related fields.

For admission consideration, applicants must have completed, with a grade average of B or better, an undergraduate program substantially equivalent to the Bachelor of Architecture program at the University of Arizona. Students without this background may be required to complete additional undergraduate course work. Applicants must submit to the College of Architecture the following: (1) a statement of purpose for entering the graduate program, (2) a proposed program of graduate studies indicating their special interests in the field, (3) a biographical summary including a record of professional work experience, (4) a portfolio of creative work including design projects, and (5) letters from three academic and/or professional references. Students are encouraged to accumulate one year of professional work experience prior to undertaking graduate study.

This program requires a minimum of 32 graduate units including at least sixteen units of architecture. The graduate study program will be planned by the student in consultation with a committee consisting of the major professor and three additional faculty members. This program must include Arch. 596a and a thesis or master's report. The thesis and the report each consist of three parts: research, written report, and graphic presentation. Candidates must pass a final oral examination over the thesis and related matters.

**MASTER OF BUSINESS ADMINISTRATION**

The M.B.A. degree program is designed to prepare women and men for leadership and administrative positions in a wide variety of organizations. It is intended for liberal arts, engineering, science and other nonbusiness majors, as well as for business majors. Previous business courses are not required. Undergraduate courses in finite mathematics and calculus are prerequisites and should be completed prior to entering the program. If the math deficiencies are not eliminated before beginning course work, students must enroll in M.I.S. 400 (a fast-paced finite math and calculus course) during the first semester.
Admission to the program is for the fall semester only. The full-time M.B.A. program is scheduled to cover four academic semesters. A four-year part-time evening program is also available.

All application materials should be sent directly to the Graduate Admissions Office in the College of Business and Public Administration. All applicants are required to submit scores for the Graduate Management Admissions Test (GMAT). (Entering students have had an average GMAT score above the 80th percentile and a four-year undergraduate grade-point average well over 3.0.) Applicants must also arrange for two letters of recommendation and two official copies of transcripts for each university and college attended. An educational/vocational resume and brief essays on several assigned topics are also required.

The M.B.A. curriculum emphasizes an integrative approach to problem solving. There are 24 units of comprehensive functional core courses, 15 units of integrative course work, and 18 units of specialization electives, for a total of 57 required units for the degree. Students with prior academic training equivalent to required core course work (with the exception of M.A.P. 500) may petition the program administrator for a waiver up to, but not exceeding, 15 units.

Full-time students completing the program in four academic semesters enroll in course work in the following sequence:


Third semester (Fall): Acct./Fin. 569 (3), Econ./M.A.P./Mktg. 568 (3), Specialization Electives (9). Total units 15.

Fourth semester (Spring): M.A.P. 571 (3); Specialization Electives (9). Total units 12.

Students may elect a specialization in auditing, managerial accounting, entrepreneurship, financial markets and investment analysis, financial institutions, health care management, human resources management, operations management, systems analysis and design, telecommunications, or marketing management, or may select courses and seminars from the approved list of general studies courses.

**MASTER OF EDUCATION**

This degree program is designed for students who are engaged or intend to engage in the profession of education. Majors are available within the College of Education and in other disciplines commonly taught in the public schools or community colleges (see approved majors below).

**Majors Within the College of Education:** bilingual/bicultural education, counseling and guidance, educational administration, educational media, educational psychology, elementary education, foundations of education, higher education, reading, secondary education, and special education.

**Other Approved Majors:** chemistry, communication, English, family and consumer resources, French, general biology, geography, German, health education, history, journalism, mathematics, Oriental studies, physics, political science, Russian, and Spanish. Students with any of these majors will have an adviser in the College of Education as well as in the appropriate major department. Other majors may be approved on an individual basis by the Graduate Council when specifically requested by the College of Education and the proposed major department. Applicants must meet the admission requirements of the College of Education as well as those of the proposed major department.

At the time this catalog was being edited, many programs in the College of Education were being redesigned. All current or prospective students should check with the Office of Student Services in the College of Education or the appropriate division for information on current admissions and degree requirements.
MASTER OF FINE ARTS

The Departments of Art, Drama, and English offer programs leading to the Master of Fine Arts degree with majors in art, drama, and creative writing respectively. Applicants must have completed appropriate undergraduate majors at this institution or one of similar standing. Deficiencies may be established if the applicant's undergraduate major differs significantly from the corresponding major at the University of Arizona. Theses are not required but the departments reserve the right to retain for departmental collections a selected work, or works, from those submitted in connection with students' work toward a degree. Final examinations are required. Applicants should contact the appropriate department and ask for instructions about submitting examples of creative work directly to the department in support of an application. Special features and requirements of the three programs are described below.

MAJOR IN ART — Applicants must submit slides of their studio work (or in the case of the photography program applicants, original photographs) directly to the Department of Art. All other application materials, including transcripts, are to be sent to the Graduate College. No application will be considered until slides or photographs, transcripts, and application forms have been received. The requirements are the same as those for the degree of Master of Arts with the following exceptions. The unit requirement for this program is sixty units, of which twelve must be in history of art and 48 in studio art courses. In lieu of a thesis, an original work, or group of such works, must be presented to the public. Review of this work will accompany the final oral examination. The exhibit may be accompanied by a written document, but the document itself will not be considered a thesis. As evidence of completion of this work, a folio of slides or photographs of the exhibition must be submitted to the Art Department graduate committee upon completion of the final examination. The candidate may be required to prepare a one-person exhibit of the work or to participate in a group exhibit during the last semester in residence.

MAJOR IN CREATIVE WRITING — The unit requirement for this program is 48 units. Required are six graduate literature courses in the English Department, including two literature seminars for writing students. The program also requires the writing of an original book-length work of fiction or poetry. The rest of the program may be in writing courses, in literature, or in courses of other departments related to the student's field of interest such as playwriting, film-writing, anthropology, history, or the literature of other languages. An examination on modern literature is given at the end of the student's work. There is no foreign language requirement.

MAJOR IN DRAMA — The unit requirement for this program is sixty units. Concentrations are available in acting-directing or in design-technical production. Applicants for the acting-directing option must submit a resume and at least three letters of recommendation and must arrange for an audition and interview. Applicants for design-technical production must submit renderings and slides or photographs of theatrical design or technical work directly to the department.

**Acting-Directing Option**: Program requirements are Dram. 430, 431 or 432, 475, 449, 451, 452, 455 or 456, 605, 606, 650, 655, six units of 497 and at least nine units of theatre history, dramatic theory, or criticism. In lieu of a thesis, each student must present a monograph on the performance of a major character including the creation of the character and a journal of rehearsal and performance, or present a monograph on the direction of a full-length play including pre-production study, analysis of the play, and record of production.

**Design-Technical Production Option**: Emphases are available in scenic design, lighting design, costume design, costume production, and technical production. Degree requirements are nine units of theatre history and/or dramatic theory and criticism and at least forty units of graduate level design, technical production and/or theatre workshop courses. In lieu of a thesis, an original design or production project must be accomplished during the University Theatre season. This will be accompanied by a written document including renderings, photographs, working drawings, and other information describing the produced creative design. This document will not be considered to be a thesis but must be presented to the advisory committee upon completion of the design project and the final oral examination.
MASTER OF LANDSCAPE ARCHITECTURE

This is a graduate professional degree program involving the investigation of new thoughts and applications which advance the art and science of landscape architecture. The program is designed to provide opportunities for individual research. Students with undergraduate preparation in design-related fields and others who have research interests in topics related to landscape architecture are encouraged to apply. Students with undergraduate preparation in other fields who plan to practice as professional landscape architects, however, should enroll in the Bachelor of Landscape Architecture program instead. For information concerning this degree see the General Catalog.

Applicants should send a two-page statement indicating their goals and their reasons for desiring graduate study in landscape architecture. They should also have three letters of recommendation sent. Both the statement and the letters should be addressed to the Graduate Admissions Committee, Program in Landscape Architecture, School of Renewable Natural Resources, University of Arizona.

The program requires completion of a minimum of thirty units of graduate credit. However, because the program is tailored to each student's goals and abilities, additional units may be required. Six to nine units may be earned for preparation of the required thesis. A more detailed description of this program is available from the Graduate Admissions Committee.

MASTER OF LIBRARY SCIENCE

The Graduate Library School offers a program leading to the Master of Library Science degree. This degree qualifies graduates for positions in libraries and information centers. See also the headnotes under Library Science elsewhere in this catalog. The Graduate Library School is accredited by the American Library Association.

For admission consideration, the applicant must have completed a bachelor's degree program with a well-balanced undergraduate curriculum and with a grade-point average of 3.00 or higher on a 4-point scale. Applicants must also submit scores not more than five years old on the Miller Analogies Test or the aptitude test of the Graduate Record Examination, a personal resume or statement of purpose, and two letters of recommendation to the Graduate Library School. A personal interview may be required. Applications and all supporting materials must be received by May 15 for fall admission, by November 1 for spring admission, and by March 1 for summer session admission.

The program requires completion of 38 graduate units including LIS. 502, 503, 504, 505, 506, 510, 582, and 507 or 581. Students who have completed courses similar to these at other institutions may have these courses waived as requirements. Written petition for waivers must be made to the Graduate Library School in the student's first semester in the program.

Additional graduate courses must then be substituted to bring the total number of earned graduate units up to 38. A foreign language requirement must be met by either (a) four semesters of college-level foreign language with grades of C or better (or submission of satisfactory scores on the Graduate School Foreign Language Test), or (b) two semesters of one foreign language with grades of C or better and, in addition, one of the following four options: (1) two semesters of a second foreign language with grades of C or better, (2) competence in a computer programming language (COBOL, FORTRAN, etc.), (3) competence in statistics, or (4) competence in manual communication. A final comprehensive examination is required. No thesis is required.

Holders of Arizona teaching certificates may acquire the school librarianship endorsement appropriate to their certificates by completing one of the following programs: elementary school — Li.S. 485, 502, 503, 505, and 581; secondary school — Li.S. 485, 502, 503, 505, and 581.

MASTER OF MUSIC

The School of Music offers programs leading to the Master of Music degree with majors in performance, composition, musicology, music education, and music theory. The programs are
designed for those students whose professional and artistic goals warrant study beyond the bachelor's degree and who show continued growth in the field of music they have chosen. Applicants must have completed appropriate undergraduate majors. Deficiencies may be established if the applicant's undergraduate major differs significantly from the corresponding major at the University of Arizona.

**MAJOR IN PERFORMANCE** — Applicants are admitted through a screening process that requires audition by personal interview or tape recording. Concentrations are offered in vocal performance, instrumental performance, conducting, and accompanying. The program requires a minimum of 30 graduate units and culminates in the performance of a public recital (two recitals for accompanists).

**MAJOR IN COMPOSITION** — Applicants submit a minimum of three reproduced manuscript scores (with tape recordings whenever possible) for evaluation by the composition faculty. If admitted, students must complete a minimum of 30 graduate units including 12 units in advanced composition studies. An original composition is required as a thesis. A public recital of original compositions is required to complete the degree.

**MAJOR IN MUSICOLOGY** — This major requires a minimum of 30 graduate units of which at least 12 must be in musicology. A thesis is required, as is a reading knowledge of French or German.

**MAJOR IN MUSIC EDUCATION** — Applicants for master's degree programs in music education must qualify for teacher certification prior to completion of the degree. Students may select a concentration in instrumental, choral, or general music or may participate in the design of a program suited to individual professional objectives. All programs require a minimum of 30 graduate units. No more than six units of credit in special workshops may be substituted for courses in music education. The degree culminates in a major project which demonstrates individual accomplishment of a creative, pedagogical, musical, or scholarly nature.

**MAJOR IN MUSIC THEORY** — This major requires a minimum of 30 graduate units of which at least 12 must be in music theory. A thesis is required.

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**MASTER OF PUBLIC ADMINISTRATION**

The M.P.A. degree program is designed to prepare men and women for positions of administrative leadership in public sector and nonprofit organizations, as well as in corporate organizations dealing with the public sector. Graduates may expect to pursue management careers in a wide variety of settings within organizations at local, state, national and international levels.

In addition to a basic management and public administration foundation core, the program consists of a chosen area concentration plus a chosen management skills concentration. Area concentrations are regularly offered in public management, health services administration, and long term care administration. With prior approval of the director, students may pursue special area concentrations where interests and available supporting courses warrant.

Management skills concentrations are offered in accounting, finance, human resources management, management information systems, marketing, operations management and research methods.

The program may normally be completed in four academic semesters. It consists of 54 graduate units, including 33 units of public management foundations (governmental and financial accounting, management information systems, microeconomics, public finance, organizational theory and behavior, management communication, statistics, fiscal and budgetary administration, and program evaluation methods), 12 units in the chosen area concentration and 6 units in the chosen management skills concentration. In addition, a 3 unit internship is required.

For admission consideration, applicants must submit a superior undergraduate record and an acceptable score on the Graduate Record Examination or the Graduate Management Admissions Test. Applicants must be competent in basic finite mathematics and calculus. For
those with mathematics deficiency, M.I.S. 400 must be completed before or during the first semester of graduate study.

A typical course of full-time study is as follows:

First semester: Acct. 550; Econ. 500, M.A.P. 552, 601; M.I.S. 400 (if necessary for mathematics deficiency).

Second semester: Acct. 551 or 572; Econ. 534; M.A.P. 502; M.I.S. 501.

Third semester: M.A.P. 500, 605; Area and skills concentration courses (9 units).

Fourth semester: M.A.P. 610, Area and skills concentration courses (9 units).

The Internship is usually completed in the summer between the first and the second years, though exceptions may be approved.

MASTER OF TEACHING

The graduate programs leading to the Master of Teaching degree are intended for persons currently engaged in teaching or in other appropriate programs of training and development. The two majors available are elementary education and secondary education. Since the programs in elementary and secondary education are being redesigned, all current or prospective students should check with the Office of Student Services in the College of Education or the Division of Teaching and Teacher Education for information on current admissions and degree requirements.
Requirements for Specialist Degrees

EDUCATIONAL SPECIALIST

Upon acceptance by the Graduate College, candidates for the degree of Educational Specialist are admitted by the faculty of the College of Education. The degree is granted to those who comply with the General Regulations set forth in this catalog and who satisfactorily complete the program requirements as specified by the divisions offering this degree.

ADMISSION — At the time this catalog was being edited, many programs at the specialist level were being redesigned. Please see the Office of Student Services in the College of Education or the appropriate division for information on admissions.

QUALIFYING EXAMINATION — To demonstrate acceptability to undertake work leading to candidacy for the degree, each applicant must pass a qualifying examination before or during the first term of work on an Educational Specialist program. An applicant's acceptability for work toward the degree will be judged on the basis of this examination.

TIME LIMITATIONS — Requirements for the Educational Specialist degree shall be completed within a period of six calendar years after satisfactory completion of the qualifying examination. Students who are able to demonstrate to the satisfaction of the qualifying examination committee that they have kept abreast of current developments in their areas of study may have prior course work taken for graduate credit while in a graduate degree program accepted at full value to the extent this course work is relevant to the Educational Specialist program being proposed. No more than six units taken as an unclassified graduate student, however, may be applied toward requirements for the Educational Specialist degree. If in the judgment of the examining committee, the applicant does not demonstrate possession of knowledge and concepts that prior course work would tend to suggest, relevant course work over six years old may be reduced to half credit on the proposed program of studies and such course work over ten years old may be rejected.

ADVISORY COMMITTEE — After successfully passing the qualifying examination, the student may request that the head of the major division appoint an advisory committee of three members from the division. With the concurrence of the head of another department or division, one of the committee members may be from that department or division. The chairperson of the committee will be the student's adviser. The duties of the committee are: (1) to evaluate the student's proposed program of study, (2) to make recommendations regarding the program to the Dean of the Graduate College through the appropriate division head and the Office of Student Services in Education, and (3) to be available to the student for advice as needed.

PROGRAM OF STUDY — A program of study, recommended by the division head and approved by the Office of Student Services in Education, shall be submitted promptly for the approval of the Graduate Council following successful completion of the qualifying examination. It is to be designed, in cooperation with the Advisory Council, to meet the needs of the individual student as determined by previous academic work, experience, interests, and career objectives. Please see the Office of Student Services in the College of Education or the appropriate division for information on program requirements.

FINAL EXAMINATION — When the student has completed all course work or is in the final semester of course work and has met the required standards of scholarship, he or she shall pass a comprehensive written examination covering the graduate work. An oral examination may also be required.
PROFESSIONAL EXPERIENCE — Except for school psychology, candidates are required to furnish evidence of a minimum of two years of successful teaching or administrative experience as approved by the division concerned, before the degree will be awarded.

NURSING SPECIALIST

The Nursing Specialist degree provides education and experience in a particular subspecialty area of nursing beyond the level normally attained in a master's program. Emphasis is placed upon the preparation of the practitioner. The program is an intensive one, requiring full-time attention to courses and associated seminars and practicums. Please contact the College of Nursing for current offerings.

ADMISSION — Applicants are required to submit: (1) a current license to practice as a registered nurse in one of the fifty states, (2) references attesting to professional competence, (3) evidence of satisfactory completion of a first course in statistics, (4) scores on the Aptitude Test of the Graduate Record Examination, (5) a statement indicating academic and professional goals as well as research interests, and (6) evidence of completion of a bachelor's or master's degree program substantially equivalent to the same degree program at the University of Arizona. Students without the master's degree will enter the combined Master of Science and Nursing Specialist program, but confirmation of admission to the Nursing Specialist program will be made only after a minimum of one semester of clinical work in the master's program at this institution.

PROGRAM — The program provides education and experience in a particular subspecialty area of nursing beyond the level normally attained in a master's degree program. The program is intensive and requires full-time attention to courses and associated seminars and practicums. Programs of study are individually planned in consultation with an adviser after consideration of previous academic work and experience, personal interests, and professional objectives. Two options are available: (1) An applicant with a bachelor's degree in nursing may enroll for the combined M.S. and N.S. degree programs by declaring the intent to prepare in a subspecialty area. A minimum of 60 units must be completed, including 36 from the courses required for the clinical concentration leading to the M.S. degree plus an additional 24 units of course work. This option generally requires two semesters beyond the time required for completion of the master's degree (see the headnotes under Nursing elsewhere in this catalog). The thesis will be directed toward some aspect of nursing care in the selected subspecialty area. (2) An applicant who has completed the master's degree in nursing at an institution accredited by the National League for Nursing may receive the Nursing Specialist degree by completing a minimum of 28 units.

QUALIFYING EXAMINATION — To demonstrate acceptability to undertake work leading to candidacy for the specialist degree, individuals who are taking the entire program at the University of Arizona (including the master's) will be evaluated as to their suitability on the basis of the first semester's work toward the Master of Science degree. Applicants with a master's degree in nursing from another school will be asked to demonstrate acceptability during their first term in residence, either through an examination or careful evaluation of their performance in course work.

Prior graduate credit completed in a master's program elsewhere and essentially equivalent to the master's program offered at the University of Arizona may be accepted in transfer if it is relevant to the specialist degree program at this institution and if the student has kept abreast of current developments in the field. Graduate credit to be applicable with full value toward the specialist degree shall have been earned not more than six years prior to the completion of the requirements for the degree. Graduate courses taken more than six years and not more than ten years prior to completion of degree requirements will be counted for half credit toward the degree. Work more than ten years old is not accepted toward meeting degree requirements.

A research paper and a final comprehensive examination are required for the Nursing Specialist degree.
SPECIALIST IN MICROBIOLOGY

This program is a two-calendar-year curriculum designed for students who wish to prepare for careers as supervisors in clinical or public-health laboratories, teachers in allied health programs of community colleges or other institutions, or service in environmental health departments of various governmental agencies.

Admission requirements include: (1) a bachelor's degree in microbiology or a related field; (2) sixteen units of undergraduate-level microbiology, including courses equivalent to University of Arizona courses in microbiology, general mycology, introductory immunology, and pathogenic microbiology; (3) chemistry (general chemistry and qualitative analysis—one year, organic chemistry—one year lecture and laboratory, quantitative analysis—one semester; a beginning course in biochemistry is highly recommended); (4) mathematics (a minimum of eight semester hours, including college-level algebra and trigonometry); (5) physics (one year for which trigonometry is prerequisite); (6) biology (one year of general biology or equivalent courses in botany and zoology); (7) registration with either the National Registry of Microbiologists as a microbiologist or the A.S.C.P. as a medical technologist.

Applicants must also submit scores of the Aptitude Test of the Graduate Record Examination and three recommendations on forms available from the Department of Microbiology and Immunology. Students lacking some of the units or required courses (see one through six above) will be expected to make up the deficiencies either by registering for the courses without receiving graduate credit or by examination.

To receive the Specialist in Microbiology degree, a student must demonstrate a breadth of knowledge in the field by exhibiting proficiency in several areas. These areas include: microbiology, biochemistry, computer programming, management, and education. Each student, with the assistance and direction of an advisory committee appointed by the department head, will plan an appropriate program of study with a minimum of sixty units of required and elective course work. These requirements may be satisfied by (1) obtaining a grade of B or better in an appropriate course at the University of Arizona, (2) executing successfully a comprehensive examination in an area at the 75-percent level, or (3) demonstrating an adequate (B level) performance in a course of similar content as either an undergraduate or graduate student at another institution. In the last case, such course work may be evaluated by examination or accepted at face value at the discretion of the department.

This is a terminal degree program, and no thesis is submitted. A research paper and a final comprehensive oral examination, however, are required.

Students interested in pursuing a program leading to the Doctor of Philosophy degree with a major in microbiology should follow the curriculum outline under the Master of Science degree program in microbiology described elsewhere in this catalog.
Requirements for Doctor's Degrees

DOCTOR OF PHILOSOPHY

Departments which possess special advantages for original investigation accept prospective candidates for the degree of Doctor of Philosophy. This degree requires distinguished attainment in a recognized field of learning demonstrated in a dissertation which contributes to the general fund of knowledge. It is not granted merely as a certificate of faithful performance of a prescribed program of studies and research.

RESIDENCE AND CREDIT REQUIREMENTS — The equivalent of at least six semesters of essentially full-time graduate study is required. Graduate credit earned at other approved institutions, if accepted by the major department and the Graduate Council, may be counted toward the requirements for this degree.

To meet the minimum residence requirement, the student must spend two regular semesters of essentially full-time academic work in the major field in actual residence at the University of Arizona, and at least thirty units of graduate credit must be completed at this institution. Any semester during which a student is registered for at least nine units of graduate course work or research will be counted toward meeting the residence requirement, provided that the student's full time is devoted to his or her graduate work. (See next paragraph for the only exceptions to this general requirement.)

Graduate assistants or graduate associates can discharge the minimum residence requirement in two semesters during each of which they register for nine units or more of work for graduate credit, provided their full time is devoted to their graduate work and assistantship or associateship responsibilities. Students on appointment to any teaching or research position at the University can discharge the minimum residence requirements by four semesters during each of which they register for six or more units of work for graduate credit, provided their full time is devoted to their graduate work and meeting the responsibilities of their appointments.

The dissertation requires the equivalent of at least two semesters of full-time work. Registration for eighteen units of dissertation credit (920) is required during the conduct of the dissertation, with a maximum of nine units during any regular semester. With the prior approval of the student's dissertation committee and the head of the department, dissertation work may be done in absentia.

All requirements for the degree, including work done for the master's degree (if applicable), must be met within a period of ten years.

MAJOR AND MINOR SUBJECTS — The student shall choose a major subject and either one or two supporting minor subjects. Although the minor subject or subjects will usually be taken outside the major department, minors within the major department may be permitted with the approval of the department and the Graduate College. At least 36 units of work exclusive of the dissertation must be in the area of the major subject.

QUALIFYING EXAMINATION — For the purpose of demonstrating acceptability to undertake work leading to candidacy for the doctorate, each prospective candidate must pass a qualifying examination in the proposed major field. The examination is waived at the discretion of the department in a field in which the candidate has done major work toward a completed master's degree at the University of Arizona. The examination should be taken during the first semester of residence and preferably during the first two weeks of residence. Many departments also require a qualifying examination in the minor field, but this may be waived at the option of the minor department.

PROGRAM OF STUDY — A proposed program of study recommended by the department or departments concerned should be submitted for approval by the Graduate Council on a form
provided by the Graduate College prior to the completion of half of the nondissertation units proposed. The program must conform to the requirements set forth in this catalog and those issued from time to time by the Graduate Council, including the general requirement that at least one half of the required units be offered in 500-level or above, university-credit courses, and that at least one half of the required units be offered in university graduate credit courses in which regular grades (A,B,C) have been earned.

FOREIGN LANGUAGE REQUIREMENT — Many departments have foreign language requirements for the Ph.D. degree. Doctoral students should ascertain from the department what the foreign language requirements are, if any, and how they may be satisfied.

PRELIMINARY EXAMINATION — Before admission to candidacy for the degree, the student must pass a general examination in the chosen fields of study. This examination is intended to test the student's general fundamental knowledge of the fields of the major and minor subjects of study. It shall include written portions covering the major and minor fields and, no later than six months after successful completion of the first of these portions, an oral portion which shall be conducted before a committee of the faculty appointed by the Dean of the Graduate College upon consultation with the major and minor departments. The preliminary examination will be held when essentially all course work has been completed and in any case not later than three months prior to the date of the final oral examination. No student will be permitted a second attempt to pass the preliminary examination except upon recommendation of the examining committee, endorsed by the major department and approved by the Graduate Council. The only visitors permitted at this examination are regular University faculty members.

ADVANCEMENT TO CANDIDACY — After satisfying any language requirements, passing the preliminary examination, and showing evidence of ability to do original research, the student will be recommended to the Graduate Council for acceptance as a candidate for the doctorate. These requirements must be met no later than three months prior to the date of the final oral examination.

DISSERTATION — No later than three weeks prior to the proposed date of the final examination, the completed Final Oral Examination Request Form is filed with the Graduate College. No later than three working days before the examination, a copy of the penultimate draft of the dissertation is delivered by the candidate to the Graduate College representative appointed to the examining committee. Following the examination, the Graduate College representative returns the Notice of Completion of Final Examination and Dissertation Requirements to the Degree Check Office. The candidate submits to the Graduate College for review a final copy of the completed dissertation (approved and accepted by the major department and all members of the examining committee), along with the approval pages and special abstract. After making any required corrections, the candidate submits two complete and signed copies of the dissertation to the Graduate College for delivery to the University Library. A processing fee must be paid to the University Cashier. The College of Education requires two additional copies of the dissertation, one for the College of Education files and one for the dissertation director. In other colleges, the major department, at its option, may require an additional copy for the departmental files. A manual of instructions relating to the form of the dissertation may be obtained from the Associated Students' Bookstore.

PUBLICATION OF DISSERTATION — Ph.D. dissertations are published by University Microfilms, Ann Arbor, Michigan, and a fee of $25 is charged to cover this expense. Upon certification by the student's major professor, members of the committee for the final examination, and the Graduate College, a dissertation copy, and an abstract of 350 words or less, are forwarded to University Microfilms. (This abstract is in addition to the two abstracts required for inclusion in the dissertation and must be carefully prepared for microfilming according to specifications set forth in the Dissertation Manual.) The manuscript is cataloged and microfilmed and the negative inspected and put in vault storage; the catalog information is sent to the Library of Congress for printing and distribution of cards for depository catalogs and libraries. The abstract is printed in Microfilm Abstracts and distributed to leading libraries in the United States and abroad, and to a selected list of journals and abstracting services. The copy is then returned to the University of Arizona Library.
Publication by microfilm does not preclude publication by other methods later, and successful candidates are urged to submit dissertation material for publication in a scholarly or professional journal. Suitable acknowledgment must always indicate the publication to be a dissertation, or portion of a dissertation, submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the University of Arizona.

**FINAL EXAMINATION** — When the required standards of scholarship have been met and research ability has been demonstrated, the candidate shall submit to an oral examination in defense of the dissertation, as well as any general questioning which may develop therefrom related to the field of study. The exact time and place of this examination shall be scheduled with the Graduate College at least three weeks in advance and announced publicly at least one week in advance. The examination shall be open to the public. The committee shall be appointed by the Dean of the Graduate College in consultation with the major and minor departments.

**OTHER EXAMINATIONS** — Prior to the final examination and in addition to the preliminary examination and the regularly scheduled course examinations, the candidate may be required to take any other examinations, oral or written, deemed proper by the departments concerned.

**DOCTOR OF EDUCATION**

Through the Graduate College, the faculty of the College of Education accepts prospective candidates for the degree of Doctor of Education. The degree is granted only to those who demonstrate a high proficiency in education and who present an approved dissertation. (For the requirements for the degree of Doctor of Philosophy, see above.)

At the time this catalog was being edited, many Doctor of Education programs were being redesigned. Please see the Office of Student Services in the College of Education or the appropriate division for information on admissions and program requirements.

**RESIDENCE AND CREDIT REQUIREMENTS** — The equivalent of at least six semesters of essentially full-time graduate study, including work toward a master's degree, is required. Graduate credit earned at other approved institutions, if accepted by the College of Education and the Graduate Council, may be counted toward the requirements for this degree.

To meet the minimum residence requirements, the student must spend at least two regular semesters of essentially full-time academic work in the program, beyond the master's degree, in actual residence at the University of Arizona, and at least 36 units of graduate credit must be completed at this institution. Any semester during which a student is registered for at least nine units of graduate course work or research will be counted toward meeting the minimum residence requirement, provided that the student's full time is devoted to graduate work. (See next paragraph for the only exceptions to this general requirement.)

Graduate assistants or graduate associates (half time or less) can discharge the residence requirement in two semesters during each of which they register for nine units or more of work for graduate credit, provided their full time is devoted to their graduate work and assistantship or associateship responsibilities. Students on appointment to any teaching or research position at the University can discharge the residence requirement by four semesters during each of which they complete six or more units of work for graduate credit, provided their full time is devoted to their graduate work and meeting the responsibilities of their appointments.

The dissertation is understood to require the equivalent of at least two semesters of full-time work. Registration for eighteen units of dissertation credit (920) is required during the conduct of the dissertation, with a maximum of nine units during any regular semester. If the dissertation is to be written in absentia, prior arrangements must be made through the head of the appropriate division, and must have the favorable recommendation of the Dean of the College of Education.

Requirements for the Doctor of Education degree must be completed within a period of six calendar years after the qualifying examination.

**MAJOR AND MINOR SUBJECTS** — The student will major in counseling and guidance, educational administration, educational psychology, elementary education, foundations of education,
REQUIREMENTS FOR DOCTOR'S DEGREES

higher education, reading, rehabilitation, secondary education, or special education. The student may minor either inside or outside of the College of Education as approved by the advisers and department heads concerned, by the Office of Student Services in the College of Education, and by the Graduate Council.

QUALIFYING EXAMINATION — To demonstrate acceptability to undertake work leading to candidacy for the doctorate, each applicant must pass a qualifying examination in the major field and in the proposed minor field. This examination must be taken in the first term of work beyond the master's degree during which the student is in residence at the University of Arizona. The applicant's acceptability for doctoral work will be judged on the basis of this examination. A qualifying examination in the minor field may be waived at the option of the department concerned.

PRELIMINARY EXAMINATION — Before admission to candidacy for the degree, the student must pass a general examination in the chosen fields of study. This examination is intended to test the student's general fundamental knowledge of the fields of the major and minor subjects of study. It shall include written portions covering the major and minor fields and, not later than six months after successful completion of the first of these portions, an oral portion which shall be conducted before a committee of the faculty appointed by the Graduate College upon consultation with the major and minor departments. The preliminary examination will be held when essentially all course work has been completed and in any case not later than three months prior to the date of the final oral examination. No student will be permitted a second attempt to pass the preliminary examination except upon recommendation of the examining committee, endorsed by the major division and approved by the Graduate Council. The only visitors permitted at this examination are regular University faculty members. There are four examination periods, one in each semester of course work.

ADVANCEMENT TO CANDIDACY — After passing the preliminary examination and giving evidence of ability to carry on professional studies at the highest level, the student will be recommended to the Graduate Council for acceptance as a candidate for the doctorate. These requirements must be met not later than three months prior to the final oral examination.

DISSERTATION — No later than three weeks prior to the proposed date of the final examination, the completed Final Oral Examination Request Form is filed with the Graduate College. No later than three working days before the examination, a copy of the penultimate draft of the dissertation is delivered by the candidate to the Graduate College representative appointed to the examining committee. Following the examination, the Graduate College representative returns the Notice of Completion of Final Examination and Dissertation Requirements to the Degree Check Office. The candidate submits to the Graduate College for review a final copy of the completed dissertation (approved and accepted by the major division and all members of the examining committee), along with the approval pages and special abstract. After making any required corrections, the candidate submits two complete and signed copies of the dissertation to the Graduate College for delivery to the University Library. A processing fee must be paid to the University Cashier. The College of Education requires two additional copies of the dissertation, one for the College of Education files and one for the dissertation director. A manual of instructions relating to the form of the dissertation may be obtained from the Associated Students’ Bookstore.

PUBLICATION OF DISSERTATION — Dissertations are published by University Microfilms, Ann Arbor, Michigan, and a fee is charged to cover this expense. Upon certification by the student's major professor, members of the committee for the final examination, and the Graduate College, a copy and an abstract of no more than 350 words are forwarded to University Microfilms. (This abstract is in addition to the two abstracts required for inclusion in the dissertation and must be carefully prepared for microfilming according to specifications set forth in the Dissertation Manual.) The manuscript is microfilmed and the negative inspected and put in vault storage. The manuscript is cataloged and the catalog information sent to the Library of Congress for printing and distribution of cards to depository catalogs and libraries. The abstract is included in the forthcoming issue of Microfilm Abstracts, which is distributed to leading libraries here and abroad, and to a selected list of journals and abstracting services. The first copy is then returned to the University of Arizona Library.
Publication by microfilm does not preclude publication by other methods later, and successful candidates are urged to submit dissertation material for publication in a scholarly or professional journal. Suitable acknowledgment must always indicate the publication to be a dissertation or portion of a dissertation, submitted in partial fulfillment of the requirements for the degree of Doctor of Education at the University of Arizona.

**FINAL EXAMINATION** — When the required standards of scholarship have been met and research ability has been demonstrated, the candidate shall submit to an oral examination in defense of the dissertation, as well as to any general questioning related to his or her field of study which may develop therefrom. The exact time and place of this examination shall be scheduled with the Graduate College at least three weeks in advance and announced publicly at least one week in advance. The examination shall be open to the public. The committee shall be appointed by the Dean of the Graduate College in consultation with the major and minor divisions and/or departments.

**DOCTOR OF MUSICAL ARTS**

The School of Music of the Graduate College accepts prospective candidates for the degree of Doctor of Musical Arts. The degree is granted in the fields of music education, composition, conducting, and performance. It is not granted merely as a certificate of faithful performance of a prescribed program of studies but requires demonstration of distinguished attainment. Information about the Doctor of Philosophy degree with a major in music theory will be found under “Music” in this catalog.

Preliminary admission to the program is recommended by appropriate School of Music faculty members and the Director of Graduate Studies in Music. Before a recommendation can be made, the applicant must file an application for admission to the Graduate College and must forward transcripts of all previous college work to the Dean of the Graduate College. Performers and conductors must submit a tape recording and/or have a personal audition with the area faculty concerned. Applicants for a major in composition must submit scores and tapes of their own works in performance.

**RESIDENCE AND CREDIT REQUIREMENTS** — The equivalent of at least six semesters of essentially full-time graduate study is required. Graduate credit earned at other approved institutions, if accepted by the School of Music and the Graduate Council, may be counted toward the requirements for this degree.

To meet the minimum residence requirement, the student must spend two regular semesters of essentially full-time academic work in the Doctor of Musical Arts program in actual residence at the University of Arizona, and at least 30 units of graduate credit must be completed at this institution. Any semester during which a student is registered for at least 9 units of graduate course work or research will be counted toward meeting the residence requirement, provided that the student's full time is devoted to graduate work. (See next paragraph for the only exceptions to this general requirement.)

Graduate assistants or graduate associates (half-time or less) can discharge the minimum residence requirement in two semesters during each of which they register for 9 units or more of work for graduate credit, provided their full time is devoted to their graduate work and assistantship or associateship responsibilities. Students on appointment to any teaching or research position at the University can discharge the minimum residence requirement by four semesters during each of which they register for 6 or more units of work for graduate credit, provided their full time is devoted to their graduate work and meeting the responsibilities of their appointments.

The dissertation requires the equivalent of at least two semesters of full-time work. Registration for 18 units of dissertation (920) or recital (925) credit is required during the conduct of the dissertation or preparation for the recitals. A maximum of nine units of dissertation or recital credit may be elected in any regular semester. If the dissertation is to be written in absentia, prior arrangements must be made through the head of the appropriate academic department, and must have the favorable recommendation of the School of Music.

All requirements for the Doctor of Musical Arts degree must be completed within a period of six calendar years from the date the qualifying examination is passed.
MAJOR AND MINOR SUBJECTS — The student will major in conducting, composition, music education, or performance, and choose a minor subject in another area of music or in a department other than music if approved in the candidate's program of study.

QUALIFYING EXAMINATION — For the purpose of demonstrating acceptability to undertake work leading to candidacy for the Doctor of Musical Arts degree, each applicant must pass a qualifying examination in the proposed major and minor fields and in other related areas. The minor examination may be waived at the option of the department concerned.

In order to make the most effective use of the results of the examination in establishing the student's course of study, these examinations should be taken during the first semester in residence. In addition, a personal interview, a review of the applicant's college record and musical achievement, and evidence of an ability to write in a clear and precise manner are required.

ADVISORY COMMITTEE — The Director of the School of Music, upon the recommendation of the School of Music Graduate Committee, will appoint an advisory committee representing the major and minor fields of study for each candidate. The chairperson will be the student's major professor.

PROGRAM OF STUDY — A proposed program of study recommended by the department or departments concerned should be submitted for approval by the Graduate Council on a form provided by the Graduate College prior to the completion of half of the nondissertation units proposed. The program must conform to the requirements set forth in this catalog and those issued from time to time by the Graduate Council, including the general requirement that at least one half of the required units be offered in 500-level or above, university-credit courses, and that at least one half of the required units be offered in university graduate credit courses in which regular grades (A,B,C) have been earned.

FOREIGN LANGUAGE REQUIREMENT — A reading knowledge of a foreign language will be required when, in the judgment of the student's advisory committee, such knowledge is necessary for the successful completion of the dissertation.

PRELIMINARY EXAMINATION — Before admission to candidacy for the degree, the student must pass a general examination in the chosen fields of study. This examination is intended to test the student's general fundamental knowledge of the fields of the major and minor subjects of study. It shall include written portions covering the major and minor fields and, no later than six months after successful completion of the first of these portions, an oral portion which shall be conducted before a committee of the faculty appointed by the Dean of the Graduate College upon consultation with the major and minor departments. The preliminary examination will be held when essentially all course work has been completed and in any case not later than three months prior to the date of the final oral examination. No student will be permitted a second attempt to pass the preliminary examination except upon recommendation of the examining committee, endorsed by the major department and approved by the Graduate Council. The only visitors permitted at this examination are regular University faculty members.

ADVANCEMENT TO CANDIDACY — After passing the written and oral portions of the preliminary examination and giving evidence of ability to carry on professional studies at the highest level, the student will be recommended to the Graduate Council for acceptance as a candidate for the degree of Doctor of Musical Arts. These requirements must be met no later than three months prior to the final oral examination.

DISSERTATION — No later than three weeks prior to the proposed date of the final examination, the completed Final Oral Examination Request Form is filed with the Graduate College. No later than three working days before the examination, a copy of the penultimate draft of the dissertation is delivered by the candidate to the Graduate College representative appointed to the examining committee. Following the examination, the Graduate College representative returns the Notice of Completion of Final Examination and Dissertation Requirements to the Degree Check Office. The candidate submits to the Graduate College for review a final copy of the completed dissertation (approved and accepted by the major department and all members of the examining committee), along with the approval pages and special abstract. After making any required corrections, the candidate submits two complete and signed copies of the dissertation.
to the Graduate College for delivery to the University Library. A processing fee must be paid to the University Cashier. The School of Music, at its option, may require an additional copy of the dissertation for its files. A manual of instructions relating to the form of the dissertation may be obtained from the Associated Students' Bookstore.

**PUBLICATION OF DISSERTATION** — Dissertations are published by University Microfilms, Ann Arbor, Michigan, and a fee of $25 is charged to cover this expense. Upon certification by the student's major professor, members of the committee for the final examination, and the Dean of the Graduate College, one copy and an abstract of 350 words or less are forwarded to University Microfilms. (This abstract is in addition to the two abstracts required for inclusion in the dissertation and must be carefully prepared for microfilming according to specifications set forth in the Dissertation Manual.) The manuscript is microfilmed, and the negative is inspected and put in vault storage. The manuscript is cataloged and this information is sent to the Library of Congress for printing and distribution of cards to depository catalogs and libraries. The abstract is included in Microfilm Abstracts, which is distributed to leading libraries here and abroad, and to a selected list of journals and abstracting services. The copy is then returned to The University of Arizona Library.

Publication by microfilm does not preclude publication by other methods later, and successful candidates are urged to submit dissertation material for publication through appropriate media. Suitable acknowledgment must always indicate the publication to be a dissertation or portion of a dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Musical Arts at the University of Arizona.

**FINAL EXAMINATION** — When the required standards of scholarship have been met and research ability has been demonstrated, the candidate shall submit to an oral examination in defense of the dissertation, as well as to any general questioning which may develop therefrom, related to the field of study. The exact time and place of this examination shall be scheduled with the Graduate College at least three weeks in advance and announced publicly at least one week in advance. The examination shall be open to the public. The committee shall be appointed by the Dean of the Graduate College in consultation with the major and minor departments.

**SPECIFIC REQUIREMENTS FOR THE MAJOR IN COMPOSITION** — Approval of a major in composition will be based upon evidence of creative talent and a knowledge of craftsmanship in writing music.

The student majoring in composition will, in lieu of a dissertation, write a large-scale composition scored for full or chamber orchestra (with or without soloists), for symphonic band or for voice (or chorus) and orchestra. An abstract including the formal, stylistic, and technical elements of the composition must accompany the work.

In addition to the composition of an extended work, a recital consisting of the candidate's compositions in several forms and a variety of media must be presented.

**SPECIFIC REQUIREMENTS FOR THE MAJOR IN MUSIC EDUCATION** — Applicants for the Doctor of Musical Arts degree in music education will be required to furnish evidence of at least three years of successful teaching or administrative experience in the field of music either in the public schools or at the college level.

The candidate will write in the field of specialization a dissertation which will be a scholarly contribution to the field of musical and educational knowledge.

**SPECIFIC REQUIREMENTS FOR THE MAJOR IN PERFORMANCE** — In lieu of a dissertation, the candidate must present the following four recitals: (1) a qualifying recital during the first semester in residence (this recital must include a major work assigned by the instructor of applied music and prepared independently by the student within a period of 30 days), (2) a program of vocal and/or instrumental chamber music, (3) a solo recital, and (4) a lecture-recital (must follow a successful preliminary examination).

The four recitals must include representative literature from all major periods. Each recital will be evaluated independently by the School of Music Graduate Committee and the area faculty concerned. Should the candidate's performance be judged unsatisfactory, an additional recital composed of different literature must be performed. In no case will a candidate be permitted to remain in the program should more than one recital be determined unsatisfactory.
The candidate will prepare and submit a formal document for the lecture-recital. This document, based on some aspect of performance or performance practices, must show evidence of the candidate's ability to select and organize data pertinent to the study. Ideally, it should be an original contribution to the field of knowledge in the candidate's chosen subject area.

SPECIFIC REQUIREMENTS FOR THE MAJOR IN CONDUCTING — In lieu of a dissertation the candidate must prepare and present a minimum of four recitals. The first of these, early in the candidate's residence, will serve as a qualifying recital. Candidates will demonstrate a competency in the secondary area in one or more of the recitals. A lecture-recital will be prepared and given after passing the preliminary written and oral examinations.
Departments and Courses of Instruction

COURSE LISTING INFORMATION

Course Offerings

CURRICULAR CHANGE — Course listings in the following departmental sections are subject to change. Curriculum changes approved during the first year of the catalog's biennium are listed in the Supplement to the University of Arizona Catalog, published approximately one year after publication of the biennial catalog. A copy of this publication is available upon request from the University Curriculum Office, Administration Building, Room 412a.

CLASS SCHEDULES — Because the catalog designation of semesters of offering is subject to change, students should consult the Schedule of Classes for curricular planning of a particular term. Schedules for fall and spring classes are available at the Information Desk of Registrar Data Processing, Administration Building, Room 210, in April and October, respectively. The Summer Session Schedule of Classes is available in January at the Administration Building, Room 210. For a complete statement of the student's responsibility in maintaining acquaintance with current university requirements, see the copyright page of this catalog.

PREREQUISITES — A student registering for a course must meet the prerequisites or otherwise satisfy the instructor of his or her preparation to take the course. Prerequisites can be waived only at the discretion of the instructor or department involved.

CANCELLATION OF COURSES — The University reserves the right to cancel courses not elected by an adequate number of students.

Course Numbering System

CLASSIFICATION OF COURSES — The number by which a course is designated indicates the level of the course. Graduate credit courses are listed by level as follows (for undergraduate course listings, see the General Catalog):

400-499: Advanced-level courses. Acceptable for graduate credit with the prior approval of the Graduate College, except 400-level individual studies courses (491, 493, 494 or 499, with or without subscripts).

500-599 inclusive: Graduate courses. Open to exceptionally well-qualified seniors with the prior written approval of the course instructor and the Graduate College.

600-699 inclusive: Graduate courses. Not open to undergraduate students.

700-799 inclusive: Graduate courses limited to doctoral students.

800-899 inclusive: Courses limited to students working toward degrees offered by the College of Medicine or the College of Pharmacy. Not available for credit toward other degrees.


SEMESTER COURSES (SINGLE NUMBERS) — A course designated by a single number (as Econ. 460) is one semester in length.
COURSE DESCRIPTION EXPLANATION

YEAR COURSES (DOUBLE NUMBERS) — A course designated by a double number (as Pol. 610a-610b) is continued through two successive semesters, the work of the first semester being prerequisite to that of the second unless otherwise indicated in the statement of prerequisites. Credit is awarded for the first half of the course except in a few instances when credit in the first half is contingent upon completion of the second half.

The standard course description includes a variety of symbols indicative of essential information. The following is a standard course description with the individual symbols explained in the order in which they appear in that description.

SAMPLE COURSE LISTING:

406. Social Structure in Modern Societies (3) [Rpt.] GC I 1988-89 GRD Critical review of modern theory and research on social structure and social organization in modern societies. 2R, 3L. P 6 units of sociology or CR. (Identical with Hist. 406) Smith

406. — Course number.
Social Structure in Modern Societies — Course title.
(3) — Number of units.
[Rpt.] — Only courses marked [Rpt.] may be repeated for credit. A restriction regarding the number of times a course may be repeated for credit (beyond the student’s first enrollment) or the total number of units of credit permitted for a course may be designated. [Rpt./2] indicates that the course may be repeated for credit twice, for a maximum of three enrollments in the course; [Rpt./6 units] means that the course may be repeated until the student has received a total of 6 units of credit. It is the student’s responsibility to ensure that course content is not duplicated.
GC — Graduate credit available. (Used as an identifier for 400-level courses only.)
I — Semester offered. I indicates fall semester; II, spring; S, summer.
1988-89 — Year in which course is offered. If no year designation is given, the course is offered each year.
GRD/CDT — GRD and CDT indicate that the course is available by examination. GRD indicates that the course is available by examination for a grade and credit, and CDT indicates that the course is available by examination for credit only. These options are not available for graduate credit.
Critical review...societies. — Course description.
2R, 3L — Class structure. R, L, and S indicate “recitation,” “laboratory,” and “studio.” 2R, 3L indicates that the class meets two hours of recitation and three hours of laboratory per week (based upon 15 weeks). For courses consisting of lecture and recitation periods only, the number of class hours per week is the same as the unit value and is not specified in the course description.
P — Prerequisites. Identifies courses or other experiences which must be completed prior to enrolling in the course listed.
CR — Concurrent registration. Identifies courses which must be taken during the same term as the course listed.
(Identical with Hist. 406) — Crosslisting — Identifies other departments which give credit for the same course. The course description is shown in the course list of the department with instructional responsibility for the course. If no course description appears, consult the crosslisted department.
Smith — Professor in charge.

Note: Not all of the above information may be noted in any individual course.
UNIVERSITY-WIDE "HOUSE-NUMBERED" COURSES

Most University of Arizona courses use a combination of lectures, discussions and laboratories as their basic teaching format. University-wide "house-numbered" courses identify alternative teaching formats which emphasize student participation, typically in small group or individual settings. Small-group courses are identified by numbers ending in 95, 96 or 97. The area of study for such courses is indicated through a subscript and subtitle. Individual-studies courses are those with numbers ending in 91, 93, 94, and 99, as well as all 900-level courses. Under their generic numbers and titles, and without subscripts, they are available for use by all departments at the course-number levels appropriate to the departments' academic programs. Individual studies courses at the 400-level are not available for graduate credit.

Small-Group Courses

495, 595, 695, 795. Colloquium (Credit varies) The exchange of scholarly information and/or secondary research, usually in a small group setting. Instruction often includes lectures by several different persons. Research projects may or may not be required of course registrants.

GRADES AVAILABLE: A, B, C, D, E, I, S/P, * W.

496. Proseminar and 596, 696, 796. Seminar (Credit varies) The development and exchange of scholarly information, usually in a small group setting. The scope of work shall consist of research by course registrants, with the exchange of the results of such research through discussion, reports, and/or papers.

GRADES AVAILABLE: A, B, C, D, E, I, S/P, * W.

497, 597, 697, 797. Workshop (Credit varies) The practical application of theoretical learning within a group setting and involving an exchange of ideas and practical methods, skills, and principles.

GRADES AVAILABLE: A, B, C, D, E, I, W.

*Special (i.e., S,P,C,D,E) or regular grades may be used as departmental policy dictates; however, in any single course offering, all registrants must be graded by the same system.

Individual Studies

591, 691, 791. Preceptorship (Credit varies.) Specialized work on an individual basis, consisting of instruction and practice in actual service in a department, program, or discipline. Teaching formats may include seminars, in-depth studies, laboratory work and patient study.

GRADES AVAILABLE: S/P, C, D, E, I, W.

593, 693, 793. Internship (Credit varies) Specialized work on an individual basis, consisting of training and practice in actual service in a technical, business, or governmental establishment.

GRADES AVAILABLE: S/P, C, D, E, I, W.

593I. Legislative Internship (9) Working experience at the Arizona State Legislature; responsibilities draw upon student's area of major expertise and include preparing written and oral reports, summarizing legislative proposals, and providing information to legislators and legislative committees. Participating programs include but are not limited to: architecture, economics, English, geography and regional development, history, hydrology, journalism, management, management information systems, marketing, political science, psychology, public administration, secondary education, sociology, statistics, and urban planning. Students in other programs are eligible and should consult the department head or, in the case of the College of Law, the dean, for appropriate arrangements.

GRADES AVAILABLE: A, B, C, D, E, I, W.

594, 694, 794. Practicum (Credit varies) The practical application, on an individual basis, of previously studied theory and the collection of data for future theoretical interpretation.

GRADES AVAILABLE: S/P, C, D, E, I, W.

599, 699, 799. Independent Study (Credit varies) Qualified students working on an individual basis with professors who have agreed to supervise such work.

GRADES AVAILABLE: S/P, C, D, E, I, W.

900. Research (Credit varies) Individual research, not related to thesis or dissertation preparation, by graduate students.

GRADES AVAILABLE: S/P, C, D, E, K, W.
908. **Case Studies** (Credit varies) Individual study of a particular case, or report thereof.
   GRADES AVAILABLE: S/P, E, K, W.

909. **Master's Report** (Credit varies) Individual study or special project or formal report thereof submitted in lieu of thesis for certain master's degrees.
   GRADES AVAILABLE: S/P, E, K, W.

910. **Thesis** (Credit varies) Research for the master's thesis (whether library research, laboratory or field observation or research, artistic creation, or thesis writing). Maximum total credit permitted varies with the major department.
   GRADES AVAILABLE: S/P, E, K, W.

920. **Dissertation** (1 to 9) Research for the doctoral dissertation (whether library research, laboratory or field observation or research, artistic creation, or dissertation writing).
   GRADES AVAILABLE: S/P, E, K, W.

925. **Graduate Recitals** (1 to 9) For graduate students in music performance.
   GRADES AVAILABLE: S/P, E, K, W.

930. **Supplementary Registration** (1 to 9) For students who have completed all course requirements for their advanced degree programs. May be used concurrently with other enrollments to bring total number of units to the required minimum.
   GRADE AVAILABLE: K.

*Graduate students doing independent work which cannot be classified as actual research will register for credit under course number 599, 699, or 799.

**Graduate students who have completed the course requirements of their programs and will be taking examinations or completing courses or projects initiated at an earlier date should register for supplementary registration. Students completing requirements for advanced degrees must be registered during the semester or summer term in which requirements are completed, or during the previous semester or term if requirements are completed during an intersession. Students who have previously enrolled for all the regular courses required for their degrees may register for supplementary registration (course number 930, one to nine units). All graduate students using university facilities or faculty time must register for a minimum of 3 units of 930 during fall and spring semesters, and for one unit of 930 during summer sessions, if not registered for anything else. Credit received for this course is in addition to the units required for the advanced degree.

**ACADEMIC DEPARTMENTS AND COMMITTEES**

Permanent graduate-credit courses offered by the University of Arizona are listed on the following pages by academic unit in alphabetical order. For locations of departmental officers, see “College and Department Locations” at the end of this catalog.

**ACCOUNTING**

Professors Russell M. Barefield, Head, William B. Barrett, Dan S. Dhaliwal, William L. Felix, Jr., Dee L. Kleebsie
Associate Professor William S. Waller
Assistant Professors Joseph Fisher, Marcia S. Niles, Graeme W. Rankine, William K. Salatka, Jeffrey W. Schatzberg, S. Mark Young

The department offers a program leading to the Master of Accounting degree with a major in accounting. The department also participates in programs leading to the Master of Business Administration, Master of Public Administration, and Doctor of Philosophy (major in business administration) degrees. For information concerning these degrees see Requirements for Master's Degrees/Master of Business Administration, Master of Public Administration and see also Business Administration and Management and Policy headnotes elsewhere in this catalog.

401. **Advanced Accounting I** (3) GC II Theory and methodology involved in the preparation of consolidated financial statements and in accounting for partnerships. P, 300b or CR.

402. **Financial Accounting Standards** (3) GC II In-depth coverage of selected authoritative pronouncements and other special topics in financial accounting. P, 300b.

405. **Foundations of Accounting and Auditing Theory** (3) GC III Theoretical frameworks and analytical tools appropriate to the development and implementation of accounting and auditing theories. P, 310, M.A.P. 275.
410. **Advanced Cost Accounting** (3) GC II Theoretical issues of process and standard costing, performance measurement, differential cost analysis, and other selected topics. P, 310, 405.

420. **Advanced Business Law** (3) GC II GRD (Identical with M.A.P. 420).

422. **Advanced Federal Taxation** (3) GC II Introduction to advanced topics: taxation of corporations and stockholders' transactions in stocks; taxation of partnerships and fiduciaries; gift and estate taxation. P, 320, 401.

431. **Principles of Auditing** (3) GC I II The opinion formulation process of the professional auditor; the auditor's reports, professional standards, internal and operational auditing. P. 300b, 405 or M.A.P. 375.

461. **Accounting Information Systems** (3) GC I II The analysis, design and implementation of information systems, with special emphasis on accounting applications. P, 310 or 551, M.I.S. 121. Credit allowed for this course or 471 but not both. (Identical with M.I.S. 461)

472. **Fund Accounting** (3) GC II Budgetary and financial accounting, control, and reporting for governments and other not-for-profit organizations. P, 210, 272, or 550.

510. **Principles of Profit Planning and Control** (3) I The design and use of accounting information for managerial planning and control purposes. P, 310 or 551.

511. **Behavioral and Economic Aspects of Information Systems** (3) I (Identical with M.I.S. 511)

523a-523b. **Estate Planning and Taxation** (2-2) I II Advanced topics on gift and estate taxation; emphasis on the planning and structuring of financial activities to minimize the impact of income and wealth-transfer taxes. P, 422, M.A.P. 426 or CR.

526a-526b. **Corporation Taxation** (2-2) II I Advanced topics in the taxation of corporations and of stockholders' transactions in corporate shares. P, 401, 422.

527. **Tax Aspects of Real Estate Transactions** (2) II Gains and losses on sales and exchanges of property for tax purposes; capital and ordinary gains and losses, realization, transfer by gift or at death, use in trade or business, installment sales, and depreciation recapture provisions. P, 401, 422.

528. **Taxation of Partnerships** (2) II Concepts and principles of partnership income taxation and the uses of partnerships for tax planning. P, 401, 422.

531. **Responsibilities of the Public Accountant** (3) II A professional course for those who expect to pursue public accounting as a career. P, 431.

550. **Financial Accounting Analysis** (3) I II Principles and procedures underlying basic financial accounting processes and their application in the preparation and analysis of financial statements. Advanced degree credit available for nonmajors only. Open only to students admitted to BPA graduate programs.

551. **Managerial Use of Accounting Data** (3) I II Case studies and text readings focused on utilization of accounting data in determining the possible results of alternative executive decision. Advanced degree credit available for nonmajors only. Open only to students admitted to BPA graduate programs. P, 550, Econ. 500a or CR, M.A.P. 552 or CR.

553a-553b. **Financial Accounting** (3-3) I I Theory and methodology of net income determination; accounting for assets, liabilities, and owners' equity. Credit allowed for this course or 300a-300b, but not for both. P, 210 or 551.

556. **Tax Factors in Business Decisions** (3) II Introduction to the federal taxation of income for all types of taxpayers and to the taxation of transfers of wealth, with emphasis on the effect of taxes on business decisions. Open only to students admitted to BPA graduate degree programs. Not open to accounting majors. Credit allowed for this course or 320, but not for both. P, 210 or 551.

567. **Design and Control of Production Systems** (3) II (Identical with M.I.S. 567)

569. **Information and Financial Decision Support for Investment Planning** (3) II Accounting and finance theory for investment planning and implementation. An MBA integrative course. Open only to students admitted to BPA graduate programs. P. 550, Fin. 511. (Identical with Fin. 569)

570. **Management and Evaluation of Information Systems** (3) II (Identical with M.I.S. 570)

581. **Financial Accounting Theory** (3) II Topics in accounting theory and alternative accounting practices. P. 300b or 553b.

596. **Seminar**
   a. **Computers in Auditing** (3) II (Identical with M.I.S. 596a)

610. **Contemporary Managerial Accounting Thought** (3) II Special topics in accounting theory and research. Of special interest to doctoral students. P, 510.


696. Seminar
   a. Auditing (1 to 3) III
   b. Managerial Accounting (1 to 3) III
   c. Taxation (1 to 3) III
   d. Theory (1 to 3) III
   e. Behavioral (1 to 3) III

AEROSPACE AND MECHANICAL ENGINEERING


Associate Professors Thomas F. Balsa, Kee-Ying Fung, Edward B. Haugen (Emeritus), Juan C. Heinrich, Edward J. Kerschen, Parviz E. Nikravesh, Kumar N. R. Ramohalli, Bruce R. Simon

Assistant Professors Ara Arabyan, Abhijit Chandra, Ari Glezer, Shiv P. Joshi, Seth H. Lichter, Arne J. Pearlstein, Robert A. Petersen

Associate Department Head Karl M. Pattison

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in aerospace engineering or in mechanical engineering. Students in either major may select one of the following interdisciplinary options: biomedical engineering, energy systems engineering, materials engineering, or reliability engineering. For information concerning these options see Engineering elsewhere in this catalog.

A Bachelor of Science degree from an aerospace or a mechanical engineering curriculum of a recognized institution of higher education is required of applicants to the graduate program. In general, a grade average of "B" or better in previous academic work is expected. Graduates from other engineering, mathematics, and physical sciences curricula may be admitted provisionally. All applicants must submit scores from the Graduate Record Examination general test and Engineering subject test.

Majors

AEROSPACE ENGINEERING — Master of Science and Doctor of Philosophy degree programs prepare students for advanced work in aeronautics and astronautics. Several specializations are available, as listed under Mechanical Engineering below.

MECHANICAL ENGINEERING — Master of Science and Doctor of Philosophy degree programs prepare students for advanced work in many fields, including aerodynamics; flight mechanics and propulsion; biomedical engineering; energy systems engineering; engineering design and materials selection; fluid mechanics and heat transfer; interactive graphics and structural analysis; automatic control and optimization; reliability engineering and probabilistic design; solar energy; solid mechanics and structural dynamics; space systems engineering.

Degrees

MASTER OF SCIENCE — All students are required to complete 31 units of graduate work, including 24 at the 500 level and 1 unit of 696. A student may elect to present a Master's thesis (up to six units) or a Master's report (up to three units). All students are required to complete 532a-532b. (Students in the reliability engineering option may take 413a-413b as a substitute.) Normally, no more than three units of independent study or sponsored-projects courses may be taken for degree credit. All students are expected to attend the weekly graduate seminar. A final oral examination is required.
DOCTOR OF PHILOSOPHY — Students should take the Qualifying Examination during their first semester in residence. After completing all or nearly all the required course work and satisfying the foreign language requirement, the Preliminary Examination may be scheduled. Written examination on the major subject is given after the student has passed the written examination on the minor subject. Minor subjects may be chosen from other engineering, physical sciences, or mathematics departments. All students are expected to attend the weekly Aerospace and Mechanical Engineering Seminars.


406. Engineering Quality Control (3) GC I (Identical with S.I.E. 406)

408. Reliability Engineering (3) GC I Time-to-failure, failure-rate, and reliability determination for early, useful and wear-out lives; equipment reliability prediction; spare parts provisioning; reliability growth; reliability allocation. P, Math. 223, S.I.E. 320. (Identical with S.I.E. 408)

413a-413b. Reliability and Quality Analysis (3-3) GC 413a: Probability theory and statistical models in reliability, life testing, and design; descriptive and mathematical statistics, basic graphical and analytical data analysis techniques. 413b: Monte Carlo methods in reliability analysis, polynomial curve fitting and linear models, Bayes estimation, decision analysis in engineering design, stochastic processes in design. P, Math. 223.

417. Clinical Engineering (3) GC II (Identical with E.C.E. 417)

418. Physiology for Engineers (4) GC I (Identical with Psio. 418)

419. Physiology Laboratory (2) GC I (Identical with Psio. 419)


423. Probabilistic Mechanical Design (3) GC I Application of probability theory and statistics to mechanical and structural design; modern mechanical reliability methods; design philosophy. P, C.E. 217; CR 409.


430. Mechanical Vibrations (3) GC I Free and forced vibrations of simple mechanical systems; effects of damping; introduction to multidegree of freedom systems. P, 232, Math. 254.


436. Finite Element Methods of Structural Analysis (3) GC I II Matrix algebra, computers, theory of elasticity, work and strain energy, energy theorems, the finite element, the assembled structure, programming aspects of the problem, general purpose programs, application to aerospace structures. P, 409.


438. Composite Materials (3) GC II Classification and characteristics of composite materials; mechanical behavior of composite materials, micro- and macro-mechanical behavior of laminae; mechanical behavior of laminates; mechanical behavior of short fiber composites. P, 310, C.E. 217.

442. Heat Transfer (3) GC I II Study of conduction, convection and radiation heat transfer, with applications to engineering problems. P, 331a, 340a.

445. Direct Energy Conversion (3) GC II (Identical with N.E.E. 445)

453. Air Conditioning Engineering (3) GC I Analysis and design of systems and components for control of temperature, humidity, air cleanliness and acoustics; applications to residential and commercial buildings. P, 340b, CR 331a. (Identical with N.E.E. 453)

458. Wind Energy Conversion Systems (3) GC I Aerodynamic theory of vertical and horizontal axis propellers and windmills; optimal design of blades and electrical components; lab. and field measurements of operating systems. 3R, 1L. Field trips. P. 331a, E.C.E. 208.

460. Aerodynamics (3) GC II Basic equations and their approximation; potential flow theory; fundamentals of airfoil and wing theory; axisymmetric flows; application to aerodynamics of wings and bodies. P. 361, 432.

461. Gasdynamics (3) GC II Thermodynamics review; equations for one-dimensional flow; wave propagation and acoustics; isentropic flow; shock waves; simple two-dimensional flows; friction and heat addition. P. 331a, 340a.

463. Dynamics of Space Flight (3) GC I Spacecraft dynamics; orbital and attitude maneuvers, lunar and interplanetary transfer, re-entry. P. 232.

466. Stability and Control of Aerospace Vehicles (3) GC I Static and dynamic stability of rigid and nonrigid vehicles; automatic control of aircraft, missiles and spacecraft. P. 361.

467. Solar Energy Engineering (3) GC I (Identical with N.E.E. 467)

469. Energy Engineering Laboratory (3) GC I II (Identical with N.E.E. 469)

485. Biomechanical Engineering (3) GC II One subject covered yearly from: Biomechanical-solidechanics (orthopedic, vascular, muscle, skin); feedback control (physiological systems); heat transfer, thermodynamics (temperature regulation exercise, hyperthermia, instrumentation). P. 310, 331b, 340b, CR 409.

502. Advanced Finite Element Analysis (3) II (Identical with E.M. 502)

503. Modeling and System Identification in Dynamic Engineering Systems (3) I 1987-88 Principles of mathematical modeling of engineering problems; state and parameter identification techniques; lumped and distributed system; open loop (explicit) and closed loop (implicit) applications; frequency and time domain representation; deterministic and stochastic inputs. P. 310, CR 405.


505. Modern Control Theory (3) II 1988-89 Controllability and stability for linear and nonlinear systems, observer design, qualitative methods of optimal control and game theory applied to control system design. P. 405.

506. Advanced Quality Control and Reliability (3) II (Identical with S.I.E. 506)

508. Advanced Reliability Engineering (3) II Extension of 408; Complex systems reliability; maintainability engineering; reliability and availability of maintained systems; operational readiness; system effectiveness; maintainability demonstration. P. 408, S.I.E. 420. (Identical with S.I.E. 508)

510. Airplane and Helicopter Design (3) I Helicopter and airplane design and analysis; optimization of takeoff, climb, specific range, endurance; energy methods. P. 466.

512. Advanced Probabilistic Design (3) II Continuation of 423: advanced methods for mechanical and structural reliability analysis, system reliability analysis, random loading models, applications to fatigue, fracture, buckling, creep, etc. P. 423.

518. Reliability Testing (3) II Mean-time-between-failure and reliability confidence limits; sequential testing; sampling; accelerated, sudden-death, and suspended-items, non-parametric, and Bayesian testing. P. 408, S.I.E. 420. (Identical with S.I.E. 518)

520a-520b. Fundamentals of Fluid Mechanics (3-3) 520a: Fundamental equations of motions; surface tension; kinematics of vorticity; integral solutions; irrotational flows; simple viscous flows. P. 331b, CR 532a. 520b: Small-disturbance inviscid theory; low Reynolds number flow; vorticity dynamics; boundary layers. P. CR 532b.


532a-532b. Engineering Analysis (3-3) 532a: Mathematical models; operational techniques; functions of a complex variable; Fourier analysis. P. Math. 254. A.M.E. 532b: Linear analysis; ordinary and partial differential equations; methods of solution.

538. **Finite Element Analysis in Nonlinear Solid Mechanics** (3) I Finite element methods, including material nonlinearity (elastic, plastic, viscoelastic); geometric nonlinearity (finite deformations), numerical solution methods, and nonlinear programs. P. 436.

539. **Advanced Structural Mechanics** (3) II Advanced problems in structural analysis using the finite element method; analysis and optimization of complex systems; nonlinear and composite structures and material systems; application to other disciplines. P. 436. (Identical with E.M. 539)

540. **Advanced Thermodynamics** (3) I Reversible and irreversible macroscopic thermodynamics; selected engineering applications. P. 331a, 340a.

542. **Convective Transport Phenomena** (3) I Convective energy, mass and momentum transfer; internal and external flow; exact, approximate and numerical solutions; application to current problems. P. 442, CR 532a, computer programming ability.


545. **Combustion Generated Air Pollution** (3) II Pollutant formation in combustion processes and methods of control; diffusion models for atmospheric dispersion, including plume rise calculations. P. 331a, 340a. (Identical with Ch.E. 545)

546. **Nature of Turbulent Shear Flow** (3) II 1988-89 Physical phenomena in turbulent shear flows; experimental techniques; observations and physical consequences; prediction methods; recent advances. P. 532a-532b

553. **Aerodynamics of Propulsion** (3) I 1987-88 Interior ballistics of rocket motors; ramjets, turbojets, turbfans; detonation wave theory; combustion chamber instability analysis; nozzle design. P. 461.

556. **Combustion Gasdynamics** (3) II 1987-88 Aerothermochemistry; fluid mechanics, thermodynamics, chemistry of propulsion and air pollution; reaction kinetics, combustion stability, detonation; singular perturbations in deflagration. P. 331a, 461.

560. **Fluid Mechanics of Viscous Flows** (3) I Behavior of viscous fluids over a range of Reynolds numbers; Navier-Stokes equations; boundary layer equations; slow flow; compressible boundary layers. P. 520b.

561. **Compressible Aerodynamics** (3) II Inviscid flow of compressible fluids; governing equations and methods of solution for subsonic, transonic, supersonic, and hypersonic flows. P. 532a, 461.

567. **Advanced Solar Engineering** (3) II (Identical with N.E.E. 567)


615. **Hydrodynamic Stability** (3) I Introduction to linear stability theory in fluid mechanics; the Orr-Sommerfeld equation, behavior of eigensolutions, stability limits. P. 520a-520b, 532a-532b.

616. **Convective Stability** (3) I 1987-88 Linear and nonlinear stability theory for thermally or chemically stratified flows; doubly-diffusive effects; analytical and numerical methods; material's processing and geophysical applications. P. 520a-520b, 532a-532b.

621. **Advanced Computational Aerodynamics** (3) I Governing equations for aerodynamic applications; iterative techniques for solving partial differential equations; grid generation and multi-grid techniques; applications to compressible viscous flows. P. 421, 520b, 532b.

695. **Colloquium**
   - a. Research Conference (1) I II

696. **Seminar**
   - g. Graduate Seminar (1) I II

**AGRICULTURAL BIOCHEMISTRY AND NUTRITION**

*(See Nutritional Sciences)*
AGRICULTURAL ECONOMICS

Professors Jimmye S. Hillman, Head, Robert C. Angus, A. Gordon Ball, Bartley P. Cardon, Robert S. Firch, Roger W. Fox, Maurice M. Kelso (Emeritus), Robert O. Kuehl, William E. Martin

Associate Professors David L. Barkley, Dennis C. Cory, Eric A. Monke

Assistant Professors David K. Blough, Roger A. Dahlgran, Merle D. Faminow, Bonnie C. Saliba, Gary D. Thompson, Paul N. Wilson

The department offers a program leading to the Master of Science degree with a major in agricultural economics. A broad spectrum of agricultural economics subject matter is presented by the department, while special emphasis is given to the economics of natural resources. In cooperation with the Department of Economics, work is also offered leading to the Doctor of Philosophy degree with a major in economics, emphasis in agricultural or natural resource economics.

Students in the Master of Science degree program who complete a thesis are required to complete 30 semester units of which up to 6 units of credit may be for thesis research. Master of Science students not completing a thesis must complete 33 semester units. All Master of Science students must complete a final oral exam.

403. Market functions, costs, price forecasting, and regulation in the movement of agricultural products. Advanced degree credit available for nonmajors only. P, 339, Econ. 300. Faminow

404. Application of production economics principles and analytical techniques to the solution of agricultural economics problems. Advanced degree credit available for nonmajors only. P, Math. 117e, Econ. 300. Barkley/Thompson

412. Review and analysis of economic growth and development in Latin America with special emphasis on the agricultural sector. P, Econ. 201a-201b. (Identical with Econ. 412 and Anth. 412) Fox

414. Identification of current U.S. nonmetropolitan problems, economic principles useful in analyzing these problems, and possible program alternatives for rural area development. P, Econ. 201b or Geog. 305. (Identical with Geog. 414) Barkley

440. (Identical with Ws.M. 440)

442. (Identical with Or.S. 442)

450. Applying business principles to problems confronting farm-ranch and incorporated agribusiness firms in the acquisition, allocation, control and transfer of capital resources. P, 215, or Econ. 300 and 3 units of accounting. Wilson

464. Economic analysis of the policy issues and proposals impacting on agriculture and rural America, with emphasis on the historical and continuing role of government in price and income policies. Advanced degree credit available for nonmajors only. Hillman

467. (Identical with Or.S. 467)

470. (Identical with N.R.R. 470)

471. (Identical with Geog. 471)

476. Economic principles useful in analyzing natural resource problems and policies in the Southwest and nationwide. P, Econ. 201a-201b. (Identical with Econ. 476, W.R.A. 476, and Ws.M. 476) Saliba


480. (Identical with Ws.M. 480)

500. Study of the research process in agricultural economics as an efficient means for acquiring reliable knowledge for problem solutions. Martin

504. Theory of the firm and industry; single and multiple products; risk and uncertainty. (Identical with Econ. 504) Barkley/Wilson
International Agricultural Economic Development (3) II The role of agriculture in economic growth and development, including economic policies related to agriculture, and to world trade in agricultural commodities. (Identical with Econ. 512) Fox/Monke

Agricultural Price and Marketing Analysis (3) II Market organization, efficiency, and functions in a dynamic economy. (Identical with Econ. 513) Faminow

Cost-Benefit Analysis (3) II Theoretical bases and empirical techniques, with emphasis on LDCs. Consumer-producer surplus; social and private costs; macroeconomic distortions; non-market goods; uses in policy analysis. (Identical with Econ. 514 and M.A.P. 514) Monke

Operations Research in Applied Economics (3) I Application of linear, nonlinear, and multiple objective programming, decision theory, and simulation to problems of agricultural production, marketing, policy, and natural resource use. P, Econ. 361, Math. 123. (Identical with Econ. 515) Thompson

Statistical Methods (2) I II Concepts and methods of inferential statistics, including probability distributions, estimation and testing hypotheses for common statistical problems. 10-week course. P, Math 117e. (Identical with Gene. 539) Kuehl/Blough Note: A student should also take a third related unit, taught during the last five weeks of the semester and selected from among the following options: 539a, 539n, 539r, 539s.

Analysis of Variance (1) I II P, 539. (Identical with Gene. 539a)

Nonparametric Methods (1) I P, 539. (Identical with Gene. 539n)

Regression Analysis (1) I II P, 539. (Identical with Gene. 539r)

Sample Surveys (1) II P, 539. (Identical with Gene. 539s)

Design and Analysis of Experiments (3) II Statistical principles of research design for experimental and observational studies; introduction to the linear statistical model for analysis of data from research studies including techniques for complete block and incomplete block designs; factorial experiments; covariates and polynomial response functions. P, 539a. Kuehl


Natural Resource Economics and Public Policy (3) II Advanced economic theory and evaluation of land and water resource issues and public policies for graduate students in natural resource-related disciplines. Topics include water quality, water allocation, public lands management, and valuation of non-market resources. P, Econ. 361 or 476. (Identical with Econ. 577, W.R.A. 577, and Ws.M. 577) Saliba

AGRICULTURAL EDUCATION

Professors Floyd G. McCormick, Head, Gordon J. Graham, Clinton O. Jacobs (Emeritus), Kenneth S. Olson, Phillip R. Zurbrick
Associate Professor Christopher J. Kalangi
Assistant Professors David E. Cox, Glen M. Miller

The department offers programs leading to the Master of Science and the Master of Agricultural Education degrees with a major in agricultural education.

Degrees

MASTER OF SCIENCE — The program requires the completion of at least twenty units in agriculture and agricultural education. Supporting work shall be in business administration, education, psychology, sociology or in other approved disciplines appropriate to teaching, extension, and similar educational work. Thirty units, including a thesis (for which a maximum of six units may be earned) must be completed.

MASTER OF AGRICULTURAL EDUCATION — For information concerning this degree see Requirements for Masters' Degrees/Master of Agricultural Education elsewhere in this catalog.

Extension Program Planning and Evaluation (3) GC (Identical with H.E.E. 448)

Workshop
  a. Curriculum Development (1 to 3) [Rpt./3] GC I II
  b. Occupational Experience Program (1 to 3) [Rpt./3] GC I II
  c. Youth Leadership Development (1 to 3) [Rpt./3] GC I II
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d. Continuing Education in Agriculture (1 to 3) [Rpt./3] GC I II
e. Program Planning and Evaluation (1 to 3) [Rpt./3] GC I II
i.* Extension Communications (1 to 2) [Rpt./2] GC (Identical with H.E.E. 497i)
r.* Public Relations in Extension (1 to 2) [Rpt./2] GC (Identical with H.E.E. 497r)

538. Philosophy and Principles of Extension Education (3) I Social and economic significance of extension education in domestic and international situations. P; 12 units of ag. or t.c.r. (Identical with H.E.E. 538)

539. Extension Education Methods (3) II Acquisition of competencies in the development and application of non-formal education methods used by change agents to diffuse practical information. P; 6 units of a.ed. or education. (Identical with H.E.E. 539)

540. International Agricultural Extension Education (3) I Identification and discussion of a number of critical factors peculiar to agricultural extension and rural development in developing countries. Working and living overseas; country studies.

542. Education for Agricultural Entrepreneurship (3) II Pedagogy of developing motivation, skills and knowledge needed to start small enterprises in agriculture. Field trips. P; 6 units of macro/micro-economics with emphasis upon management.

597. Workshop
c.* Extension Credibility and Accountability (1 to 2) [Rpt./2] (Identical with H.E.E. 597c)
d.* Extension Supervision and Administration (1 to 3) [Rpt./2] (Identical with H.E.E. 597d)
g.* Microcomputers-Extension (1 to 2) [Rpt./2] (Identical with H.E.E. 597g)
t. Principles of Extension Training (1 to 3) I (Identical with H.E.E. 597t)
u. Evaluation in Extension Education (1 to 3) I (Identical with H.E.E. 597u)
v. Volunteer Staff Development in Extension (3) I (Identical with H.E.E. 597v, which is home)
w. Administration of Extension Programs (1 to 3) I (Identical with H.E.E. 597w)

*Offered only through the Cooperative Extension Service Winter School.

601. Advanced Agricultural Education Methods (3) [Rpt./3] I II Problems in organizing and conducting programs of instruction in vocational and extension education. P; eight units of a.ed. or education.

615. Investigations and Studies In Agricultural Education (3) I Study and analysis of research literature, methods, techniques and procedures for conducting investigations; selecting a problem and developing plans for a study. P; 9 units of a.ed. or education. Zurbrick

620. Program Evaluation in Agricultural Education (3) I Objective educational program evaluation procedures useful for strengthening and enhancing effectiveness of formal and nonformal programs in agricultural and vocational education. Field trips.

621. Program Planning (3) II Developing programs in agricultural teaching and extension; situation analysis, objectives, policies, content, procedures, and evaluative criteria. P; 6 units of a.ed. McCormick

622. Adult Vocational Education (3) II Organization, content, and techniques for conducting adult vocational education programs; characteristics of adult learners; issues affecting adult vocational education. P; bachelor's degree and one year teaching experience.

AGRICULTURAL ENGINEERING


Associate Professors M.D. Cannon (Emeritus), Wayne E. Coates, Dennis L. Larson

Assistant Professor Muluneh Yitayew

The department offers graduate work leading to a Master of Science degree in Agricultural Engineering and a Ph.D. degree in Irrigation Engineering.

Concentrations for agricultural engineering majors are available in irrigation; water resources; mechanization of field and vegetable crop production; environmental control and materials handling in livestock, dairy, and poultry production; agricultural systems analysis; and agricultural energy systems.

Students with adequate undergraduate preparation in engineering will be considered for admission to a degree program.

A thesis is normally required, but the requirement may be waived for a student who is the senior author of a manuscript published or accepted for publication in a refereed professional journal.
406. Applied Hydraulics (3) GC I GRD Fundamentals of hydraulics applicable to the irrigation of agricultural lands, including fluid properties, hydrostatics, irrigation flow characteristics, open channel and pipeline applications, and measurement of flowing water. P, Math. 118, 123 or 125a, Phys. 102a. Yilayew


425. Agricultural Engineering Design (3) GC I Selected design problems in the fields of agricultural machinery, buildings, and irrigation. 1R, 6L. P, six units of agricultural engineering courses at the 400-level. Larson

450. Irrigation Principles and Management (2) GC I GRD Principles of operating farm irrigation systems, evaluation of systems, selection of systems, basic drainage principles, energy management, basic irrigation scheduling. P, 250 or a water related course, Math. 117e, S.W. 200; CR A.En. 451.


455. Irrigation Engineering (3) GC II Introduction to irrigation systems, irrigation water supply, and irrigation management; basic designs. P, C.E. 321. (Identical with C.E. 455)


463. Energy from Biomass (3) GC II Biomass energy sources; collection and processing methods; thermal, anaerobic digestion and fermentation conversion processes, energetic, economic and environmental issues. 2R, 3L. P, A.M.E. 340a. (Identical with N.E.E. 463) Larson

465. Food Engineering (3) GC II 1988-89 Fundamentals of fluid flow, materials handling, heat transfer, refrigeration, freezing and drying as applied to food processing. (Identical with N.F.S. 465)


551. Water Management for Small Scale Agriculture (3) S Evaluation, design, construction and maintenance of water harvesting, runoff farming and other small scale water management systems. Intended for professionals from developing countries. Daily field work. Field trips. Fee.


560. Soil-Water Dynamics (3) II 1988-89 (Identical with S.W. 605)


568. Advanced Irrigation Management (3) II 1987-88 Irrigation scheduling using Jensen-Haise and Penman equations for predicting evapotranspiration; determination of crop coefficients; production functions, economics, and energy considerations. P, 450 or 455 or S.W. 520.

565. Surface Irrigation Analysis (3) I 1987-88 Analysis of design and operating criteria for basin, border and furrow irrigation systems, effect of field parameters on system design. Evaluation criteria for existing systems. P, 455.

566. Sprinkler Irrigation Analysis (3) II 1987-88 Analysis of design and operating criteria for intermittent and continuously moving sprinkler systems, hydraulics of sprinkler pipe systems, system evaluation, requirements of sprinkler heads. P, 456.
AGRICULTURE

657. **Trickle Irrigation Analysis** (3) II 1988-89 Analysis of design and operating criteria for trickle or drip irrigation systems, hydraulics of emitters and pipe systems. P, 456.

696. **Seminar**

a. Soils, Water and Agricultural Engineering (1) [Rpt./1] II (Identical with S.W. 696a) Wiersma

**AGRICULTURE**

Within the College of Agriculture programs are offered leading to the Master of Science (M.S.), Master of Agricultural Education (M.Ag.Ed.), Master of Landscape Architecture (M.L.Arch.), and Doctor of Philosophy (Ph.D.) degrees as indicated in the following list of departments and majors:

Agricultural Economics

*agricultural economics* ........................................... M.S.

Agricultural Education

*agricultural education* ........................................... M.S./M.Ag.Ed.

Agricultural Engineering

*agricultural engineering* ........................................... M.S.

*irrigation engineering* ........................................ Ph.D.

Animal Physiology (Committee)

*animal physiology* ........................................ M.S./Ph.D.

Animal Sciences

*animal science* .................................................. M.S.

*dairy science* .................................................. M.S.

*poultry science* ................................................ M.S.

Entomology

*entomology* ..................................................... M.S./Ph.D.

Nutrition and Food Science

*dietetics* ....................................................... M.S.

*food science* ................................................... M.S.

Nutritional Sciences

*nutritional sciences* ........................................ M.S./Ph.D.

Plant Pathology

*plant pathology* ................................................. M.S./Ph.D.

Plant Protection (Committee)

*plant protection* ................................................ M.S.

Plant Sciences

*agronomy and plant genetics* ................................ M.S./Ph.D.

*horticulture* ..................................................... M.S./Ph.D.

Renewable Natural Resources

*landscape architecture* ......................................... M.L.Arch.

*range management* ............................................. M.S./Ph.D.

*renewable natural resources studies* ...................... M.S./Ph.D.

*watershed management* ......................................... M.S./Ph.D.

*wildlife and fisheries science* .............................. M.S./Ph.D.

Soil and Water Science

*soil and water science* ........................................... M.S./Ph.D.

Veterinary Science

No graduate majors except in cooperation with certain other departments.

In special cases, an undergraduate field of concentration different from but related to the intended graduate major may be admissible.

Students with a special interest in genetics are referred to Genetics elsewhere in this catalog. For further information concerning any of the programs listed above, see the appropriate departmental headnotes and also see *Requirements for Graduate Degrees* elsewhere in this catalog.
The Agricultural Experiment Station offers the graduate student in agriculture an opportunity to participate in current research programs. The student may be assigned to a staff member of the Agricultural Experiment Station, under whose direction the research necessary to the writing of an acceptable thesis or dissertation is conducted. Residence credit may be earned for certain graduate courses offered at University facilities away from the Tucson campus.

**General Course in Agriculture**

450. **Alternative Futures in Energy and Environment** (3) I GC Energy and environment status and future alternatives; interaction of food-fiber production and natural resource use, with emphasis on student discussion of diverse views. Caldwell

**AGRONOMY AND PLANT GENETICS**

*(See Plant Sciences)*

**AMERICAN INDIAN STUDIES**

Committee on American Indian Studies

Professors Barbara Babcock (English), James W. Clarke (Political Science), Vine Deloria, Jr. (Political Science), Lawrence J. Evers (English), Jerrold Levy (Anthropology), N. Scott Momaday (English), James Officer (Anthropology), J. Jefferson Reid (Anthropology), Susan W. Steele (Linguistics), Robert K. Thomas

Associate Professors Courtney Cleland (Sociology), Thomas M. Holm (Political Science), Alice S. Paul (Elementary Education)

Assistant Professor Ofelia Zepeda (Linguistics), Director

The Committee on American Indian Studies offers a Master of Arts degree with a major in American Indian studies that is designed to prepare students to teach at the college and university level and to work in community development and social programs.

Applicants must submit scores on the Graduate Record Examination, two letters of recommendation, and the personal and academic data called for on the American Indian Studies application form. Applicants are also invited to submit vitae, published articles or other materials relevant to admission.

**MASTER OF ARTS** (major in American Indian studies) — 30 units, plus a six-unit thesis. The course work consists of 15 units of core courses, including 484a-484b, 502a-502b, and three units to be determined by the Committee. In addition, the student must complete 15 units in a field of concentration chosen from art, language, anthropology, literature, education, business or any other related area approved by the Committee. The student should work closely with three faculty advisers to develop a challenging individual program. In addition to the thesis, a final master's examination is required.

The Department of Political Science offers a Master of Arts degree with a major in political science with an emphasis on Indian policy that is designed to prepare students to work in tribal and private organizational work, to teach at the college and university level, and to work in a variety of public agencies in the area of civil rights and social programs. A concentration in American Indian studies provides students with a thorough background in the political history of the American Indian and the federal government and provides the tools and analytical skills necessary to understand the past and present situation of the American Indian, thus preparing the student for policy-making, tribal planning or other government positions. For information concerning this concentration, also see the Department of Political Science.

404. **Sociology of the Southwest** (3) GC I (Identical with Soc. 404)

415a-415b. **Southwestern Indian Arts** (3-3) GC (Identical with Anth. 415a-415b)

416. **Contemporary Indian America** (3) GC II 1987-88 (Identical with Anth. 416)

423. **Peoples of Mexico** (3) GC II (Identical with Anth. 423)
ANATOMY

430. The Anthropology of Visual Art (3) GC II 1988-89 (Identical with Anth. 430)
445a-445b. Structure of a Non-Western Language (3-3) [Rpt.:2] GC (Identical with Ling. 445a-445b)
449a-449b. Folklore (3-3) GC (Identical with Engl. 449a-449b)
461. Race and Ethnic Relations (3) GC I II (Identical with Soc. 461)
477a. Ethnic Literature (3) GC (Identical with Engl. 477a)
482. Hopi Language in Culture (3) GC II (Identical with Anth. 482)
484a-484b. Development of Federal Indian Policy (3-3) GC (Identical with Pol. 484a-484b)
487. Race and Public Policy (3) GC I (Identical with Pol. 487)
502a-502b. Dynamics of Indian Societies (3-3) Philosophies, institutions and characteristics of tribal life in North America. 502a: American Indian life-styles prior to European contact. 502b: Impact of European immigration on tribal groups of North America. (Identical with Anth. 502a-502b)
595. Colloquium
   a. Theory and Indian Studies (3) II P, 502a-502b or 484a-484b.
596. Seminar
   h. American Indian Law and Policy (3) [Rpt.:2] I II (Identical with Pol. 596h, which is home)
m. Studies in the Oral Tradition (3) [Rpt./9 units] II (Identical with Engl. 596m, which is home)

ANATOMY

Professors Robert S. McCuskey, Head, Jay B. Angevine, Jr., Joseph T. Bagnara, Bryant Benson, Mac E. Hadley, Philip H. Krutzsch
Associate Professors David E. Blask, Mary J. C. Hendrix, C. Ward Kischer, Albert V. LeBouton
Assistant Professor Christopher A. Leadem

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in anatomy.

The undergraduate major need not be in the biological or chemical sciences, but the applicant must have completed courses in mathematics through calculus and analytical geometry; inorganic and organic chemistry; a year of general physics; and at least sixteen units in the biological sciences. It is advisable that the applicant present at least one course in comparative anatomy, genetics, or general physiology and a year of general zoology or biology. A limited number of deficiencies may be satisfied after admission and, if appropriate, graduate credit may be allowed. Applicants must submit scores on the aptitude test and one advanced test (biology preferred) of the Graduate Record Examination and four letters of recommendation from former science instructors familiar with their academic ability and personal character.

Degrees

MASTER OF SCIENCE — This degree is offered only in rare instances when individuals qualified to study for the doctorate are forced to terminate early. A final oral examination, a thesis based upon original research, and reading proficiency in one foreign language are required.

DOCTOR OF PHILOSOPHY — The degree program includes course work in gross anatomy, microscopic anatomy, and neuroanatomy. If acceptable courses have already been completed in one or more of these subjects, the student will be allowed to audit the corresponding course and assist in the laboratory. Acceptable minor subjects are anthropology, physiology, biochemistry, pharmacology, microbiology, or the biological sciences. At least three one-semester courses must be completed in the minor field.

Doctoral students majoring in other disciplines may, with the approval of an anatomy minor adviser, select anatomy as a minor field. The minor program will consist of at least sixteen units in anatomy.

456. Developmental Biology (3) GC I (Identical with M.C.B. 456)

457. Experiments in Developmental Biology (4) GC II (Identical with M.C.B. 457)

467R. Endocrinology (3) GC II Neural and endocrine integration in the regulation of mammalian physiological functions. P, M.C.B. 103. (Identical with M.C.B. 467R)

467L. Endocrinology Laboratory (1) GC II Techniques in endocrinology. P, CR 467R (Identical with M.C.B. 467L)

495. Colloquium
   a. Introduction to the Neurosciences I (2) GC (Identical with Med. 495a, which is home)

500. Topics in Pigment Cell Biology (2) I Selected topics on the development function and control of normal and abnormal pigment cells in various pigmentary phenomena. (Identical with M.C.B. 550)

555. Cancer Biology (3) II 1988-89 (Identical with Micr. 555)

558. Advanced Subjects in Endocrinology (2) [Rpt.] I Selected topics in vertebrate and invertebrate endocrinology. P, 467R. (Identical with M.C.B. 558)

601. Human Gross Anatomy (8) I Comprehensive survey of the development and gross structure of the human body. P, Chem. 103b, 104b, 243b, 245b; Phys. 102b; consult department before enrolling.

602. Microscopic Anatomy (5) I Essentials of microscopic human anatomy. P, Chem. 103b, 104b, 243b, 245b; Phys. 102b; consult department before enrolling.

603. Microscopic Structure (1 to 3) II Selected concepts of structural organization at light and electron microscopic levels of the anatomy and development of the cells, tissues, and organs of vertebrates. P, 601, 602.

604. Gross Human Anatomy (2 to 6) [Rpt.] II Study in depth of the gross human anatomy of selected areas or systems. P, 601, 602.

605. Neurosciences (6) II Essentials of mammalian neural development, structure and function. P, Chem. 103b, 104b, 243b, 245b; Phys. 102b; M.C.B. 410a-410b. Consult department before enrolling. (Identical with Psio. 605)


610a-610b. Anatomical Techniques (1 to 4 - 1 to 4) Introduction to special techniques and procedures of analytical anatomy. P, 601, 602; consult department before enrolling.

615. Topics in Neural Plasticity (2) (Identical with M.C.B. 615)

616. Introduction to Anatomical Literature (1) I II A problem-oriented, bibliographic approach to basic anatomical references. Primarily for those students planning a career in anatomy and wishing to prepare themselves for further graduate study. 3L.

696. Seminar
   b. Biological, Structural and Functional Interactions (1) [Rpt./4] II Open to majors only. P, Chem. 103b, 104b, 243b, 245b, Phys. 102b.

801. Human Gross Anatomy (8) I No grade is given until the full 8 units are completed.

802. Microscopic Anatomy (5)

805. Neurosciences (6) II (Identical with Psio. 805)

891. Preceptorship
   a. Anatomy (3 to 12) [Rpt./12 units]

ANIMAL PHYSIOLOGY

Committee on Animal Physiology (Graduate)

Professors Fred B. Roby, Chairperson, Clyde S. Card, Robert B. Chiasson, Mac E. Hadley, Timothy G. Lohman, Dewey E. Monty, Jr., Raymond E. Reed, James N. Shively, Gerald H. Stott (Emeritus), Charles M. Tipton

Associate Professors Ronald E. Allen, Ronald W. Hilwig

Assistant Professors Joy C. Bunt, Roger M. Enoka, William A. Schurg, Douglas R. Seals, Mark E. Wise
The interdisciplinary Committee on Animal Physiology offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in animal physiology. Participating faculty are from the departments of Anatomy, Animal Sciences, Exercise and Sport Sciences, and Veterinary Science. Information on the various concentrations within animal physiology may be obtained on request.

Applicants should have a fundamental knowledge of zoology (including anatomy, physiology, and genetics), chemistry, mathematics, and physics. Applicants must submit scores on the general test of the Graduate Record Examination.

A thesis is required for the Master of Science degree. Suggested fields for the doctoral minor are animal sciences, biochemistry, the biological sciences, chemistry, exercise and sport sciences, nursing, nutrition, pharmacology, veterinary science, or other discipline approved by the committee.

Related Courses

Refer to the appropriate department for course descriptions. Courses which are applicable to the program are A.Ec. 539, 539a, 539n, 539r, 539s, 540; An.S. 413, 414, 415R, 415L, 430, 436, 501, 585, 601, 635, 684; Ecol. 431; 464a-464b, 468L, 468R; Ex.S.S. 530, 550, 695a; M.C.B. 410a-410b, 412, 467R, 467L, 558; N.F.S. 406a-406b, 615, 617, 620; Psio. 601, 605; Stat. 461; V.Sc. 400a-400b, 405, 423, 458, 459, 601.

ANIMAL SCIENCES


Associate Professors Ronald E. Allen, R. Spencer Swingle

Assistant Professors Sue DeNise, Vincent Guerrero, William A. Schurg, Mark E. Wise

The department offers programs leading to the Master of Science degree with a major in animal science, dairy science, or poultry science. Concentrations are available in animal breeding and genetics, animal nutrition, animal physiology, and meat science and muscle biology.

Admission is generally dependent upon an undergraduate major in some field of animal agriculture and a basic background in biological, chemical, and physical sciences.

A thesis is required but may be waived in unusual circumstances at the option of the department. Candidates who do not complete a thesis must present a minimum of 36 graduate units and an acceptable professional paper. Approval for a Master of Science program without a thesis must be obtained no later than nine months after admission to the degree program or within twelve months after provisional admission or admission as an International Special student, whichever is sooner. Supporting work is available in agriculture, biochemistry, chemistry, ecology and evolutionary biology, microbiology and immunology, molecular and cellular biology, nutrition and food science, physiology, plant sciences, statistics, systems and industrial engineering, veterinary science and in soil and water science.

Graduate programs leading to the Doctor of Philosophy degree are administered by interdepartmental committees: Animal Physiology, Genetics, and Nutritional Sciences.

413. Principles of Animal Breeding (3) GC II Basic concepts involved in the improvement of economically important traits of livestock through application of genetic principles. Field trips. P, 213 or Ecol. 321 or P.L.S. 228; Math. 117e. (Identical with Gene. 413)


415R. Physiology of Reproduction (3) GC I Study of the organs of reproduction and their accessories; physiology and endocrinology as related to the process of reproduction and milk secretion. P, Chem. 101b, Chem. 102b, 3 units of animal anatomy/physiology. (Identical with V.Sc. 415R)
415L. Physiology of Reproduction Laboratory (1) GC I Practice in semen collection and storage, artificial insemination, and hormone assay. P or CR, 415R. (Identical with V.Sc. 415L)


436. Applied Animal Nutrition (4) GC II Application of principles of nutrition to the feeding of livestock and poultry, nutrient composition and characteristics of feeds, nutrient requirements and diet formulation. 3R, 3L. P, 430.


463. Food Analysis (3) GC II 1988-89 (Identical with N.F.S. 463)

472. Dairy herd Management (3) GC I Proper milking, efficient housing, and health management of dairy cattle; marketing milk from the farm; milk production costs. Field trip. P, 430.

473. Swine Production (2) GC I The production, feeding and management of swine in intensive production systems. Field trip. P, 430.

474. Sheep Production (2) GC II The production, feeding and management of sheep on the farm and ranch. 1R, 3L. P, 430.


501. Animal Growth and Development (2) II 1988-89 Growth and development of domestic animals, with emphasis on skeletal muscle, bone and adipose tissue growth, from the cellular level to the whole animal. P, N.F.S. 406a or Bioc. 460 or 462a.

513. Quantitative Genetics (3) I 1988-89 Theory of quantitative genetics including idealized populations, forces that change gene frequency, breeding systems, and estimation of genetic parameters in a population. P, 6 units of genetics. (Identical with Gene. 513)


596. Seminar a. Animal Sciences (1) [Rpt./3] I II

601. Bioenergetics (2) I (Identical with N.F.S. 601)

609. Nutritional Biochemistry Techniques (3) II (Identical with N.F.S. 609)

615. Chemistry and Metabolism of Lipids (3) I 1987-88 (Identical with N.F.S. 615)

622. Mineral Metabolism (2) I 1987-88 (Identical with N.F.S. 622)

635. Ruminant Nutrition (3) I Recent findings in ruminant nutrition; the physiochemical processes of digestion and absorption; importance and metabolism of rumen microflora; normal metabolism and abnormal metabolic disorders; modes of action of feed stimulants. P, 430, 436; Chem. 241a, 243a.


687. Environmental Physiology of Domestic Animals (3) II 1988-89 Physiological, behavioral and anatomical responses of domestic animals to their environment, with emphasis on adaptive mechanisms. P, 413, 415R, 430, 3 units of general physiology/anatomy.
ANTHROPOLOGY


Associate Professors Constance Cronin, Mary Ellen Morbeck, Richard A. Thompson, Norman Yoffee, Stephen L. Zegura

Assistant Professors Mark Nichter, John W. Olsen, Thomas K. Park

The department offers programs leading to the Master of Arts and Doctor of Philosophy degrees with a major in anthropology. Concentrations are available in archaeology, cultural anthropology, linguistics, or physical anthropology.

Each applicant is required to submit scores on the aptitude test of the Graduate Record Examination taken within the last five years, a detailed statement of professional goals, and two letters of recommendation from instructors who are in a position to predict the applicant's potential as a graduate student.

Degrees

MASTER OF ARTS — No thesis is required. A minimum of twelve units in anthropology core courses and eighteen units in supporting work must be completed. Supporting courses may be chosen from Southwestern studies, applied anthropology, American Indian studies, cultural resource management, museology, secondary education, archaeology, cultural anthropology, linguistics, physical anthropology, or general anthropology. Specific course requirements for programs in cultural resource management, forensic anthropology, medical anthropology, and museology are listed in literature available from departmental advisers.

DOCTOR OF PHILOSOPHY — The major consists of 36 or more units of course work plus the dissertation. The minor, consisting of fifteen or more units, may be taken within the department. Special requirements include reading knowledge of a foreign language and a working knowledge of modern statistical methods.

The Bureau of Applied Research in Anthropology, a division of the Department of Anthropology, is a regional and international center for basic and applied research relating to culture change, urban and rural living, technological innovation, demography, and cross cultural management. Extensive archaeological, ethnological, and osteological collections are available in the Arizona State Museum. Field training in archaeological techniques is offered on both the graduate and undergraduate levels at the University of Arizona Archaeological Field School, which is operated jointly by the department and the Arizona State Museum. The Laboratories of Tree-Ring Research, Isotope Geochemistry, Paleoenvironmental Studies, and Paleontology provide opportunities for climatic and chronological studies of special interest to advanced students in archaeology.

400. Processes of Culture Change (3) GC II Intensive investigation of specific theories and varieties of culture change. P, 200.

401. Ancient Mesopotamia (3) GC I 1988-89 Sumerian, Babylonian, and Assyrian civilization from the first cuneiform documents to the fall of the neo-Babylonian empire, with special attention to issues of sociopolitical organization. (Identical with Hist. 401 and OrS. 401)

402. Kinship and Social Organization (3) GC II Principles in the comparative study of social systems; types of social structure. P, 200, or 9 units of sociology (Identical with Soc. 402)
108 DEPARTMENTS AND COURSES OF INSTRUCTION

403. Anthropology of Conflict Resolution (3) GC II 1987-88 Decision making, conflict, and violence from a cross-cultural perspective, aiming to build both understanding of conflict processes and skills for managing and resolving them. 2R, 3L.

404. Sociology of the Southwest (3) GC I (Identical with Soc. 404)

405. Urban Adaptation of Ethnic Groups (3) GC I 1987-88 A survey of adaptations of ethnic and social groups to urban areas, focusing on a different group or region each semester.

407. Peasant Communities (3) GC I Comparative analysis of traditional and contemporary peasant communities. On-going cross-cultural research project. (Identical with Soc. 407)

408. Anthropology and Public Policy (3) GC II Examines the development, goals, techniques, and practices of anthropology as a policy science.

409. Economic Anthropology (3) GC II Analysis of production, exchange, distribution, consumption, property, economic surplus, inheritance, and types of economic structure. P, 200, or 12 units of economics. (Identical with Econ. 409)

411. Anthropology of Religion (3) GC I Comparative approaches to the study of religion; systems of ritual and symbolization in the primitive world; shamanism and possession; religious movements; religion in the modern world. (Identical with Reli. 411)

412. Agricultural Economic Development in Latin America (3) GC II (Identical with A.Ec. 412)

413. Ethnology of the Southwest (3) GC II Culture history and economic, social, and religious institutions of the living people of the Southwest. P, 200.

414a-414b. Indians of the Southwest (3-3) GC S History, arts and crafts, economics, social institutions, religions, and mythology of the present-day Indians of the Southwest.

415a-415b. Southwestern Indian Arts (3-3) GC 415a: Prehistoric utilitarian and aesthetic arts. 415b: The art of the modern Indians of the Southwest. 415a is not prerequisite to 415b. (Identical with A.In.S. 415a-415b and Art 415a-415b)

416. Contemporary Indian America (3) GC II 1987-88 The historical development and contemporary significance of the reservation system in the life of the Native American of the United States. (Identical with A.In.S. 416)

417. Cultures of Ancient Mexico (3) GC S Archaeological and ethnohistoric survey of the civilizations of ancient Mexico from earliest times to the period of the Spanish Conquest. Field trips. Fee.

418a-418b. Scientific Illustration -Photography (2 to 4 - 2 to 4) GC (Identical with Ecol. 418a-418b)

419. Psychological Anthropology (3) [Rpt.1] GC II Critical and historical survey of interrelationships between cultural and personal phenomena, with focus on childhood and adolescence, gender relations, dreaming and emotion.

420a-420b. Contemporary American Culture (3-3) GC 1987-88 Diverse perspectives on American values as expressed in organization of kinship, space, bureaucracies, media, social classes, ethnic groups, religious sects and movements. 420a is not prerequisite to 420b.


422a-422b. Pre-Columbian Art (3-3) GC (Identical with Art 422a-422b)

423. Peoples of Mexico (3) GC II Cultural background and contemporary economic, social, and religious life of the Indian and mestizo populations of Mexico. (Identical with A.In.S. 423 and M.A.S. 423)

424. Gender and Social Identity (3) GC II Theories of sexual equality and inequality, plus an overview of sex roles and sex status in different types of societies and in different areas of social organization. (Identical with W.S. 424)

425. Ethnology of South America (3) GC I 1987-88 Comparative study of culture and history of South American indigenous peoples, including contemporary situation and Latin American policies toward them. P, 200.

427. Religion and Mythology of Mesopotamia (3) GC II 1987-88 Readings in translation of Sumerian and Babylonian myths and rituals stressing anthropological techniques in the interpretation of Mesopotamian cosmology. P, 100. (Identical with Or.S. 427 and Reli. 427)

428. Anthropology of Law (3) GC II 1988-89 Issues in the anthropology and history of law, focusing on the nature of law in its social context; selected case studies. (Identical with Or.S. 428)


430. The Anthropology of Visual Art (3) GC II 1988-89 An introduction to the anthropology of visual art and the interdisciplinary methodologies and techniques of studying art and aesthetics cross-culturally as sociocultural phenomena. (Identical with A.In.S. 430, Engl. 430)
ANTHROPOLOGY 109

431. Anthropology and Development (3) GC II 1987-88 The role of anthropology in interdisciplinary projects involving economic development and planned change on the national and international levels.

432. Peoples of the Pacific (3) GC I 1988-89 Populations and cultures of Polynesia, Micronesia, and Melanesia; variability of these "natural laboratory" settings in an ecological framework.

433. Advanced Scientific Illustration (4) GC S (Identical with Ecol. 433)

435. Principles of Archaeological Fieldwork (3) GC II Introduction to the principles of archaeological fieldwork, with emphasis on method and theory of survey and excavation. 2R, 3L. P, 235.


437. The Relationship of Early Hominids and Contemporary Faunas (3) GC II 1988-89 The faunal association of contemporary animals and hominids world-wide. Peopling the New World. Methods utilized to analyze fossil assemblages when associated with hominids.

438. Zooarchaeology (3) GC I Animals in relation to man, with emphasis on past cultures, especially in the Southwest; morphology of animal skeletons; identification and interpretation of fragmentary remains.


440. Laboratory in Zooarchaeology (3) GC 1988-89 Fragmentary animal remains in archaeological interpretation. Diagnostic morphological features; role in cultural interpretation. Analytical techniques; lab. analysis; report preparation. 1R, 6L.

441. Organization of Museums (3) GC I An intensive introduction to museum studies, with emphasis on the history, philosophy, structure, and function of museums.

442. Museum Collections Management (3) GC I Principles and procedures governing the acquisition, documentation, care and use of museum collections. 2R, 3L. P, 441.

443a-443b. The Archaeology of Neolithic and Bronze Age Greece (3-3) GC (Identical with Clas. 443a-443b)


446. Introduction to Museum Conservation (3) GC II A basic introduction to the examination of the nature and properties of materials in anthropological collections and their deterioration, restoration, and preservation.

449a-449b. Folklore (3-3) GC (Identical with Engl. 449a-449b)

450. Social Stratification (3) GC I II (Identical with Soc. 450)

451. Archaeology of North America (3) GC I Intensive survey of the development of culture in North America from the time of the initial peopling of the New World to the historic period.

452R. Archaeology of the Southwest (3) GC I Development of culture in the prehistoric Southwest from the late Pleistocene to the historic period. Field trip.

452L. Archaeology of the Southwest (3) GC II The nature of archaeological data recovered in the Southwest, with emphasis on their potential for the drawing of both cultural and chronological inferences. P, 452R.

453. Mesoamerican Archaeology (3) GC I Development of culture in Mexico and Central America from the early hunters and gatherers through the conquest of the Aztecs and Mayas by the Spanish. (Identical with M.A.S. 453)

454. Andean Archaeology (3) GC II Development of culture in the Andean countries of South America from hunters and gatherers of the terminal Pleistocene through Inca civilization.


456. Old World Prehistory (3) GC II Man's cultural development in the Old World, as revealed by prehistoric archaeology, from earliest evidence through the development of agricultural villages.

457. Prehistoric Mesopotamia (3) GC I 1987-88 Theories of the rise of civilization tested against archaeological data from Mesopotamia with comparative material from other areas. Time period: end of the Paleolithic to historic (Sumerian) civilization. (Identical with OrS. 457)

458. Race and Ethnic Relations (3) GC I II (Identical with Soc. 461)

460. Introduction to Quaternary Ecology (3) GC I (Identical with Geos. 462)

463. Classical Field Archaeology (3) [Rpt./1] GC S (Identical with Clas. 463)

464a-464b. Introduction to Dendrochronology (3-3) GC (Identical with Geos. 464a-464b)
110  DEPARTMENTS AND COURSES OF INSTRUCTION

465.  **Women in International Development** (3) GC II The impact of international development on women as agricultural producers, householders, migrants, workers in formal/informal labor markets and participants in planned change. (Identical with W.S. 465; F.C.R. 465)

466.  **Paleoanthropology** (3) GC I Evidence for human and nonhuman primate evolution including laboratory study of fossil casts and modern skeletal biology. P, 265 or consult dept. before enrolling.

468.  **Human Osteology** (3) GC I Human osteology for the archaeologist and physical anthropologist; techniques of in situ and laboratory identification, preservation and measurement. P, consult dept. before enrolling.

470a-470b.  **Human Adaptability** (3-3) GC Study of human adaptability focusing on physiological plasticity, growth, nutrition, population ecology, demography, epidemiology and paleopathology. P, 265 or consult dept. before enrolling. 470a is not prerequisite to 470b. (470a identical with Gero. 470a)

471.  **Introduction to Indic Civilization** (3) GC I (Identical with Or.S. 471)

473.  **Primate Anatomy** (4) GC I 1987-88 Comparative primate functional anatomy from an anthropological viewpoint including extensive laboratory dissection and study of behavior, ecology, and evolution. P, 265 or consult dept. before enrolling.

474R.  **Ethnobotany** (3) GC II Survey, with emphasis on cultural uses of plants, both past and present; discussions of contributions to the theory and techniques of the emergence of agriculture, archaeological botany, ethnomedicine, and other aspects of ethnobotany. P, 8 units of biology or anthropology.

474L.  **Ethnobotany Laboratory** (1) GC II Field-lab course treating sampling, processing, storage, and identification techniques, procedures, and interpretation in selected areas of ethnobotany. Field trips. P, 8 units of biology or anthropology.

475.  **Origins and Development of Cultivated Plants** (3) GC I Evaluation of theories of origins and early development of cultivated plants in general, with attention given to crop plants of world-wide economic importance and selected crops of local economic importance. Three-day field trip. P, Ecol. 321.

476.  **Language in Culture** (3) GC II Survey of the nature of the interrelationships between language and other cultural phenomena. P, 276. (Identical with Ling. 476)

477.  **Discourse and Text** (3) GC II 1987-88 Analysis and cross-cultural comparison of patterns of communication in discourse; modern approaches to discourse and text. P, 276, Ling. 200 or consult department before enrolling. (Identical with Ling. 477)

481a-481b.  **Archaeology of Syria-Palestine in the Bronze and Iron Ages** (3-3) GC (Identical with Or.S. 481a-481b)

482.  **Hopi Language in Culture** (3) GC II A conversational introduction to Third Mesa dialect of Hopi, with emphasis on cultural context and covering essentials of Hopi language structure. (Identical with A.ln.S. 482)

484a-484b.  **Akkadian Linguistics** (3-3) GC 1988-89 Introduction to the standard literary language of the Babylonians and Assyrians. (Identical with Or.S. 484a-484b)

485.  **Social Organization of India and Pakistan** (3) GC I (Identical with Or.S. 485)

486.  **Comparative Community Development** (3) GC I (Identical with Soc. 486)

487.  **Poverty and Health** (3) GC II (Identical with Nurs. 487)

488a.  **The Prehistory of East Asia** (3) GC I The origins and subsequent development of prehistoric cultures in China, Japan, Korea, Mongolia, Siberia and Southeast Asia. Broad concepts such as cultural change and environmental adaptation are stressed in order to draw parallels among these geographically and culturally diverse regions. (Identical with Or.S. 488a)

488b.  **The Archaeology of Pre-Han China** (3) GC II The origin and florescence of Chinese culture and civilization from an archaeological perspective. An in-depth survey of Chinese prehistory and early history from the early Pleistocene to the third century BC. 488a is not a prerequisite for 488b. P, 100 or consult department before enrolling. (Identical with Or.S. 488b)

489.  **Anthropology and Education** (3) GC II The application of anthropological theory and methodology to education.

495.  **Colloquium**
   a.  **Bilingual Health Communication** (3) GC II (Identical with Nurs. 495a)

496.  **Proseminar**
   f.  **Ceramic Analysis** (3) GC I

501a-501b. Medical Anthropology (3-3) [Rpt./2] 501a: The anthropology of health, illness and sickness. Cultural perceptions of health, ethnopharmacology, illness causality and classification. 501b: Each semester the course will concentrate on a different world region. Examine indigenous medical traditions, changing health profiles, the interface between modern traditional medicine, and patterns of health care utilization.

502a-502b. Dynamics of Indian Societies (3-3) (Identical with A.In.S. 502a-502b)

514. Late Quaternary Geology (3) I (Identical with Geos. 514)

524. Theoretical Population Genetics (3) I (Identical with Ecol. 524)

561. Paleoindian Origins (3) I Chronological development of Paleo-indian occupation of the New World in relation to environmental changes of the Quaternary Period; site discoveries, case studies, hypothesis on the peopling of the Americas. Field trip. (Identical with Geos. 561)

580a-580b. Cross-Cultural Communication (3-3) 580a: Linguistic Fieldwork. 580b: Cultural Fieldwork. 580a is not a prerequisite to 580b.

581. Quaternary Palynology (4) II 1987-88 (Identical with Geos. 581)

583. Sociolinguistics (3) I Contributions of the ethnography of communication, language variation studies, and conversational-discourse analysis to the interdisciplinary development of sociolinguistics. (Identical with Ling. 583)

584a-584b. Readings in Akkadian (3-3) 1987-88 Readings in selected literary, religious and economic texts designed not only to improve language mastery but to use those documents in elucidation of specific topics in Mesopotamian culture. P, 484a-484b. (Identical with Or.S. 584a-584b)

588. Clinical Anthropology (3) I (Identical with Nurs. 588)

596. Seminar
   c. The Dynamics of Human Subsistence (3) II 1987-88 Consult department before enrolling.
   e. Pre-Columbian Art (3) [Rpt./4] I (Identical with Art 596e, which is home)
   q. Near Eastern Archaeology (3) [Rpt.] I II (Identical with Or.S. 596q, which is home)
   r. Quaternary Geochronology (1 to 4) I II (Identical with Geos. 596r, which is home)

597. Workshop
   a. Physical and Forensic Anthropology I (2) I Consult dept. before enrolling.
   b. Physical and Forensic Anthropology II (2) II Consult dept. before enrolling.

600. Survey of Cultural Anthropology (3) I Intensive introduction, overview, and synthesis of cultural anthropology.

635. Survey of Archaeology (3) I Major features of cultural development from earliest evidence to early civilizations. A basic introduction to method and theory in archaeology at an introductory graduate level.

642a-642b. Advanced Field Course in Archaeology (3-3) S Archaeological methods, theory, and field techniques. 642a: Three-week field excavation and survey; 642b: Three-week laboratory processing and analysis. Registration limited. Contact department for application; return by April 1.

645. Early Civilizations (3) [Rpt./2] II Comparative analysis of early civilizations from both the Old World and the New World, with emphasis on regularities in cultural development. P, 454, 456, 457, or 650.

650. Ancient Civilizations of Mesoamerica (3) 1987-88 Comparative study of cultural development in Mesoamerica, with emphasis on agricultural beginnings, settlement pattern and urbanization, hieroglyphic writing, and calendrical systems.

665. Survey of Physical Anthropology (3) II Modern physical anthropology including evolutionary theory, genetics, skeletal biology, primatology, paleoanthropology, human growth, adaptability and demography.


679. Language and Ethnography (3) I 1988-89 Training in the use of ethnographic method in linguistic and cultural research where naturally occurring speech is data. Analysis of data from observation, tape recording and videotaping. P, 6 units of linguistics.

680. Survey of Linguistic Anthropology (3) II Major theoretical and methodological issues in linguistic analysis. Language as a cultural code, biological foundations, universals and typology, language and social reality, textual analysis.

695. Colloquium
   a. Forensic Anthropology (2) [Rpt./6 units] II 2R, 1L. P or CR 468 and 597b.
DEPARTMENTS AND COURSES OF INSTRUCTION

696. Seminar
a. Archaeology (1 to 3) II
b. Cultural Anthropology (1 to 3) II
c. Linguistic Anthropology (1 to 3) II
d. Physical Anthropology (1 to 3) II
e. Museology (1 to 3) II

APPLIED MATHEMATICS

Committee on Applied Mathematics

Professors David W. McLaughlin, Chairperson (Applied Mathematics and Mathematics), Gregory R. Baker (Mathematics), Bruce R. Barrett (Physics), Harrison H. Barrett (Radiology), James M. Cushing (Mathematics), Chandra Desai (Civil Engineering), Donald G. Dudley (Electrical and Computer Engineering), William Faris (Mathematics), Hermann Fasel (Aerospace and Mechanical Engineering), Paul C. Fife (Mathematics), Hermann Flaschka (Mathematics), Robert L. Gall (Atmospheric Sciences), Barry C. Ganapol (Nuclear and Energy Engineering), W. Martin Greenlee (Mathematics), Joseph F. Gross (Chemical Engineering), Robert L. Hamblin (Sociology), David L. Hetrick (Nuclear and Energy Engineering), Frederic A. Hopf (Optical Sciences), William B. Hubbard (Lunar and Planetary Sciences), J. Randolph Jokipii (Astronomy, Planetary Sciences), George L. Lamb, Jr. (Mathematics, Optical Sciences), Willis E. Lamb, Jr. (Optical Sciences, Physics), Averill M. Law (Management Information Systems), Eugene H. Levy (Lunar and Planetary Sciences), Donald E. Myers (Mathematics), Marcel F. Neuts (Systems and Industrial Engineering), Alan C. Newell (Mathematics, Arizona Research Laboratories), Charles M. Newman (Mathematics), Adrian N. Patrascioiu (Physics), Michael L. Rosenzweig (Ecology and Evolutionary Biology), Hanno Rund (Mathematics), William M. Schaffer (Ecology and Evolutionary Biology), Alwyn Scott (Electrical and Computer Engineering), William R. Sears (Aerospace and Mechanical Engineering), Vernon L. Smith (Economics), Orestes N. Stavroudis (Optical Sciences), Randall Richardson (Geosciences), Moshe Shaked (Mathematics), Michael E. Sobel (Sociology), Malur K. Sundareshan (Electrical and Computer Engineering), Simon D. White (Steward Observatory)

Associate Professors Thomas F. Balsa (Aerospace and Mechanical Engineering), Peter J. Downey (Computer Science), William Filippone (Nuclear and Energy Engineering), K. Y. Fung (Aerospace and Mechanical Engineering), Juan C. Heinrich (Aerospace and Mechanical Engineering), Edward J. Kerschen (Aerospace and Mechanical Engineering), Richard E. Michod (Ecology and Evolutionary Biology), Olgiert Palusinski (Electrical and Computer Engineering), Tudor Ratiu (Mathematics), Randall Richardson (Geosciences), Moshe Shaked (Mathematics), Michael E. Sobel (Sociology), Malur K. Sundareshan (Electrical and Computer Engineering), Simon D. White (Steward Observatory)

Assistant Professors Chris K. Jones (Mathematics), John Palmer (Mathematics), Eugene W. Myers, Jr. (Computer Science), Arne J. Pearlstein (Aerospace and Mechanical Engineering), Timothy W. Secomb (Arizona Research Laboratories)

The committee offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in applied mathematics.

The program in applied mathematics encourages and supports cross-disciplinary research covering a broad spectrum of disciplines in science, engineering and business in which mathematics and modeling play fundamental roles. Students have considerable flexibility in the design of their individual programs. The program attempts to draw out from young men and women their ability to think maturely and more laterally and to train them in all facets of modern applied mathematics. Standards are high but the rewards are great, and graduates have made successful careers in industry and academia.
For both the master’s and doctoral degrees, student programs are quite flexible and individually designed. Essentially, their basic structures involve a selection of some foundation courses in mathematics, a number of other courses both inside and outside the Department of Mathematics, and participation in a problem seminar. Entering students are expected to know advanced calculus and basic probability theory, although they can take such courses as graduate students. The foundation courses include numerical analysis, ordinary differential equations, statistics, stochastic processes, and methods of applied mathematics. in the problem seminar, different faculty members (primarily nonmathematicians) present in-depth analysis of problems arising in their research.

A doctoral dissertation in applied mathematics applies mathematics to a problem arising in an applied discipline or develops mathematical methods for a class of such problems.

Those interested in detailed information about requirements and examinations should contact the committee.

Committee members are currently involved with a variety of research activities, many benefiting from interdisciplinary cooperation. Subjects currently include aerodynamics, analysis of algorithms, applications of Markov processes, applications of theoretical computer science, astrophysical plasma physics, asymptotic methods, biological modeling, boundary layer theory, calculus of variations, combinatorial optimization, cosmic rays, differential equations, differential games, digital image processing, dynamic meteorology, ecology, economics of uncertainty, eigenvalue problems, electrical geophysics, electromagnetic theory, evolution of reproductive strategies, experimental economics, feedback systems, fluid dynamics, fusion devices, gauge field theory, heavy ion reaction theory, human problem solving, hybrid computation, image processing, integral and functional equations, interactive computer graphics, laser theory, limit theorems for probability, mathematical ecology, mathematical modeling and political violence, mathematical physics, mathematical programming, microcirculation, microeconomic theory, networks, non-experimental research design, nonlinear optimization, nonlinear optics, nonlinear partial differential equations, nonlinear wave propagation, non-numerical computing, nuclear many-body theory, nuclear reactor analysis and safety, numerical analysis, numerical modeling, operations research, operator theory, optical pulse propagation, optimal control, parameter estimation, particle transport theory, pattern recognition, perturbation methods, pharmacokinetics, physiological fluid mechanics, plasma physics, population dynamics, power plant simulation dynamics, probability theory, quantum electronics, quantum mechanics, quantum optics, radio astronomy, reaction-diffusion equations, reactor dynamics, relativity, signal processing, simulation, singular perturbations, soil mechanics, statistics, statistical mechanics, stochastic equations, structure of finite nuclei, system identification, systems theory, tensor calculus, and wave propagation.

**ARABIC**
*(See Oriental Studies)*

**ARCHITECTURE**


Associate Professors Harry der Boghosian, Dennis Doxtater, Robert W. Dvorak, Robert L. Nevins

The College of Architecture offers a program leading to the second professional degree, Master of Architecture. For information concerning this degree program, see Requirements for Master's Degrees/Master of Architecture elsewhere in this catalog.

**403. Solar Utilization in the Built Environment** (3) GC I Survey of solar energy utilization principles, methods and case studies focused upon building and site planning design.

**412. Advanced Graphics** (3) GC Advanced graphics, with specific emphasis on photographic techniques for use in portfolio preparation; general review of professional public relations presentation techniques.
114  DEPARTMENTS AND COURSES OF INSTRUCTION

413.  Architecture and the Arid Region (2) GC I Studies of the relationship between architecture and the climatic characteristics of arid regions with emphasis on passive cooling techniques.

414.  History of Architecture: American Architecture (2) GC II Developments in American architecture from the colonial to the early modern period. P, 6 units of art history or architectural history. Nonmajors may petition to enroll.

428.  Field Methods in Environmental Psychology (3) GC II (Identical with Psyc. 428)

429.  Pre-Design Services (3) GC II Principles and operations of gathering, analyzing, interpreting, translating and presenting information and ideas pertinent to architectural design.

433.  Lightweight Construction Techniques (3) GC II Survey of lightweight construction techniques, including pneumatics, tensile membranes, three-dimensional cable nets, grid shells and flexure stiff plates.

439.  Construction Documents (3) GC I Content, intent, functions and practice of preparing documents needed for various construction delivery systems.

444.  Site Planning (2) GC II Studies relating to design determinants for development of outdoor space. Lectures and exercises dealing with individual design criticism including topography, hydrology, climate, and vegetation. Final project summarizing and applying all criteria to a realistic development project is required. (Identical with Ping. 444)

451.  Topics in Architecture (6) GC I Studio work in one of the following: building design, community design, computer-aided design, design development, historic preservation, design technologies, economics and politics in architecture, housing design, design in arid regions, or energy-conscious design. Offerings are limited by faculty availability, and all topics may not be offered each year. Other topics may be introduced.

452.  Senior Project (6) GC I II Studio-based project related to one of the topics in 451. Project should demonstrate a synthesis of knowledge or development of theoretical concepts. P, 451.

459.  Ethics and Practice (3) GC I Standards and values of architectural services and professional project and practice management.

469.  Computer Graphics in Architecture (3) GC I Introduction to the theory, techniques, and applications of computer-aided design, centering on computers in the design process using two and three dimensional graphics to represent architectural data bases. Lectures and seminars on technical topics, plus intensive experience on graphic work stations.

473.  Introduction to the Conservation of Cultural Resources (3) GC I An overview of the Historic Preservation movement in America, including discussion of concepts, rationale for and methods of resource utilization, implementation of plans, legislation, etc. Field trips.

480.  Computer Applications in Architecture (3) GC II Advanced self selected projects exploring potential applications in computer-aided design with emphasis on graphic modeling. Seminars on technical topics with use of outside consultants. P, 470.

484.  Planning the Built Environment (2) GC I A lecture survey dealing with the origins and implications of the physical manifestations of communal ordering systems. An analytic vocabulary is developed with which current and historic settlement patterns are visually compared to discover spatial attributes as a dimension of human experience.

487.  Space: A Social-Cultural View (3) [Rpt./1] GC I Human, socio-cultural use of space including processes of symbolic expression. Investigation of the role of space through ethnographic readings describing both ritual and architectural examples. Consult department before enrolling.

497.  Workshop i.  Community Design for Non-Designers (3) GC I Field trips. Open to nonmajors only. (Identical with L.Ar. 497i and Ping. 497i)

596.  Seminar a.  Readings in Architecture (2) [Rpt.] I II Open to majors only.

597.  Workshop a.  Architecture (3 to 8) [Rpt.] I II Open to majors only. (Identical with Ping. 597a)

ARID LANDS RESOURCE SCIENCES

Committee on Arid Lands Resource Sciences (Graduate)

Professors Robert B. Bechtel (Psychology), Stanley M. Davis (Hydrology and Water Resources), Martin M. Fogel (Renewable Natural Resources), Paul S. Martin (Geosciences), Richard W. Reeves (Geography), Ervin H. Zube (Renewable Natural Resources)
Associate Professors Michael E. Bonine (Oriental Studies), James C. Wade (Agricultural Economics)

The Committee on Arid Lands Resource Sciences offers programs leading to the Doctor of Philosophy degree (but not the master's degree) with a major in arid lands resource sciences. Special interdisciplinary concentrations combining aspects of the biological, physical, and social sciences, not available in the usual major-minor degree programs, may be used by advanced students with promising research projects and strong interests in arid lands.

Interested students should communicate with the chairperson of the Arid Lands Resource Sciences Doctor of Philosophy program, presenting a brief summary of their career goals and proposed dissertation research areas.

Following admission, the study program will be arranged and supervised by a committee of appropriate faculty members. Doctoral students with majors in other fields may use arid lands resource sciences as a minor field.

ART


Assistant Professors Andrew Polk, Jeryldene Wood

The department offers programs leading to the Master of Fine Arts degree with a major in art and the Master of Arts degree with a major in art history or art education.

Admission to advanced degree programs requires appropriate undergraduate preparation at this institution, or one of similar standing, not more than ten years prior to the date of entry.

Degrees

MASTER OF FINE ARTS — Concentrations are available in painting, drawing, sculpture, the print processes, ceramics, metalwork, graphic design, photography, fibers and combined media. For further information concerning this degree see Requirements for Master's Degrees/Master of Fine Arts elsewhere in this catalog.

MASTER OF ARTS (major in art history) — Applicants may be admitted with 18 units of undergraduate credit in art history or with 12 such units plus a substantial amount of credit in related areas of study.

The Master of Arts with a major in art history requires a minimum of 30 units in art history, including three units of 511, six units of 596, and three to six units of 910. With the approval of the adviser, other courses may be substituted for a portion of the 24-unit art history requirement. A maximum of 9 units may be in individual studies including 900 and 910. A reading knowledge of French or German must be demonstrated before the Comprehensive Examination may be taken and the Comprehensive Examination be passed prior to undertaking thesis work. The Comprehensive Examination may be taken no more than twice. A thesis is required.

A concentration in museum studies is available. For further information contact the Art Department.

MASTER OF ARTS (major in art education) — Applicants must have completed an undergraduate program in art education or in art with a teaching credential in art. Slides or photographs of previous studio work must be submitted directly to the Department of Art before admission can be considered.
All students must complete at least 15 units in art education courses, including one Art 496 seminar each semester of enrollment; Art 530, and Art 633. Each student must elect to take 3 units of 910, or in lieu of thesis, 3 units of 900. A final oral examination is required.

Special facilities for graduate work include the works devoted to art within the T. E. Hanley Collection of 37,000 volumes; the Samuel H. Kress Collection of 14th to 19th Century European art, including the surviving panels of the Retablo of Ciudad Rodrigo by Fernando Gallego; the Charles Leonard Pfeiffer Collection of American art, consisting of more than 100 contemporary American paintings; the Edward Joseph Gallagher III Memorial Collection of contemporary American paintings and European, Latin American, and Oriental objects of art; and miscellaneous collections, including the University Print Collection of notable examples of various graphic arts. The University of Arizona Museum of Art schedules exhibitions from these collections and, from time to time, other exhibitions of general or special interest.

**Studio**

405. **Figure Drawing III** (3) [Rpt./5] GC I II Advanced drawing with emphasis on personal expressive development. 6S. P. 6 units of 305.

409. **Drawing Critique** (3) [Rpt./5] GC I II Individual exploration and development of visual concepts through drawing, accompanied by individual and class critiques. P. 6 units of 405.

441. **Advanced Photography** (3) [Rpt.] GC I II Current trends, philosophies and experimentation in still photography. 2R, 2S. P. 341, acceptance of portfolio by Portfolio Committee.


447. **Mixed Media Book** (3) [Rpt./1] GC I II Investigation of the book as a format for presenting visual material; the process of making simple books. Contemporary bookmakers will be presented. 2R, 2S. Field trips. P. 12 units of studio art courses.

452. **Advanced Lithography** (3) [Rpt./5] GC I II Autographic lithography as personal creative medium and professional skill; multiple-color printing with emphasis on controls and quality. 6S. Field trips. P. 352.

453. **Alternative Methods in Printmaking II** (3) [Rpt./2] GC I II Continuation of 353 with emphasis on personal direction, content, and experimentation. 6S. P. 353.

454. **Advanced Relief and Intaglio** (3) [Rpt./5] GC I II Traditional modes of relief block and intaglio plate printmaking expanded via individual research and experiment; emphasis on development of personal aesthetic and professional standards. 6S. Field trips. P. 251.

456. **Portfolio Preparation** (3) [Rpt./1] GC I II Final approach to completion of portfolio. Student's portfolio is critiqued in areas of order, style, and degree of presentation to bring it to a professional level. 6S. P. 9 units of graphic design courses and approval of portfolio by Portfolio Committee.

456. **Editorial Illustration** (3) [Rpt./1] GC I Problems in editorial and book illustration. 6S. P. 9 units of illustration courses and approval of portfolio by Portfolio Committee.

468. **Graphic Design Studio** (3) [Rpt./1] GC I Classroom experience in a professional designer capacity with studio solutions to graphic design problems submitted from campus and community. 6S. Field trips. Consult department before enrolling. P. 9 units graphic design courses, acceptance of portfolio by Portfolio Committee.

469. **Experimental Illustration** (3) [Rpt./2] GC I Experimentation, interpretation and problem-solving through illustration. 6S. Field trips. P. 368, 369, acceptance of portfolio by Portfolio Committee.

471. **Advanced Jewelry and Metalsmithing I** (3) [Rpt./4] GC I Advanced study of the various materials and methods in the construction of jewelry and metalwork. 6S. P. 9 units of metalwork.

472. **Advanced Jewelry and Metalsmithing II** (3) [Rpt./1] GC II Advanced Problems in design and execution of jewelry and metalsmithing projects. Preparation of professional credentials including portfolio, photographing, rendering, exhibitions, and resumes. P. 471.

473. **Advanced Ceramics** (3) [Rpt./5] GC I III Individual studio research and instruction, with emphasis on personal creative development. 1R. 4S. P. 373.

476. **Advanced Fibers** (3) [Rpt.] GC I II Individual interpretations of concept into finished fiber works. P. 276; 9 units of intermediate fibers.

480. **Painting III** (3) [Rpt./5] GC I II Advanced painting concepts, with emphasis on personal expressive development and change. 6S. P. 6 units of 360.

481. **Readings in Contemporary Art** (3) GC I Discussion of contemporary art and artists, based upon assigned readings and slide presentations. Field trips.
483. **Combining Media** (3) [Rpt./5] GC Individual and group projects, including collages, constructions, image sequences, and elements from other art forms (sound, language, movement, etc.).


487. **Advanced Sculpture** (3) [Rpt./5] GC I II 6S. P, 387.

489. **Extensions of the Figure** (3) [Rpt./2] GC I II Life modeling in clay over armatures and other techniques. 6S. P, 287.

505. **Graduate Figure Drawing** (3) [Rpt./5] I II Special problems in drawing, using the classroom model and outside sources as references for personal expression. 6S.

509. **Graduate Drawing Critique** (3) [Rpt./5] I II Individual exploration in drawing media and visual concepts. Classroom and individual critiques.

565. **Graduate Graphic Design Problems** (3) [Rpt./1] I II Two- and three-dimensional design considerations with emphasis on conceptualization and presentation. 6S. Field trips. P, acceptance of portfolio by Portfolio Committee.

567. **Graduate Illustration** (3) [Rpt./1] I II Exploration of any optical material or phenomenon as a possible solution to illustration problems. 6S. P, 466, acceptance of portfolio by Portfolio Committee.

580. **Graduate Painting** (3) [Rpt./5] I II Graduate study in painting with an emphasis on the development of a personal imagery and body of work. 6S.

585. **Graduate Watercolor Painting** (3) [Rpt./5] I II High level experimentation in personal expression with watercolor and related media. Demonstration and critique.

596. **Seminar** p. **Photography and Language** (3) [Rpt./1] II 2R, 2S. Open to majors only.

s. **3-D Concepts** (3) [Rpt./3] I I I

600. **Painting Concepts** (3) [Rpt./2] I II Presentation of one's painting concepts and the concepts of others, citing parallel influences, research, related ideas and implications for highly concentrated student and faculty discussion.

642. **Studio Photography Critique** (3) [Rpt./5] I II Investigation of practical methods of critique and their influence on an artist's developing body of work. Limited to art majors with photography concentration.

671. **Graduate Jewelry and Metalsmithing** (6 to 10) [Rpt./6] I II Graduate study in all phases of jewelry and metalwork. 12 to 20S.

673. **Graduate Studio in Ceramics** (6 to 10) [Rpt./6] I II S Studio research and instruction with emphasis on personal creative development. 12 to 20S. Field trips. P, 473.

676. **Graduate Fiber Studies** (6 to 10) [Rpt./6] I II Graduate experimentation in all aspects of fiber work, with emphasis on the development of a personal style within the medium. 12 to 20S. P, 476.

680. **Graduate Studio** (6 to 10) [Rpt./6] I II P, 12 units of graduate credit in art.

687. **Graduate Problems in Sculpture** (3) [Rpt./6] I II Personal response to form and composition using a variety of technical means including welding, casting, carving and nontraditional techniques. 6S. P, 487.

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**Art History**

411. **Roman Art and Architecture** (3) GC The origin and development of Italian art and architecture from Etruscan beginnings through the Republic to the late Empire. P, both surveys (117, 118) or 6 units of ancient history. (Identical with Clas. 411)

412a-412b. **Medieval Art** (3-3) GC 412a: I II Arts of the nomadic invasions of Western Europe and Hiberno-Saxon, Merovingian, and Carolingian art. 412b: II 1987-88 Survey of Ottonian, Romanesque, and Gothic art from A.D. 1000 through 1250. 412a is not prerequisite to 412b.

413a-413b. **Renaissance Art in Italy** (3-3) GC Painting, sculpture and architecture in Italy. 413a: I 13th-15th centuries. 413b: II High Renaissance to 1600. P, 6 units of history or art history. 413a is not prerequisite to 413b.

414a-414b. **Netherlandish Art** (3-3) GC 414a: Development of painting in the Netherlands and France from the 14th through the 16th centuries. 414b: Painting, sculpture, and architecture in Holland and Flanders. P, 6 units of history or art history. 414a is not prerequisite to 414b.

415a-415b. **Southwest Indian Arts** (3-3) GC (Identical with Anth. 415a-415b)

417a-417b. **19th-Century European Art** (3-3) GC Painting and sculpture. 417a: From the French Revolution to about 1850. 417b: From about 1850 through Impressionism. P, 6 units of history or art history.

418a-418b. **20th-Century Art** (3-3) GC Painting and sculpture in Europe. 418a: 1886 to World War I. 418b: Between the World Wars. P, 6 units of history or art history. 418a is not prerequisite to 418b.
422a-422b. Pre-Columbian Art (3-3) GC 422a: Art of the high cultures of Mesoamerica, with the focus on architecture, sculpture, painting and crafts prior to European contact. 422b: Pre-Columbian art of Central and South America, with particular attention to the Andean area. 422a is not prerequisite to 422b. (Identical with Anth. 422a-422b)

424a-424b. History of Photography (3-3) GC 424a: From its invention to 1895; impact of photography on the art and culture of the 19th century. 424b: As an art medium from 1895 to 1965. P, 6 units of art history. 424a is not prerequisite to 424b.

428. 17th- and 18th-Century Art in Italy and France (3) GC Painting, sculpture, and architecture of the Baroque and subsequent periods. P, 6 units of history or art history.

429a-429b-429c-429d. American Art (3-3-3-3) GC Art in the United States. 429a: Colonial art. 429b: 19th century art. 429c: From 1900 through 1940. 429d: Twentieth century American art from the 1930s to recent times. May be taken in any order. P, 6 units of history or art history.

511. Methods of Art History (3) I Major intellectual approaches to the visual arts developed within the past 150 years. Field trips. Open to majors only.

596. Seminar
   a. American Art (3) [Rpt./2] I
   b. Problems in Renaissance-Baroque (3) [Rpt./2] II
   c. Studies in Medieval Art (3) [Rpt./2] I II
   d. Pre-Columbian Art (3) [Rpt./4] I Consult instructor before enrolling. (Identical with Anth. 596e)
   e. History of Photography (3) [Rpt./4] I II P, 424a or 424b.

693. Internship
   a. Art Museum Training (1 to 6) [Rpt./12 units] I II Open to students concentrating in museum studies only. P, 12 units of graduate art history courses.
   b. Curatorial Training for Archives of Photography (1 to 6) [Rpt./12 units] I II Open to students concentrating in museum studies only. P, 511, 12 units of graduate art history courses.
   c. Archivist Training for Collection of Photography (1 to 6) [Rpt./12 units] I II Open to students concentrating in museum studies only. P, 12 units of graduate art history courses.
   d. Archives of Photography: Preservation/Cataloging (1 to 6) [Rpt./12 units] I II Open to students concentrating in museum studies only. P, 511, 12 units graduate art history courses.

Art Education

431. The Nature of Artistic Expression (3) GC II A discipline-based study of the visual arts providing knowledges and skills necessary to understand and discuss works of art in an historical setting, place works of art in an aesthetic context, and express ideas through art materials. P, 430.

436. Community Arts Careers (3) GC I Structure and function of community arts agencies with emphasis on their relationship to art education theory and practices.

438. Art Criticism in Art Education (3) GC Methods of analyzing art works and aesthetic experiences appropriate to art classroom teaching. Videotapes, films, and readings illustrate concepts and terminology.

530. Introduction to Research in Art Education (3) I II Development of competency in application of language, methods, and diverse research procedures used in the visual arts and education as demonstrated by a scholarly written research report.


630. History and Philosophy in Art Education (3) Critical examination of literature containing fundamental concepts that have shaped the development, scope, and current significance of art education.

633. Issues and Recent Research in Art Education (3) I The identification of problems in art education at various curricular levels; examination of related research with possible implications for practice. P, T.T.E. 493b (in art), or teaching experience.

635. Art Instruction in Higher Education (3) I Philosophy of art learning and teaching in higher education. Training in processes of instruction in art for community colleges, four-year colleges, and universities. P, 15 units of graduate study in art education, art history, or studio art.
ASTRONOMY

Professors Peter A. Strittmatter, Head, J. Roger Angel, George V. Coyne, William F. Hoffmann, J. R. Jokipii, Frank J. Low, George H. Rieke, Elizabeth Roemer, Thomas L. Swihart, Rodger I. Thompson, William G. Tifft, Neville J. Woolf

Associate Professors John Black, Adam Burrows, William J. Cocke, Charles J. Lada, James W. Liebert, Ramesh Narayan, Andrzej G. Pacholczyk, Marcia Rieke, Raymond E. White, Simon White

Assistant Professors Craig Hogan, Christopher Impey

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in astronomy. Specializations are available within the department in theoretical or observational astrophysics and in astronomical instrumentation. In addition, the Department of Planetary Sciences offers a concentration in solar system astronomy and the Committee on Optical Sciences, through the Optical Sciences Center, offers advanced degrees and research in its own field of specialization. For further information see Optical Sciences and Planetary Sciences elsewhere in this catalog.

In view of the heavy demand for admission to the graduate program, applicants are required to submit scores from the Graduate Record Examination (Aptitude and Advanced Test in Physics). Applications for financial aid must be supported by letters of recommendation. Undergraduate majors in physics, mathematics, or astronomy are preferred but exceptions may be made for applicants with other majors in special circumstances.

For the Master of Science degree, a written document but not a formal thesis is required. One foreign language is recommended but not required. A final oral examination is required.

For the Doctor of Philosophy degree the language requirement may be satisfied with Russian, German, or French.

Successful completion of the introductory course sequence, consisting of 515, 502, 522, 575 or 540, 535, 585 for alternate years, as well as 3 graduate physics courses, constitutes demonstration of qualification for more advanced graduate work in either the Master of Science or the Doctor of Philosophy program.

Doctoral students from other departments who elect to minor in astronomy must complete 12 acceptable graduate units in astronomy including at least 6 units at the 500 level.

The facilities of the University of Arizona Observatories, which are associated with the Department of Astronomy, are available for student research. The 90-inch, 36-inch, and 20-inch reflecting telescopes are located at the Kitt Peak Observing Station, 48 miles southwest of Tucson and within the grounds of the Kitt Peak National Observatory. A dormitory and office building provide facilities for overnight and extended observing periods. The Steward Observatory, in collaboration with the Smithsonian Astrophysical Observatory, has constructed a 6-element Multiple Mirror Telescope equivalent in light gathering power to a conventional 176-inch telescope. Campus observing facilities include a 21-inch reflector, the 5-inch James refractor, and the Warner and Swasey transit instrument. The 7-inch Bailey photographic refractor is located on Tumamoc Hill, within a few minutes' drive of the campus. All telescopes have a wide range of modern auxiliary photometric, spectroscopic, and photographic equipment. The 90-inch telescope has, as well, TV acquisition and guidance systems and provision for computer-controlled telescope operation and data acquisition. The Observatory is developing on Mt. Graham a 10-meter telescope for work at mm and sub-mm wavelengths in collaboration with the Max Planck Institute for Radio Astronomy in Bonn, West Germany. The campus buildings provide lecture rooms, research laboratories, staff and student offices, and technical facilities.

Instrumental equipment at the observing stations located in the Catalina Mountains includes a 61-inch reflecting telescope used for a variety of investigations, including high-resolution photography of the moon and planets; a five-foot reflector, a 40-inch reflector, and a 28-inch reflector, all used principally for photoelectric photometry, including investigations in the infrared; an 18/27/48-inch Schmidt telescope for wide-field infrared photometry; and several smaller instruments. A 21-inch telescope for planetary photography is located on Tumamoc Hill. Staff members of the Lunar and Planetary Laboratory participate in supervision of doctoral dissertations.
The principal areas of research at the Steward Observatory include galactic and extragalactic investigations, both observational and theoretical; mm wave and sub-mm wave astronomy; infrared astrophysics; spectrographic and photometric research on single and multiple stars; astronomical instrumentation, theoretical investigations of stellar atmospheres and interiors, the interstellar medium, star formation, and magnetohydrodynamics and general relativity applied to astrophysical problems.

400a-400b. Theoretical Astrophysics (3-3) GC Stars, interstellar matter, galaxies, radio sources, cosmology. P, Math. 254, 6 units upper-division physics.

403. Introduction to the Solar System (3) GC I (Identical with Pty.S. 403)

404. Exploration of the Solar System (3) GC I S (Identical with Pty.S. 404)

502. Introductory Astronomical Instrumentation and Technique (3) I 1988-89 Survey of instrumentation and techniques applicable to astronomical problems; noise sources, mechanical and optical technology, spectrum analyzers, polarimetry, image analyzers, video and electronic techniques.

515. Gaseous Nebulae and the Interstellar Medium (3) II 1988-89 Ionization equilibrium; heating and cooling of H I and H II regions; determination of physical conditions from emission-line spectra; dark reflection nebulae; interstellar grains.


535. Stellar Structure (3) II 1987-88 Virial theorem; gas spheres in hydrostatic equilibrium; polytropes; convective and radiative equilibrium; equations of state; opacities; nuclear reaction rates; stellar model computation; stellar atmospheres and evolution. Strittmatter

540. Basic Properties of Galaxies (3) II 1988-89 Classification, mass determination, photometric properties, dust and gas content, stellar content, systems and clusters, distance scales, galactic dynamics. Tifft/Strittmatter

545. Stellar Atmospheres (3) I 1987-88 Radiative transfer, gray atmosphere, opacity, line formation, non-LTE, curves of growth, stellar hydrodynamics.

551. Satellite and Planetary Perturbation Theory (3) II (Identical with Pty.S. 551)

556a-556b. Electrodynamics of Conducting Fluids and Plasmas (3-3) 1988-89 (Identical with Pty.S. 556a-556b)

575. General Relativity and Cosmology (3) II 1988-89 General relativity, with applications to cosmology and stellar structure; formation of stars and galaxies. Cockett/Weymann


ATMOSPHERIC SCIENCES

Professors E. Philip Krider, Head, George A. Dawson, Robert L. Gall, Benjamin M. Herman, A. Richard Kassander (Emeritus), John A. Reagan (Electrical and Computer Engineering), Richard M. Schotland, William D. Sellers, Dean O. Staley, Sean A. Twomey

Associate Professor Kenneth C. Young

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in atmospheric sciences. In conjunction with the facilities of the Institute of Atmospheric Physics, concentrations are available in physical meteorology, physical climatology, atmospheric electricity, atmospheric radiation, atmospheric chemistry, and atmospheric dynamics.

An undergraduate major or minor in meteorology is not required for admission but some knowledge of the field is desirable. Applicants with undergraduate majors in physics are particularly encouraged to apply.
Degrees

MASTER OF SCIENCE — 30 units of graduate work, including 441a-441b, 451a, and three 500 or 600-level atmospheric sciences courses, are required. All candidates must submit a thesis or a manuscript which has been judged by the student’s committee to be acceptable for publication in an approved scientific journal and must pass a comprehensive written examination in the major field.

DOCTOR OF PHILOSOPHY — In addition to the College requirements, the candidate must demonstrate a reading knowledge of a foreign language approved by his or her committee.

421. Physical Climatology (3) GC II Heat and water balances of the earth-atmosphere system viewed from both the local and global scales; paleoclimatology and theories of climatic change; man's impact on climate. P, 171.

441a-441b. Dynamic Meteorology (3-3) GC Thermodynamics and its application to planetary atmospheres, hydrostatics, fundamental concepts and laws of dynamic meteorology. P, Phys. 121; Math. 254.

450. Air Pollution Meteorology (3) GC 1988-89 Theoretical description and experimental practice relating to the dispersion of gases and particulate matter in the atmosphere. Attention given to the scales of dispersion and the scales of atmospheric turbulence as related to local, regional and global pollution. P, 300 or consult department before enrolling.

451a-451b. Physical Meteorology (3-3) GC Introduction to atmospheric physics, including atmospheric radiation, fluid mechanics, aerosol physics, cloud physics, and atmospheric electricity. P, Phys. 121; Math. 254.

465. Mesoscale Meteorology (3) GC II 1987-88 Description and dynamics of weather systems of the mesoscale. Topics may include fronts, thunderstorms, gravity waves, lake effect storms and sea breezes. P, 300.

471. Synoptic Analysis (3) GC I 1988-89 Principles of meteorological analysis, including surface and upper-level charts, cross-sections, kinematic analysis, structure of the troposphere and tropospheric systems, thermodynamic diagrams. 1R, 6L. P, CR 441a, or 300.

472. Weather Forecasting (3) GC II 1988-89 Techniques for weather forecasting and actual forecasting experience; advanced synoptic analysis. 1R, 6L. P, 471.

489. Sunlight and Skylight (3) GC II 1987-88 The nature of the sun and solar radiation. Optical phenomena in the atmosphere such as mirages, rainbows, haloes, and glories. P, 451a.


530. Micrometeorology (3) I 1987-88 Theoretical aspects of atmospheric turbulence, including discussions of laminar flow, turbulent flow, the mechanical energy equations, and the shear stress and the wind profile. P, 441b.

535. Air/Sea Interactions (3) I 1988-89 Physical characteristics of the oceans; the dynamics of ocean currents and their interactions with the atmosphere; El Nino and other teleconnections between the oceans and the atmosphere. P, 300.


560. Aerosol Science (3) I 1987-88 Physics, mechanics, and optics of individual atmospheric aerosol particles. Topics include formation, dynamics, nucleation and growth, coagulation, scattering and absorption of radiation, and aerosol technology. (Identical with E.C.E. 560)

585. Tropospheric Chemistry (3) I 1987-88 A study of tropospheric chemistry, with emphasis on the controls and feedbacks involving the major constituents, the cycles of the minor constituents, methods of measurement, and applications.


595. Colloquium a. Atmospheric Measurement Techniques (1 to 3) II 1987-88

641. Theoretical Meteorology (3) I Methods of solution of the hydrodynamic equations; identification and analysis of acoustic, gravity, Kelvin-Helmholtz, inertial, Kelvin, barotropic and baroclinic waves. P, 441b.


656a-656b. **Atmospheric Optics and Radiation** (3-3) 1988-89 Theory of atmospheric radiative transfer processes; specific methods for solving relevant equations; applications to problems in radiative transfer and optics. P, Phys. 420. (Identical with Opti. 656a-656b)

683. **Principles of Atmospheric Remote Sensing** (3) II 1988-89 For remote sensing applications, mathematical methods are developed to infer the physical properties of the atmosphere. Techniques using optical and microwave frequencies are examined for their information content. P, 656b; Math. 254. (Identical with E.C.E. 683)

**BILINGUAL/BICULTURAL EDUCATION**

(See Language, Reading and Culture)

**BIOCHEMISTRY**


Associate Professors Hans J. Bohnert, Don P. Bourque, Wah Chiu, William J. Grimes, Jennifer D. Hall (Molecular and Cellular Biology), Martinez Hewlett (Molecular and Cellular Biology), John W. Little, Marc E. Tischler

Assistant Professors Danny L. Brower (Molecular and Cellular Biology), James F. Deatherage, Carol Dieckmann, Ivan Rayment, Elizabeth Vierling

Teaching and research in biochemistry are carried out in several locations in the University and involve the efforts of the above-listed faculty members. These individual faculty members constitute the University Department of Biochemistry, which is responsible for instruction in biochemistry in the Colleges of Agriculture, Arts and Sciences, and Medicine.

The Department of Biochemistry offers the Master of Science and Doctor of Philosophy degrees. Except in unusual circumstances, however, the department will only admit graduate students whose stated objective is the Doctor of Philosophy degree. The department also offers undergraduate instruction in programs of the Colleges of Agriculture, Arts and Sciences, and Medicine, and undergraduate Bachelor of Science and Bachelor of Arts degrees in biochemistry.

Research areas in which graduate studies may be pursued cover most modern aspects of biochemistry including electron and X-ray crystallography; electron tomography; protein structure and function; bioenergetics; plant molecular biology and biochemistry; gene regulation and expression; genetic engineering; membrane and cell surface biochemistry; muscle biochemistry and cell motility; hormone biochemistry, insect biochemistry; and protein, lipid and nucleic acid metabolism.


462a-462b. **Biochemistry** (4-3) GC Introduction to the properties and metabolism of proteins, nucleic acids, enzymes, carbohydrates and lipids. Designed primarily for majors and minors in chemistry, biochemistry and biology. P, Chem. 241b, CR 325. (Identical with Chem. 462a-462b and Tox. 462a-462b)

463. **Biochemistry Laboratory** (2) GC II Introduction to experimentation with biochemical systems, processes and compounds of biochemical importance. 1R, 5L, P, 460 or 462a, or CR 462b.

473. **Recombinant DNA Techniques** (3) GC II (Identical with M.C.B. 473)

501. **Medical Biochemistry** (5) I Comprehensive treatment of general biochemistry, oriented towards human biology, with emphasis on basic concepts; protein and nucleic acid chemistry and metabolism, enzymology, metabolism of lipids and carbohydrates, metabolic regulation and closely related topics. P, Chem. 103b, 104b, 241b, 245b; Phys. 102b.
504. Intermediate Medical Biochemistry (5) I An intermediate treatment of several areas of general biochemistry including metabolism and nutrition, genetics and membranes. Designed to build on the student's prior knowledge of biochemistry. Consult dept. before enrolling. P, 462a-462b.

555. Molecular Mechanisms of Development (3) II 1988-89 (Identical with M.C.B. 555)

561a-561b. Introduction to Biochemical Literature (1-1) II (1988-89) Discussion of the biochemical literature aimed at helping the student evaluate and report the published literature. Primarily for first year graduate students planning a career in biochemistry and desiring to prepare themselves for continued study. P, CR 462a-462b. 561a is not prerequisite to 561b. (Identical with Chem. 561a-561b)


572. Metabolic and Hormonal Control of Cell Function (3) II 1988-89 Advanced treatment of the biochemical aspects of metabolic regulation and hormone action. P, 462a-462b and 575 or consult department before enrolling. (Identical with Chem. 572)

575. Biochemical Techniques (3) I Survey of current techniques used in biochemical research including methods used to study proteins, nucleic acids, membranes, and metabolism. P, 462a-462b. (Identical with Chem. 575)

576. Biophysical Techniques (3) I Survey of current physical techniques used in biochemical research including solution properties of macromolecules, optical spectroscopy, magnetic resonance and x-ray and electron diffraction. P, 462a-462b and Chem. 480a-480b. (Identical with Chem. 576)

595. Colloquium b. Topics in Electron Microscopy (2) [Rpt./2] 1987-88 II (Identical with M.C.B. 595b, which is home)

665. Chemistry of Food Proteins (3) II 1987-88 (Identical with N.F.S. 665)

681. Introduction to Biochemical Research (1 to 2) I II Supervised research experiences in the labs. of individual faculty members. 3 or 6L. Open only to first-year majors. P, CR 561a-561b.

696. Seminar a. Biochemistry I (1 to 3) I b. Biochemistry II (1 to 3) II

800. Research (1 to 16)

801. Medical Biochemistry (5)

804. Intermediate Medical Biochemistry (5) I

891. Preceptorship a. Biochemistry (3 to 12) [Rpt./12 units]
In addition, a number of other departments offer graduate work in areas related to the biological sciences but more closely associated with professional health care. Among these are:

- Engineering (biomedical option)
- Nursing
- Nutrition and Food Science
- Pharmaceutical Sciences
- Pharmacology
- Pharmacology and Toxicology
- Pharmacy Practice
- Speech and Hearing Sciences
- Toxicology

**BIOMEDICAL ENGINEERING**
*(See Engineering)*

**BOTANY**
*(See Ecology and Evolutionary Biology)*

**BUSINESS ADMINISTRATION**

*Committee on Business Administration*

Professors William B. Barrett (Vice Dean), Chairperson, Gerald O. Bierwag (Finance and Real Estate), Dipankar Chakravarti (Marketing), William L. Felix, Jr. (Accounting), Roy E. Marsten (Management Information Systems), Jay F. Nunamaker, Jr. (Management Information Systems)

Associate Professors John Z. Drabicki (Economics), Gregory B. Northcraft (Management and Policy)

The committee offers programs leading to the Master of Business Administration and the Doctor of Philosophy degrees with a major in business administration. These programs are designed to meet the demands for teachers, consultants, and management personnel trained in the application of scientific research to business problems.

All applicants are required to submit scores on either the Graduate Management Admissions Test or the aptitude test of the Graduate Record Examination. Please check with the department prior to enrolling for the test.

**Degrees**

**MASTER OF BUSINESS ADMINISTRATION** — For information concerning this degree see *Requirements for Masters’ Degrees/Master of Business Administration* elsewhere in this catalog.

**DOCTOR OF PHILOSOPHY** — The degree program is interdisciplinary and draws heavily on the fields of mathematics, economics, and the behavioral sciences, as well as the knowledge of a specific management discipline. It is designed for those who wish to prepare for a career as a professor and who demonstrate a capacity for doing research that advances their field.

Candidates must have a bachelor’s degree and proficiency in mathematics at a minimum background of Math. 125a-125b. Individual programs may vary to take advantage of differing backgrounds or to accommodate different special interests. All students must take core requirements composed of two elements: a primary, theoretical core and a secondary, applied core. The primary core consists of the following 9 units: Econ. 501a or 511; 520; and M.A.P. 600. The secondary core consists of 9 units of research methodology courses selected with the consent of the student’s adviser which develop research application skills in the student’s major field.
In addition to the core, the program requires a major in one of the concentration fields available in the college: accounting, finance, organization behavior, operations management, management information systems, quantitative methods in business, and marketing. The minor may be chosen from any area other than the major field with the approval of the minor department or field.

BUSINESS ECONOMICS
(See Economics)

CELLULAR AND DEVELOPMENTAL BIOLOGY
(See Molecular and Cellular Biology)

CHEMICAL ENGINEERING

Professors Gary K. Patterson, Head, Milan Bier, Joseph F. Gross, Richard M. Edwards (Emeritus), Alan D. Randolph, Thomas R. Rehm, Jost O. L. Wendt, Donald H. White
Associate Professors William P. Cosart, Thomas W. Peterson, Farhang Shadman
Assistant Professors Heriberto Cabezas, Simon P. Hanson, Arne J. Pearlstein

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in chemical engineering. The graduate program is designed to provide advanced work in a core of transport phenomena, thermodynamics and reaction engineering with additional selected work in mass transfer, heat transfer, fluid dynamics, control theory, and process simulation. The following interdisciplinary options are also available: biomedical engineering, bioprocessing engineering, energy systems engineering, and materials engineering. For details concerning these options see Engineering elsewhere in this catalog.

Degrees

MASTER OF SCIENCE — Each student program must include 505, 506, and 530, and at least nine additional units of course work in chemical engineering or allied fields. A research project on an appropriate chemical engineering topic and proficiency in computer techniques are required. Ordinarily a thesis is required but, under extraordinary circumstances and with advance approval, a nonthesis program consisting of 33 units of approved course work plus two units of 696a is possible.

DOCTOR OF PHILOSOPHY — In addition to the requirements for the Master of Science degree, advanced work in mathematics, chemistry, physics, or other engineering fields is required. No foreign language is required.

402. Intermediate Engineering Analysis (3) GC I Solution of complex chemical engineering problems utilizing both analytical and numerical techniques. P. Math. 254, Ch.E. 202, CR 204.
413. Process Control and Simulation (3) GC I Theory of automatic control as applied to elementary chemical engineering processes. Use of continuous system simulation languages for study of practical control problems in the process industries. P. CR 402.
418. Physiology for Engineers (4) GC I (Identical with Psio. 418)
419. Physiology Laboratory (2) GC I (Identical with Psio. 419)
421. Topics in Real-Time Computing (3) GC I Introduction to microcomputer- and minicomputer-based real-time computing for data acquisition and process control. Includes study of various languages and operating systems. 2R, 3L.
126 DEPARTMENTS AND COURSES OF INSTRUCTION


435. Corrosion (3) GC II (Identical with M.S.E. 435)

442. Chemical Engineering Design Principles (3) GC I Preliminary economic and design principles associated with chemical process equipment. P, 201, 203, 204, 304, 305; CR 430.

443. Chemical Engineering Plant Design (3) GC II Design project from scoping and process selection, through material and energy balances, equipment design and sizing, to economic analysis of capital cost and operating expense. P, 442.


461. Chemical Process Simulation (2) GC II Use of existing large, modular computer programs for computer-aided process design and analysis; program structure, convergence accelerators and control blocks. P, 442.

465. Current Problems in Energy and Power (1 to 4) [Rpt./1] GC II (Identical with N.E.E. 465)


532. Solid-Fluid Reactions (3) I Characterization of solid structural properties; principles of heterogeneous reactions involving a fluid and a reacting solid. P, 306 and 430, or M.S.E. 450R and 412. (Identical with M.S.E. 532)

545. Combustion Generated Air Pollution (3) II (Identical with A.M.E. 545)


567. Advanced Solar Engineering (3) II (Identical with N.E.E. 567)

569. Energy Use: Analysis and Management (3) I (Identical with N.E.E. 569)


696. Seminar
   a. Chemical Engineering (1) [Rpt./6] I II
   b. Combustion (1) [Rpt./6] I II
   c. Kinetics (1) [Rpt./6] I II
   d. Pollution Control (1) [Rpt./6] I II
   e. Crystallization (1 to 3) [Rpt./6] I II
   f. Extrusion (1) [Rpt./6] I II
   g. Biomedical (1) [Rpt./6] I II
   h. New Developments (1) [Rpt./6] I II

CHEMISTRY


Associate Professors Neal R. Armstrong, Michael F. Burke, Dennis L. Lichtenberger, John V. Rund, G. Krishna Vemulapalli

Assistant Professors Peter F. Bernath, Eugene A. Mash, Jr., Jeanne E. Pemberton, Mark A. Smith, David E. Wigley

The department offers programs leading to the Master of Arts, Master of Science, Master of Education, and Doctor of Philosophy degrees with a major in chemistry. Concentrations are available in analytical, biochemistry, inorganic, organic and polymer, and physical chemistry; and can include chemical physics, materials science, optical sciences, and several other interdisciplinary fields.

Prospective students should write to the Office of Academic Affairs in the Department of Chemistry for information and brochures about the variety of research programs, the faculty involved, the facilities available, and the guidelines for the graduate program in chemistry. Teaching assistantships and/or fellowship support are available for all first-year graduate students. Research support is also available for qualified graduate students.

New students are assisted and advised by the departmental Graduate Study Committee until they are prepared to select a research program and a research adviser. The committee administers examinations for all new students during the week before registration each semester. These examinations cover various branches of chemistry, and the results are used to help students plan an appropriate graduate program.

Degrees

MASTER OF ARTS — Students who plan to teach chemistry in secondary schools will find this program adapted to their needs. A thesis is required but, at the discretion of the department, it need not embody the results of original laboratory research. All students must pass a final oral examination.

MASTER OF SCIENCE — A thesis based upon original research is required. All students must pass a final oral examination.

MASTER OF EDUCATION — See Master of Education elsewhere in this catalog.

DOCTOR OF PHILOSOPHY — The Doctor of Philosophy with a major in chemistry is primarily a research degree. The number and selection of courses is tailored to the individual student's needs and interests according to the guidelines available from the Office of Academic Affairs in the Department of Chemistry. The minor work may be satisfied within the Department of Chemistry. The foreign language requirement must be met in a language approved by the student's...
Dissertation Advisory Committee. Since teaching experience strengthens an individual's grasp of principles, a year of teaching is generally required of each student. A dissertation based upon original laboratory research is required. All students must pass a preliminary examination and a final oral examination.

400a-400b. Chemical Measurements Laboratory (2-2) GC II I Lab. work in modern chemical measurements and instrumentation. 1R, 6L. 400a: P; 424 or CR; for majors, S.I.E. 170 or 272. 400b: P; 480b.

410. Inorganic Chemistry (3) GC I Fundamentals of inorganic chemistry. P, 480a or CR.

424.* Instrumental Analysis (3) GC II Principles of modern instrumental methods of analysis treating basic instrumentation and data acquisition, spectrochemical methods, mass spectrometry, gas chromatography, and electroanalytical and thermal methods. P, 241b, 242b, 325 or 322, Phys. 102b or 103b, 180b.

440. Qualitative Organic Analysis (3) GC II 1987-88 The systematic classification and identification of organic compounds. 1R, 6L. P, 241b, 242b, 243b or 245b, 325 or 322.

446. Organic Preparations (3) GC I 1988-89 Special experimental methods for the synthesis of organic compounds. 1R, 6L. P, 241b, 242b, 243b or 245b.

460.* General Biochemistry (5) GC I (Identical with Bioc. 460)

462a-462b.* Biochemistry (4-3) GC (Identical with Bioc. 462a-462b)

480a-480b. Physical Chemistry (3-3) GC Fundamental principles of physical chemistry. P, 103b and 104b, or 105b; Math. 125b; Phys. 102b or 103b or 116 or CR.

481. Biophysical Chemistry (3) GC II Topics in physical chemistry pertinent to the biological sciences, including chemical dynamics, transport processes, thermodynamics, bonding, and spectroscopy. P, 480a.


503. Intermediate Physical Chemistry (3) I General survey of physical chemistry, including thermodynamics, structure, kinetics and electrochemistry. P, 480b.

504. Intermediate Inorganic Chemistry (3) I Principles of modern inorganic chemistry, including synthesis, structure, physical properties, and reactivity of inorganic compounds and materials.

510a-510b. Advanced Inorganic Chemistry (3-3) II I Survey at the advanced level of the chemistry of the elements. P, 440.

512. Advanced Inorganic Preparations (2 to 4) II Modern inorganic syntheses, including instruction in the use of high pressure, temperature, and vacuum techniques and in the manipulation of unstable compounds. 6 to 12L.

517. Structural Chemistry (3) II 1988-89 Introduction to the determination of structures of complex molecules by X-ray crystallography; the evaluation of structural information; current topics in structural chemistry. 2R, 3L.


521. Advanced Instrumental Analysis (3) I Topics in spectrophotometry, emission spectrometry, chromatography, electroanalysis, principles of instrumentation and data acquisition at an advanced level. P, 424, 480b.

522. Electroanalytical Methods (3) II 1988-89 Principles of electrochemistry and electroanalysis, including topics on electrochemical equilibrium and kinetics, potentiometry, voltammetry, amperometry, coulometry, chronopotentiometry, and modern cyclic and pulse methods. P, 480b.


524. Chemical Instrumentation (4) II Data acquisition and experiment control by analysis and digital techniques; design of chemical instrumentation. 3R, 3L, P, 424.

525. Chemistry of Metal Chelates (3) I 1987-88 Theory underlying the application of chelating reagents in chemical analysis. P, 523.


528. **Advanced Instrumental Laboratory (2)** I Laboratory experiments in spectrophotometry, emission spectrometry, chromatography and electroanalysis. 6L, P, CR 521.

530. **Radiochemistry and Radiation Detection (3)** I (Identical with N.E.E. 530)

540. **Organic Syntheses (3)** I Organic reactions and the methods by which they are applied to synthetic problems in organic chemistry. P, 241b, 480b.


561a-561b. **Introduction to Biochemical Literature (1-1)** (Identical with Bioc. 561a-561b)

563. **Enzymes (3)** II 1988-89 (Identical with Bioc. 563)

570. **Molecular Biology of the Cell Membrane (3)** I 1988-89 (Identical with Bioc. 570)

572. **Metabolic and Hormonal Control of Cell Function (3)** II 1988-89 (Identical with Bioc. 572)

575. **Biochemical Techniques (3)** I (Identical with Bioc. 575)

576. **Biophysical Techniques (3)** I (Identical with Bioc. 576)

580. **Introduction to Quantum Chemistry (3)** I An introduction to quantum mechanics, with applications to atomic structure and spectra, the nature of chemical bonding and molecular structure. P, 480b.

581. **Chemical Thermodynamics (3)** II Advanced concepts in both classical and modern thermodynamics, with particular emphasis on thermodynamics in solution. P, 480b.

582. **Statistical Thermodynamics (3)** I Introduction to classical and quantum statistical thermodynamics with application to ideal gases and simple solids; equations of state and elementary solution theory. P, 480b.


587. **Introduction to Molecular Spectroscopy (3)** II Modern molecular spectroscopy including rotational, vibrational, and electronic spectroscopy and their various combinations. P, 480a-480b or consult department before enrolling.


614. **Organometallic Compounds (3)** II 1987-88 Compounds containing carbon-to-metal bonds, with emphasis on those of the transition elements, and the determination of their structures. P, 410.

615. **Coordination Chemistry (3)** I 1987-88 Selected topics in the area of coordination compounds of transition metals, with particular emphasis on ligand field theory, the symmetry aspects of the spectral properties of transition metal complexes and their magnetic behavior. P, 510b or CR.

616. **Chemistry of the Main Group Elements (3)** I 1988-89 Theory, structure, and chemistry of the groups III, IV, and V elements. The chemistry of the hydrides, particularly of boron, are emphasized. Current theoretical approaches and experimental techniques are stressed. P, 510a.

618. **Computations in Chemistry (3)** I [Rpt./1] II 1988-89 State-of-the-art computational methods in chemical research, including approximate and ab initio electronic structure methods, molecular mechanics, and modeling graphics. 2R, 3L. P, consult department before enrolling.


642a-642b. **Polymer Chemistry (3-3)** II 1987-88 Synthesis, stereochemistry, and mechanisms of formation of high polymers. 642a: Condensation and ring-opening polymers. 642b: Vinyl polymers. P, 540. 642a is not prerequisite to 642b.

644. **Heterocyclic Compounds (3)** I 1987-88 The behavior of the more important heterocyclic systems. P, 540.


687. **Molecular Spectroscopy** (3) 1967-88 Applications of quantum mechanics to the interpretation of the spectra of molecules of chemical and biological interest. P, 580.

691. **Preceptorship**
   a. College Teaching (1) 1 II S
   b. Chemistry Course Development (1) 1 II S
   c. Professional Service (1) 1 II S

   *Note: A combination of 691 a, b, or c may be taken up to a total of 8 units.*

695. **Colloquium**
   a. Chemical Research Opportunities (1) 1
   b. Exchange of Chemical Information (1 to 3) [Rpt./7 units] 1 II S

696. **Seminar**
   a. Analytical Chemistry (1 to 3) [Rpt./8 units] 1 II
   b. Inorganic Chemistry (1 to 3) [Rpt./8 units] 1 II
   c. Organic Chemistry (1 to 3) [Rpt./8 units] 1 II
   d. Physical Chemistry and Chemical Physics (1 to 3) [Rpt./8 units] 1 II

697. **Workshop**
   a. NMR Methods (1 to 3) I II
   b. Electron Spectroscopy and Surface Analysis (1 to 3) I II
   c. X-Ray Crystallography (1 to 3) I II
   d. Computational Methods (1 to 3) I II
   e. Chemical Instrument Fabrication (1 to 3) I II
   f. Chemical Glasswork (1 to 3) I II
   g. New Methods in Chemistry (1 to 3) [Rpt./9 units]

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**CHILD DEVELOPMENT AND FAMILY RELATIONS**

*(See Family and Consumer Resources)*

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**CHINESE**

*(See Oriental Studies)*

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**CIVIL ENGINEERING AND ENGINEERING MECHANICS**


Associate Professors Gary L. Amy, Donald B. Hawes (*Emeritus*), Edward A. Nowatzki, Margaret S. Peterson, Robert H. Wortman

Assistant Professors Robert G. Arnold, Curtis W. Bryant, Jay S. DeNatale, Mohammad R. Ehsani, Panos D. Kiousis, Tribikram Kundu, Bruce E. Logan, James M. Witkowski

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in civil engineering and engineering mechanics. Work is directed toward research and professional development in such areas as applied mechanics, engineering materials, regional development and urban planning, highway engineering, hydraulics and fluid dynamics, sanitary and environmental engineering, soil mechanics and soils engineering, surveying and mapping, water resources, structural engineering, and transportation. Certain interdisciplinary options are available; master's degree students may select sanitary and environmental engineering or materials engineering, and doctoral students may select sanitary and environmental engineering. For further information concerning these options see *Engineering* elsewhere in this catalog.
Applicants should have completed an undergraduate major in civil engineering or engineering mechanics, but those with majors in the physical sciences or other engineering disciplines are also encouraged to apply, since such backgrounds provide excellent preparation for the approach to some areas of graduate work within the department.

**Degrees**

**MASTER OF SCIENCE** — A thesis or engineering report is required. At the option of the department, the degree may be awarded, without a thesis or engineering report, to candidates for the Doctor of Philosophy degree who have passed the preliminary examination.

**DOCTOR OF PHILOSOPHY** — A minor field may be selected from architecture, chemistry, geology, mathematics, mechanical engineering, materials science and engineering, mining engineering, nuclear engineering, physics, or systems engineering, or from within the Department of Civil Engineering and Engineering Mechanics. Still other fields are available as minors with the approval of the head of the department.

**Civil Engineering**

In addition to the courses listed below, the faculty of the Department of Civil Engineering and Engineering Mechanics is prepared to offer temporary courses in the following areas, subject to faculty availability and student interest: public works planning and engineering, construction engineering, hydraulic engineering, sanitary and environmental engineering, structural engineering, soils engineering, transportation engineering, surveying and mapping, and urban planning and engineering.

Credit for these courses is offered in both civil engineering and engineering mechanics.

407. Drainage of Irrigated Lands (3) GC II (Identical with A.En. 407)

423. Hydrology (3) GC I II Elementary treatment of major topics in hydrology, including rainfall, evaporation, groundwater, and runoff. Field trips. P, 321. (Identical with Hydr. 423)

424. Hydraulic Engineering Design (3) GC II Hydraulic criteria for design of bridges, stilling basins, gates, open-channel distribution and collection systems; sediment-transport effects; pipe networks and pumping systems. P, 322.

432a-432b. Advanced Structural Engineering Design (3-3) GC Advanced problems in the analysis and design of concrete, steel, and wood structures; yield line and plastic design methods, lateral and vertical load analysis of bridges and multistory buildings; introduction to seismic design; use of structural computer programs. 432a: P, 336. 432b: P, 337.

440. Foundation Engineering (3) GC II Site and subsurface investigations, design of footings and pile foundations; design of foundations on collapsing and swelling soils; computer methods. P, 340.

441. Stability Problems in Geotechnical Engineering (3) GC I Stability analysis for earth slopes, including planar, circular piecewise-linear, and composite-surface methods: analyses for static and steady-flow conditions; earth pressure theories and calculations for generalized conditions; design of rigid and flexible retaining structures; design of braced and tie-back shoring systems; design of reinforced earth walls; computer-aided analysis and design. P, 340.

452. Engineering Surveys (3) GC I CDTSolar and Polaris observations; mineral, public, and private land surveys; route surveying, curves, and earthwork; triangulation, photogrammetry, and modern engineering surveys. 2R, 3L. P, 151.

454. Photogrammetry (3) GC II Reading, interpretations, and geometric characteristics of aerial photographs; stereoscopic principles and their application in the production of planimetric and topographic maps. 2R, 3L. Field trips. P, 151, Math. 125a.

455. Irrigation Engineering (3) GC II (Identical with A.En. 455)

456. Boundary Surveys and Legal Principles (3) GC II Boundary control; property descriptions; public land surveys; writing and interpretation of deeds; subdivision standards; legal aspects; rights, duties and liabilities of land surveyors. Field trip.


463. Traffic Engineering (3) GC I Methods for the efficient and safe operation of transport facilities through analysis of capacity, safety, speed, parking, and volume data. P, 360.
464. **Airport Planning and Design** (3) GC II Location, analysis and design of airports and airport facilities, including aircraft characteristics, site selection, configuration, capacity, access and terminals. Field trips. P, 360.

465. **Civil Engineering Design** (3) GC I II Methods and approaches to civil engineering planning and design problems including the consideration of social, environmental, physical, and organizational constraints; application of systems concepts and analytical methods in planning and design problems and projects.

468. **Urban Transportation Planning** (3) GC II CDT Transportation planning in relation to urban development; techniques and procedures for developing long-range regional plans. P, 360 or consult department before enrolling. (Identical with Ping. 468)

471. **Water Quality Control** (3) GC II Aspects of water quality maintenance; physical, chemical and biological factors in water and wastewater treatment and natural purification. 2R, 3L. Degree credit available for nonmajors only. P, Chem. 103b. (Identical with Hydr. 471 and Ws.M. 471)

477. **Environmental Impact of Energy-Related Systems** (3) GC II Effects of energy development and utilization; legal and technological approaches to environmental quality management. (Identical with E.C.E. 477, N.E.E. 477)

479. **Environmental Air Pollution** (3) GC I Air pollution sources and pollutant control, with special consideration of the meteorological, urban, rural, industrial, and health aspects.

481. **Construction Methods** (3) GC II Introduction to estimating; construction planning and methods; selected topics of fundamental importance in construction, including the Critical Path Method and PERT. 2R, 3L. P, 336 or 337, 380 or CR.

486. **Fundamentals of Industrial Hygiene** (3) GC I (Identical with O.S.H. 486)

487. **Advanced Industrial Hygiene and Safety** (3) GC II (Identical with O.S.H. 487)

503. **Subsurface Fluid Dynamics** (3) I (Identical with Hydr. 503)

504. **Numerical Methods in Subsurface Hydrology** (4) II (Identical with Hydr. 504)

521. **River Engineering** (3) II River geomorphology, stabilization and rectification of alluvial rivers, canalization, waterborne commerce, impacts of river engineering works. P, 322.

522. **Hydropower Engineering** (3) II Hydrologic analysis, evaluation of site potential, turbine selection, power plant civil works, project feasibility. P, 322, 423.

525. **Water Quality Modeling** (3) I Deterministic and stochastic modeling of surface water systems with particular emphasis on water quality management functions. Applications and modifications of Streeter-Phelps technique for predicting oxygen levels in streams. P, 321. (Identical with W.R.A. 525)

526. **Water Quality Management** (3) II (Identical with W.R.A. 526)


532. **Advanced Strength of Materials** (3) II Advanced problems in the analysis of deformable solids including curved beams, nonprismatic beams, torsion of thin-walled members, beam on elastic foundation, inelastic deformation.

533. **Plastic Analysis and Design** (3) II Material and member behavior to full plasticization; redistribution of forces; plastic design of continuous beams and frames; influence of axial and shear forces; deflections and rotations; alternating plasticity; shakedown analysis. P, 432 or consult department before enrolling.

536. **Computer-Aided Geometric Design** (3) I (Identical with A.M.E. 536)

537. **Prestressed Concrete Structures** (3) II Behavior, analysis, and design of statically determinate and indeterminate prestressed concrete structures. P, 337.

544. **Soil Stabilization** (3) II Purpose of soil stabilization; stabilization using mechanical means, cement, asphalt, lime, salt and resins; factors governing stabilization techniques; special application. P, 340.

547. **Seepage and Earth Dams** (3) I Principles of flow in porous media; analytical and approximate solutions of confined and unconfined flow; seepage erosion piping and filter design; earth and rock fill dam construction and design; stability analyses. P, 340.

548. **Numerical Methods in Geotechnical Engineering** (3) I Brief statements and applications of numerical methods based on closed-form solutions, finite difference, finite element and boundary element methods for problems involving soil structure interaction such as piles, retaining walls, group piles, underground works; seepage; and consolidation. P, 340, 402.

560. **Ground-Water Management** (3) II (Identical with W.R.A. 560)

561. **Structural Design of Flexible Pavements** (3) I Analysis of loads, stresses, material characteristics, and environmental factor for the theoretical and practical design, construction and maintenance of pavements. P, 340, 361.
562. **Structural Design of Rigid Pavements (3)** II Analysis of loads, stresses, material characteristics, and environmental factors for the theoretical and practical design, construction and maintenance of these pavements. P, 340, 361.


565. **Quick Response Transportation Planning Methods (3)** I 1987-88 Quick response transportation tools for subarea, problem and policy analysis, and strategic planning in the urban setting. (Identical with Ping. 565)

566. **Highway Geometric Design (3)** II 1988-89 Study of geometric elements of streets and highways, with emphasis on analysis and design for safety. P, 463.


574. **Solid and Hazardous Waste Management (3)** I Engineering, legal, planning, and management aspects of solid and hazardous wastes; overview of waste generation, collection, transport, processing, recovery, and disposal; emphasis on municipal wastes.

575. **Microbiology of Environmental Engineering (3)** I Microbiological concepts and their application to natural and engineered systems for upgrading water and wastewater quality. 2R, 4L. P, 370.

576. **Chemistry of Environmental Engineering (3)** I Chemistry of natural waters and water and wastewater treatment processes. Chemical thermodynamics, equilibria and kinetics are applied to environmental systems. Lab. emphasizes analytical methods. 2R, 3L. P, 370.

596. **Seminar**
   a. **Sanitary and Environmental Engineering (1 to 3)** II
   b. **Geomechanics/Mechanics (1) [Rpt./2]** II (Identical with E.M. 596b)


621. **Sediment Transportation (2)** I Erosion, transportation and deposition of sediments by flowing water; sediment properties and their measurement; bed load and suspended load movement; river behavior and control. P, 321.

622. **Open-Channel Flow (3)** I Continuity, energy and momentum principles applied to steady and unsteady flow in open channels; channel controls, transitions, flood routing, and models. P, 322.

623. **Flow through Hydraulic Structures (3)** II 1988-89 Subcritical and supercritical flow through culverts, bridges, spillways, stilling basins, transitions, bends; hydrologic effects on inflow; pumps and turbines. P, 322.

624. **Planning and Design of Multipurpose Water Resources Projects (3)** II Design of water resource systems for surface water supply, flood control, hydropower and navigation, either as single purpose or as multipurpose projects; brief review of environmental, economic and legal aspects. Field trips. P, 321, 423.

633. **Reinforced Concrete Members (3)** I Inelastic behavior of beams and columns; short- and long-term beam deflections; combined bending, shear, and torsion in beams; behavior under load reversals; analysis and design of beam to column connections and shear walls. P, 432b.

637. **Soil-Structure Interaction (3)** I 1987-88 Explanation of soil-structure interaction, closed form and numerical solutions, beams, axially and laterally loaded piles and walls, wave equation for piles, group piles, slabs on deformable media. P, 640 or 641 or consult department before enrolling.

640. **Advanced Soil Mechanics (3)** I Site investigation and in situ testing; shear strength of sands and clays; interpretation of laboratory test results; consolidation theory: one-dimensional infinitesimal and finite strain; slope stability. P, 340.


642. **Engineering Characteristics of Soil (3)** II Advanced theories of mechanical and physical aspects of soil. Lab testing including index parameters, compaction, consolidation, shear strength; introduction to critical state and plasticity aspects. 1R, 6L. P, 640.


648. Constitutive Laws for Engineering Materials (3) II 1987-88 Statement of axioms of continuum mechanics strain, stress and nonlinear behavior. Laboratory testing including hyperelasticity, hypoelasticity, rate type models, plasticity review, hardening, volume change and dilatancy, softening, inherent and induced anisotropy, laboratory testing and implementation. P, E.M. 505, 603, or consult department before enrolling. (Identical with E.M. 648)


671. Advanced Water and Wastewater Analysis (3) II Advanced chemical, physical and microbiological analyses as related to water and wastewater quality and advanced treatment process design. 1R, 6L. P, 371.

673. Advances in Water and Waste Reclamation and Reuse (3) II Theory, application, and evaluation of currently developing techniques in water and waste reclamation and reuse. P, 675.

675. Wastewater Treatment (3) I Administration, financing, design, construction, and operation of wastewater disposal systems. P, 371.


Engineering Mechanics

In addition to the courses listed below, the faculty of the Department of Civil Engineering and Engineering Mechanics is prepared to offer temporary courses in the following areas, subject to faculty availability and student interest: public works planning and engineering, construction engineering, hydraulic engineering, sanitary and environmental engineering, structural engineering, soils engineering, transportation engineering, surveying and mapping, and urban planning and engineering. Credit for these courses is offered in both civil engineering and engineering mechanics.

402. Introduction to Finite Element Methods (3) GC I II (Identical with C.E. 402)

502. Advanced Finite Element Analysis (3) II Approximation functions, Lagrangian and Hermitian interpolation, isoparametric elements and numerical integration; mixed, hybrid and boundary element methods, nonlinear analysis, nonlinear problems in solids under static and dynamic loads, time integration schemes, fluid and heat flow coupled problems and mass transport. P, 402 or consult department before enrolling. (Identical with A.M.E. 502)

505. Continuum Mechanics (4) I 1987-88 Analysis of deformation, principal stresses and strains, velocity fields, and rate of deformation; constitutive and field equations; elementary elasticity.

539. Advanced Structural Mechanics (3) II (Identical with A.M.E. 539)

596. Seminar
b. Geomechanics/Mechanics (1) [Rpt./2] II (Identical with C.E. 596, which is home)

603. Elasticity Theory and Application (3) I General three-dimensional equations of elasticity; problems in plane stress, plane strain, extension, torsion; energy and residual (Galerkin) methods; applications to rings, beams, plates, torsion and other problems. P, C.E. 217, 302 or S.I.E. 270.

604. Plasticity Theory and Application (3) II Yield conditions and flow rules for perfectly plastic and strain hardening materials; application to various elastoplastic problems such as bars, cylinders and plates; effect of volume change behavior, isotropic and anisotropic hardening plasticity with expanding/contracting yield surfaces.


635. Matrix Methods in Structural Mechanics (3) I Formulation of the force and displacement methods; the finite element method, with application to bar, beam, plate, and shell structures; organization and development of computer programs; linear and nonlinear systems. P, C.E. 331 or A.M.E. 436.
637. **Plates and Shells** (3) I Theory and analysis of circular, rectangular and continuous plates by classical, numerical and approximate methods; introduction to in-plane forces and shells. P, C.E. 336 or A.M.E. 434.


648. **Constitutive Laws for Engineering Materials** (3) II 1987-88 (Identical with C.E. 648)

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**CLASSICS**

Professors David Soren, Head, Norman Austin, Albert Leonard, Jr., Garnet D. Percy (Emeritus)  
Associate Professors Richard C. Jensen, Jon D. Solomon, Thomas D. Worthen  
Assistant Professor Holt Parker

The department offers a degree of Master of Arts with a major in classics with concentrations in classics (Greek/Latin) or classical archaeology. The graduate courses are open to all graduate students with the permission of the instructor, with the exception of 510, 553, and 599, which are open only to students admitted to the Master of Arts degree program in Classics.

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401. **Latin Reading Course** (3) [Rpt.] GC I II Extensive readings in one of the following: epic, lyric, drama, history, oratory, satire, epistles, novel, philosophical, technical or medieval literature. P, 201b.

402. **Greek Reading Course** (3) [Rpt.] GC I II Extensive readings in major Greek authors including Homer, Plato, and the historians and dramatists. P, 202b.

403a-403b. **History of Greece** (3-3) GC (Identical with Hist. 403a-403b)

404a-404b. **History of Rome** (3-3) GC (Identical with Hist. 404a-404b)

409. **Greek Composition** (3) GC II Analysis of Greek prose style and practice in composing Greek prose. P, 202b.


411. **Roman Art and Architecture** (3) GC (Identical with Art 411)

412. **Topics in Greek Philosophy** (3) [Rpt./1] GC Extensive readings in Greek in one of the following areas of Greek philosophy: the pre-Socratics, Plato's ethics and epistemology, Aristotle's Nicomachean Ethics.

413. **Augustan Literature** (3) GC II Survey of the major writers of the Augustan Age, the period from about 30 B.C. to 14 A.D., with the exception of the Eleigiac poets. Readings in Latin. P, 201b.

414. **Medieval Latin** (3) GC Survey of Latin literature during the thousand years between the end of the classical period and the beginning of the Renaissance. Readings in Latin. P, 201b.

415. **Latin Love Elegy** (3) GC Intensive reading in the Latin texts of Ovid, Tibullus and Propertius.

443a-443b. **The Archaeology of Neolithic and Bronze Age Greece** (3-3) GC History, art and culture of prehistoric Greece through the study of archaeological excavations. 443a: Paleolithic through the end of the Middle Bronze Age. 443b: The Minoan and Mycenaean cultures of the Late Bronze Age. 443a is not prerequisite to 443b. P, 6 units in classics, history, or anthropology. (Identical with Anth. 443a-443b)

454. **Greek and Roman Sculpture** (3) GC A survey of the development of classical sculpture from the eight century B.C. to circa 300 A.D. P, 340a-340b.

456. **Greek and Roman Painting** (3) GC Greek vase painting from the Dipylon vases of the Geometric period in Athens to the Orientalizing animal styles of Corinth and the Black and Red figured attic style. Also, survey of ancient Roman painting and mosaics. P, 340a-340b.

457. **Greek Architecture** (3) GC A survey of the architecture and architects of Greece from the Neolithic to Roman periods including such sites as Nèa Nikomedia, Aegina, Lerna, Tyrsyn, Mycenae, Athens and Corinth. P, 340a-340b.

463. **Classical Field Archaeology** (3) [Rpt./1] GC S Field training and lecture program for students beginning in archaeology; includes trench supervision, stratigraphy, locus theory, and oral and written reports on field techniques. Offered on several archaeological sites in the Mediterranean area. P, consult department before enrolling. (Identical with Anth. 463)

470. **Greek Philosophy** (3) GC [Rpt./1] (Identical with Phil. 470)
488. History of Byzantium (3) GC II (Identical with Hist. 488)


511. Greek Lyric Poetry (3) Intensive study in Greek of the early Greek Lyric writers from Archilochus to Bacchylides, including Pindar. P, 202b.

512. Topics in Greek Drama (3) Close reading in Greek of either (1) tragedy — one play each by Aeschylus, Sophocles and Euripides or (2) comedy — two plays of Aristophanes, one of Menander. P, 202b.

513. Roman Drama (3) Representative plays of Plautus, Terence and Seneca, read in Latin. P, 201b.

514. Homer (3) Close reading of selections from the Iliad and Odyssey in Greek and an introduction to the critical secondary literature. P, 202b.

515. Cicero (3) The life of Cicero illustrated by means of close reading of selected works in Latin (pro Caelio, selections from the Philippiques, the Verrine Orations) as well as selections from his letters. P, 201b.

553. Introduction to Graduate Study in Classical Archaeology (3) An historiographic survey of classical archaeology with discussion of Heinrich Schliemann, Luigi Palma de Cesnola, Charles Follin McKim and others. P, 340a or 340b.

554. Topics in Greek and Roman Architecture and Urbanism (3) Research papers on an aspect of ancient architecture which involves not only monuments themselves but attempts to consider a building in its physical and cultural setting. P, 340a or 340b.

555. Topics in Greek and Roman Archaeology (3) Research papers and oral presentations on different aspects of Greek and Roman archaeology; preparation in writing scholarly articles for refereed journals. P, 340a or 340b.

556. Greek and Roman Provincial Archaeology (3) Survey of classical archaeology in ancient Tunisia, Cyprus, Portugal and Turkey. P, 340a or 340b.

595. Colloquium
   1. Advanced Studies in Ancient History (3) [Rpt./5] II (Identical with Hist. 595f, which is home)

596. Seminar
   a. Ancient Greek Literature (3) Open to graduate majors only.
   b. Latin Literature (3) Open to graduate majors only.
   c. Aegean, Roman and Mediterranean Provincial Archaeology (3) Open to graduate majors only.

CLINICAL ENGINEERING
(See Engineering)

CLOTHING, TEXTILES AND INTERIOR DESIGN
(See Family and Consumer Resources)

COMMUNICATION

Professors Michael Burgoon, Head, Judee K. Burgoon, Henry L. Ewbank, Jr., Kionda Lynn (Emerita), Alethea S. Mattingly (Emerita), Frank L. Meyskens (Internal Medicine)
Associate Professors James W. Davis, Henry C. Kensi, Jr. (Political Science), Margaret Neale (Management and Policy), Robert W. Sankey, David A. Williams
Assistant Professor David B. Buller

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in communication. Work leading to the Master of Education degree with a major in communication also is offered in cooperation with the College of Education.

Four program options are available for the Master of Arts degree, the departmental program with a thesis or nonthesis option and the interdisciplinary program with thesis or nonthesis. The thesis option requires a minimum of 31 units, including four thesis units; 36 units are required in the nonthesis alternative. Those electing a departmental program may count a maximum of three units taken outside the department toward the required minimum. Those electing an interdisciplinary program (e.g., organizational communication concentration) must take a minimum of nine units outside the department. These nine outside units must provide the
student with a coherent concentration in a specific area outside the department and be approved by the Director of Graduate Studies. Three units of internship and/or independent study may be included in the required minimum. The thesis option is strongly encouraged for master's students planning to enter a doctoral program. For those interested in applied programs that will prepare them for positions in industry and government, flexibility in designing individual programs exists.

Doctoral students must complete at least 36 units of course work in the major (including up to nine units from the master's degree), one or two minors, plus the dissertation, and must demonstrate proficiency in a scholarly research tool. A maximum of six units of internship and/or independent study, not including those counted toward the Master of Arts degree, may be included in the required minimum.

Students in the master's program are required to complete courses 610 and 620, plus a methods course, and have a total of 12 units at the 500 or 600 level in communication, including 610 and 620 but not including independent study, internship, and thesis credits. Doctoral students are required to complete courses 610, 620, 660, and 670. For both master's and doctoral students, all courses to be counted toward the minimum hours requirements must carry a grade of B or better (or P or better for S/P Special Grades).

In addition to the materials required by the Graduate College, applicants for admission must file with the department a departmental application form, three letters of recommendation, and Graduate Record Examination scores. Applicants for the doctoral program must submit a master's thesis or other evidence of scholarly writing.

403. Theories of Small Group Communication (3) GC I II Theories of small group communication, their research backgrounds, and their relevance to communicative interaction in small groups.

409. Theories of Mass Communication (3) GC II An in-depth analysis of theories of the social effects of various mass media sources on society.

411. Bargaining, Negotiation, and Conflict Management (3) GC I Consideration of advanced problems in group interaction, with emphasis on the analysis and solution of communication problems.

412. Organizational Communication (3) GC Analysis of interpersonal and group communication practices affecting goal achievement in business, governmental, and professional organizations.

415. Nonverbal Communication (3) GC I Theory and research on nonverbal communication codes (kinesics, touch, voice, appearance, use of space, time and artifacts) and social functions (impression formation and management, relational communication, emotional expressions, regulation of interaction, social influence).

417. Relational Communication (3) GC II The relational communication process and messages people use to define interpersonal relationships, including dominance-submissiveness, affection, involvement and similarity. P, 104.

421. Political Communication (3) GC I 1988-89 Investigation and analysis of communication principles and practices in contemporary campaigns for elective office.

423. Topics in Rhetorical Theory (3) [Rpt./1] GC Intensive reading and analysis of the works of major rhetorical theorists. Each semester will focus on a specific era or perspective.


428. Communication Research Methods (3) GC II 1988-89 Theories of communication and their research backgrounds; research methodology in communication behavior studies.

445. Communication of Poetry (3) GC I Types of poetry analyzed, with emphasis on their differentiation for oral presentation; preparation for and presentations of a public recital. P, 106.

446. Communication of Fiction (3) GC II Analysis of short stories and selected short novels, with emphasis on point of view, tone, and characterization in preparation for performance. P, 106.

447. Group Communication of Literature (3) GC I 1988-89 Study in forms, styles, and aesthetics of Readers Theatre, Chamber Theatre, and the documentary; examination of essay, biography, short fiction, novel, and dramatic literature for group reading. P, 3 units in communication, drama, or English.

462. Communication and Human Relationships (3) GC S An advanced course enabling students to inventory, evaluate, and develop oral communication skills in the interpersonal, group, and organizational dimensions of their lives. P, senior standing.

496. Proseminar

525. Rhetorical Criticism (3) I 1987-88 Systems of criticism; rationale of approaches to the critical act; analysis of representative criticism of rhetorical events and movements.
138 DEPARTMENTS AND COURSES OF INSTRUCTION

610. **Communication Theory I** (3) I An overview of theoretical perspectives on the role of verbal and nonverbal communication in the process of generating and understanding development of interpersonal relationships.

620. **Communication Theory II** (3) II An overview of historical and theoretical perspectives on communication strategies used in social influence attempts from interpersonal to mass media contexts.

621. **Theory Construction in Communication** (3) I Theoretical and metatheoretical positions in the discipline of communication with an emphasis on approaches to analyzing and developing original theories.

660. **Research Methodologies I** (3) I An introduction to research methods and designs used in contemporary communication research.

670. **Research Methodologies II** (3) II Advanced study of research design and statistical analysis in contemporary communication research.


696. **Seminar**
   a. **Rhetorical Criticism** (3) [Rpt./3] II
   b. **Literature as Communication** (3) [Rpt./3] II
   c. **Rhetorical Theory** (3) [Rpt./3] II
   d. **Social Influence** (3) [Rpt./3] II
   e. **Mass Media** (3) [Rpt./3] II
   f. **Linguistic Investigations and Applications** (3) [Rpt./3] II (Identical with Ling. 696f)
   g. **Argumentation** (3) [Rpt./3]
   h. **Organizational Communication** (3) [Rpt./3] II
   i. **Interpersonal Communication** (3) [Rpt./3] II
   j. **Information Processing and Management** (3) [Rpt./3] II
   k. **Research Methods** (3) [Rpt./3] II

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**COMPARATIVE LITERATURE AND LITERARY THEORY**

*Committee on Comparative Literature and Literary Theory (Graduate)*

Professors J. Douglas Canfield, *Director* (English), Barbara A. Babcock (English), Lawrence J. Evers (English), N. Scott Momaday (English), Suresh Raval (English), Herbert N. Schneidau (English), Jonathan Beck (French and Italian), Richard P. Kinkade (Spanish and Portuguese), Eliana S. Rivero (Spanish and Portuguese), Robert ter Horst (Spanish and Portuguese), David H. Chisholm (German), Alex De Jonge (Russian and Slavic Languages), Norman Austin (Classics), Adel Gamal (Oriental Studies), Robert M. Gimello (Oriental Studies)

Associate Professors Susan H. Aiken (English), Jerrold E. Hogle (English), Patrick J. O'Donnell (English), Charles Sherry (English), Ingeborg Kohn (French and Italian), Adele Barker (Russian and Slavic Languages), Jon Solomon (Classics), Leslie Flemming (Oriental Studies), Esther Fuchs (Oriental Studies), Ronald C. Miao (Oriental Studies)

Assistant Professors Tenney Nathanson (English), Linda Zwinger (English), Lise Leibacher (French and Italian), Frances Aparacio (Spanish and Portuguese), Marie Chan (Oriental Studies)

The Committee on Comparative Literature and Literary Theory offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in comparative literature and literary theory. The cooperating departments include English, French and Italian, Spanish and Portuguese, German, Russian and Slavic Languages, Classics, and Oriental Studies. Students may choose their literatures from these departments or any other area in which the University affords expertise, such as American Indian Studies. The master's degree is considered primarily as leading to the Ph.D. degree.

Admission to the program is based on the following kinds of evidence: (1) Excellent undergraduate performance in language and literature (preferably majors and minors) as indicated by a transcript. (2) Three letters of recommendation from persons familiar with the student's performance in language and literature. (3) An example of the student's writing on a literary topic. For students applying for the doctoral program this must be an article-length and article-quality piece that will serve as a qualifying exam.
In addition, students wishing to study in English, French, German, Spanish and Russian should submit the following kinds of evidence of competence (scores in verbal aptitude and area competence are expected to be above the 75th percentile): (a) GRE Aptitude test, with emphasis on verbal competence. (b) GRE Subject test in one literature (not available in Russian). (c) GRE Subject test in another literature, or (d) GSFLT exam in a second language. (e) TOEFL exam for foreign students. Applicants' linguistic competence to do graduate-level work in the literatures of the particular languages will be judged by a special committee.

**MASTER OF ARTS** — Degree requirements include at least 36 units: 24 units in graduate-level literature courses in at least two original languages; no more than 12 units may be taken in the student's native language; no more than 6 units may be taken below the 500 level; 6 units 503a-503b; 3 units in a basic linguistics course (such as Ling. 500); 3 units 550. A final examination evaluated by the Executive Committee, augmented by at least one specialist in the area of the paper.

**DOCTOR OF PHILOSOPHY** — Degree candidates are required to take at least 36 units for the major, no more than 12 units of which can be below the 500 level; 18 units dissertation; and a minor. Course work (at least 6 units of which must be in 596) aimed at a preliminary exam in (a) a genre of a period (or some other justifiable combination) in at least two literatures; (b) a branch of literary theory; (c) either (1) a third literature, same genre, same period, or (2) an ancillary discipline (such as anthropology, linguistics, history, American Indian studies, women's studies) or an interdisciplinary combination. If a discipline is chosen and one of the student's literatures under (a) above is in his or her native language, the student must pass a reading exam in a second foreign language.

**MINOR** — Supporting areas of study will be approved by the CPLT Director and Executive Committee and may be obtained through any academic unit offering an approved doctoral minor.

503a-503b. Introduction to Comparative Literature and Literary Theory (3-3) Major theories of East and West, 503a: Theories of representation in the West. 503b: Non-Western theories of literature (American, Chinese, Japanese, Indian, and Arabic). (503a is identical with Engl. 503a; 503b is identical with Or.S. 503b)

550. Modern Theories of Criticism (3) Twentieth-century theories of criticism most apposite to the study of literature, such as semiotics, structuralism, post-structuralism.

596. Seminar a. Comparative Literature and Literary Theory (3) [Rpt.] I II

**COMPOSITION**

(See Music)

**COMPUTER ENGINEERING**

(See Electrical and Computer Engineering)

**COMPUTER SCIENCE**

Professors Ralph E. Griswold, David R. Hanson
Associate Professors Gregory R. Andrews, Acting Head, Peter J. Downey, Christopher W. Fraser
Assistant Professors Scott E. Hudson, Eugene W. Myers, John C. Peterson, Larry L. Peterson, Richard D. Schlichting

The Department of Computer Science offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in computer science. Areas of research interest within the department currently include programming languages, operating systems, distributed processing, analysis of algorithms, software engineering, computer engineering, and computer graphics.
Applicants for admission should hold an undergraduate degree in computer science or a related field. In addition to the application materials submitted to the Graduate College, applicants must submit to the department scores from the General Test of the Graduate Record Examination, as well as from the Computer Science Subject test. The department requires that two letters of recommendation also be submitted.

A brochure describing admissions requirements and degree programs in detail is available from the department.

402. Mathematical Logic (3) GC II 1987-88 (Identical with Math. 402)
421. Simulation Modeling and Analysis (3) GC (Identical with M.I.S. 421)
430. Software Tools (3) GC I II Techniques for the design and implementation of programs that assist in programming: filters; file managers; editors; text processors. P, 327, 342.
443. Theory of Graphs and Networks (3) GC II (Identical with Math. 443)
452. Principles of Operating Systems (3) GC I II Concepts of modern operating systems; concurrent processes; process synchronization and communication; resource allocation; kernels; deadlock; memory management; file systems; protection mechanisms. P, 237 or E.C.E. 271b; CR 430.
453. Translators and Systems Software (3) GC II Design and implementation of translation-oriented systems programs: macroprocessors; preprocessors; assemblers; loaders; linkers; introduction to compilers. P, 237, 430.
472. Continuous-System Simulation (3) GC I (Identical with E.C.E. 472)
473. Theory of Computation (3) GC I II Mathematical preliminaries; finite automata, regular expressions, applications; context-free grammars, pushdown automata, Turing machines, undecidability. P, knowledge of a programming language; Math. 243 or 215. (Identical with Math. 473)
474. Digital Logic Design (3) GC II (Identical with E.C.E. 474)
475a-475b. Mathematical Principles of Numerical Analysis (3-3) GC (Identical with Math. 475a-475b)
476. Computer Architecture (3) GC I Functional overview of computer systems; interconnection of basic components; input/output; interrupts; virtual addressing; stack architecture; microprogramming; microprocessors. P, 237, 342. (Identical with E.C.E. 476)
478. Computational Methods of Algebra (3) GC II (Identical with Math. 478)
479. Game Theory and Mathematical Programming (3) GC II 1987-88 (Identical with Math. 479)
520. Principles of Programming Languages (3) II Global semantics of algorithmic languages, including scope of declarations, data types, retention, block structure, binding time, subroutines, coroutines, extensibility; implementation issues. P, 430.
521a-521b. Advanced Systems Modeling and Simulation (3-3) (Identical with M.I.S. 521a-521b)
525. Principles of Computer Networking (3) II Theory and practice of computer networks, emphasizing the principles underlying the design of network software and the role of the communications system in distributed computing. Topics include data representation, channel semantics, synchronization, resource naming, and resource sharing. P, 430, 452.
541a-541b. Computer-Aided Information Systems Analysis and Design (3-3) (Identical with M.I.S. 541a-541b)
545. Analysis of Algorithms (3) II Time, space complexity; recurrences; algorithm design techniques; lower bounds; graph, matrix, set algorithms; sorting; fast Fourier transform; arithmetic complexity; intractable problems. P, 342, 473, Math. 362.
552. Principles of Concurrent Programming (3) I Fundamental concepts of concurrent programming; synchronization mechanisms based on shared variables and message passing; systematic development of correct programs; paradigms for distributed programming. P, 452, 473.
555. Principles of Compilation (3) I Finite automata and lexical analysis; context-free grammars; parsers; parser generators; code generation; graph-theoretic approaches to optimization. P, 453, 473.
571. Digital Systems Design (3) I II (Identical with E.C.E. 571)
573. Microprocessors, Minicomputers and Real-Time Distributed Processing (3) II (Identical with E.C.E. 573)

575a-575b. Numerical Analysis (3-3) (Identical with Math. 575a-575b)

620. Advanced Topics in Programming Languages (1 to 3) [Rpt./12 units] I Design, implementation, and compilation of programming languages; specific topics to be determined by current literature and faculty and student interest.

630. Advanced Topics in Software Systems (1 to 3) [Rpt./12 units] I Problems in design and development of large systems of programs; specific topics to be determined by current literature and faculty and student interest.

645. Advanced Topics in Algorithm Analysis (1 to 3) [Rpt./12 units] II Design and analysis of algorithms; specific topics to be determined by current literature and faculty and student interest.

652. Advanced Topics in Operating Systems (1 to 3) [Rpt./12 units] II Operating system design, development, analysis, and performance; specific topics to be determined by current literature and faculty and student interest.

674. Sequential Circuits and Automata (3) I (Identical with E.C.E. 674)

696. Seminar
   a. Foundations of Computing (3) [Rpt./2] I II S P, Ph.D. candidate or consult department before enrolling.

CONDUCTING
(See Music)

CONSUMER STUDIES
(See Family and Consumer Resources)

CORRECTIONAL ADMINISTRATION
(See Management and Policy)

COUNSELING AND GUIDANCE
(See Family and Consumer Resources; Educational Foundations and Administration)

CREATIVE WRITING
(See English)

CRIMINAL JUSTICE ADMINISTRATION
(See Management and Policy)

DAIRY SCIENCE
(See Animal Sciences)

DANCE

Committee on Dance

Professor John M. Wilson, Chairperson
Associate Professors Isa Bergsohn, Nina Janik

The Committee on Dance offers a dance concentration within a drama major, Master of Arts degree, in cooperation with the Drama Department. Interested students should consult the Committee on Dance.
142 DEPARTMENTS AND COURSES OF INSTRUCTION

445. Advanced Choreography (2) I GC Movement qualities, motif development, and geometric principles applied to group composition. 4S. P, 245b.

460a-460b. Advanced Ballet (2-2) [Rpt./1] GC P, 440a-440b.

496. Proseminar
d. Dance-Related Art Forms (2 to 3) GC II 1988-89 (Identical with Dram. 496d) Bergsohn

541. Professional Level Modern Dance Technique (3) [Rpt./1] P, 441a-441b. Wilson

543. Dance Ensemble (2) [Rpt./1] I II Rehearsal methods, repertorial development, and performance of dance with particular emphasis on ensemble. 4S. P, repertory audition; intermediate level in modern and ballet (340, 341).

545. Literary Resources for Choreography (3) II 1988-89 Studies in primary world literature, in drama, and in psychology of personages as sources for choreographic themes; presentation of motifs and scenario. 6S. P, 445. Wilson (Identical with Dram. 545)

595. Colloquium
a. Evaluation of Dance and Body Technique (2) I P, intermediate level ballet or modern dance techniques. (Identical with Dram. 595a)

697. Workshop
a. Concert Production and Choreography (1 to 4) [Rpt./4 units] I II 4-8S. P, 445.

DIETETICS
(See Nutrition and Food Science)

DRAMA

Professors Sam Smiley, Head, Robert C. Burroughs (Emeritus), Irene F. Comer (Emerita), J. Michael Gillette, Robert A. Keyworth (Emeritus), Frank K. La Ban, Peter R. Marroney (Emeritus)

Associate Professors Harold W. Dixon, Rosemary Gipson, Richard T. Hanson, Peggy Kellner, William A. Lang, Peter Lehman, Mary Z. Maher, Patricia D. Van Metre, Jeffrey L. Warburton

Assistant Professor Dianne J. Winslow

The Department of Drama is committed to providing professional training at the undergraduate and graduate levels in the theatre arts through a program of performance-centered activities and creative studies, the object of which is to insure that each student acquires a thorough understanding and appreciation of the theatre and cinema arts through classroom study, studio/laboratory training, and University Theatre productions. The program is designed to instill in the student the highest academic standards and professional skills required to initiate a career in educational and/or professional theatre.

The Department of Drama offers programs leading to the Master of Arts and the Master of Fine Arts degrees with a major in drama. The Master of Arts is an academic degree with a critical and scholarly emphasis. The Master of Fine Arts degree is a professional training program emphasizing artistic achievement. Admission is competitive and based on an evaluation of the applicant’s professional potential, trainability, and talent. The program encompasses a rigorous regime of studio training, classroom study, and University Theatre production.

In cooperation with the Department of Drama, the Committee on Dance offers a program of advanced study which leads to a Master of Arts in drama with a dance concentration. For a listing of graduate courses, see Dance.

Production and Performance

404. Musical Theatre III (3) GC II Intensive scene study and exploration of the major historical styles and genres of the American musical theatre. 2R, 2S. Open to majors only. P, 304 and audition.

416. **Theatre Graphics III** (2) GC II Advanced practical color theory in pigment and light, scenographic rendering mediums and techniques. P, 120.

420. **Advanced Lighting Design** (3) GC II Special problems, practice and trends in designed light for theatrical productions. P, 220.

421. **Lighting and Sound Technology** (3) GC II Applied theory and techniques associated with sound system and visual effects in the theatre. 2R, 3L.

423. **Scene Painting** (3) GC I Techniques and methods of scenic painting.


425. **Advanced Stagecraft** (3) GC I Advanced studies in scenic construction methods and techniques. P, 111.

427. **Advanced Stage Costume Construction** (3) GC II Advanced techniques in costume construction, including period pattern design, cutting and draping techniques. P, 116.


430. **Stage Management** (2) GC I Principles and techniques of stage management, practical applications, problems and analysis of stage managing. P, 111, 151.

431. **Theatre Publicity and Box Office** (2) GC I Publicity, press releases, sales, advertising, display techniques, subscription procedures. P, 12 units of drama.

432. **Theatre Management** (2) GC II Amateur, educational and professional theatre organization and management; theatrical contracts, professional unions and representative organizations. P, 12 units of drama.

436. **Shakespeare through Performance** (3) GC I Understanding Shakespeare's plays through performance. Performance-oriented analysis compels a thorough comprehension of the ideas, emotions, attitudes, and intent of the plays being studied.

449. **Acting V** (3) GC I Intensive study of classical acting styles with emphasis on Shakespeare. Individual and group performance. 2R, 2S. P, 251 and audition.


452. **Acting VII** (3) GC I Rpt. 1 Audition material, techniques and research into problems of a professional career in the theatre, television, motion pictures and related fields. 2R, 2S. P, 305, 449.

453. **Acting VIII** (3) GC II Intensive scene study and character analysis. Survey and review of major modern acting theories and techniques. 2R, 2S. P, 452.

455. **Directing I** (3) GC I Basic techniques of stage directing including play analysis, director-actor communication and technical problems of movement, composition, picturization and blocking. 2R, 2S.

456. **Directing II** (3) GC II Techniques of stage direction with the study of factors leading to a completed production; special attention given to director-designer communication and the production process. Direction of one-act plays. 2R, 2S. P, 455.

457. **English Phonetics** (3) GC II Scientific study of the sounds of speech; emphasis on laws and principles determining articulatory features, dialect variation, sound change, and sound as communication context. (Identical with M.Ar. 467)

475. **Screen Acting Techniques** (3) GC II Principles and techniques of various performance methods involved in acting for television and motion pictures; basic problems faced by the professional actor seeking employment in these media; on camera experience with directed exercises and dramatic scenes. 2R, 3L. (Identical with M.Ar. 475)

496. **Proseminar**  
a. Portfolio (1 to 2) GC I II

497. **Workshop**  
a. Technical Production (1 to 6) [Rpt./20 units] GC I II S  
b. Costume Production (1 to 6) [Rpt./20 units] GC I II S  
c. Lighting/Sound (1 to 6) [Rpt./20 units] GC I II S  
d. Production Design (1 to 6) [Rpt./20 units] GC I II S  
e. Scenic Design (1 to 6) [Rpt./20 units] GC I II S  
f. Performance (1 to 6) [Rpt./20 units] GC I II S

545. **Literary Resources for Choreography** (3) II 1988-89 (Identical with Dnc. 545)

595. **Colloquium**  
a. Evaluation of Dance and Body Techniques (2) I (Identical with Dnc. 595a)

605. **Advanced Voice and Movement for the Actor I** (4) Rpt./I Advanced study and exercise in voice and movement for the actor: relaxation, breathing, physical and vocal freedom, resonance, articulation and improvisation including the Linklater Approach, I.P.A., and Neutral Mask. 2R, 4S.
606. **Advanced Voice and Movement for the Actor II** (4) [Rpt./1] II Continued advanced study and exercise in voice and movement for the actor: standard stage speech, stage dialects, period customs, manners and movement. 2R, 4S. P, 605.

650. **Experimental Theatre I** (3) I Post-Stanislavsky experimental theatre techniques and theories of the first half of the twentieth century. Rehearsal and performance of select projects.

651. **Experimental Theatre II** (3) II Theories and techniques of avant-garde theatre. Rehearsal and performance of select projects.

655. **Advanced Directing I** (3) I Techniques of analyzing and staging classical texts for a contemporary audience; use of directorial style and the adaptation of directorial philosophies with an emphasis on the staging of Shakespeare. 2R, 2S. P, 456.

656. **Advanced Directing II** (3) II Techniques of analyzing and staging classical texts for a contemporary audience; use of directorial style and the adaptation of directorial philosophies with an emphasis on staging the plays of Moliere, the English Restoration, and similar historical texts. 2R, 2S. P, 655.

696. **Seminar**
   a. Contemporary Trends (1 to 3) II
   b. Special Topics in Acting (1 to 3) II
   c. Special Topics in Directing (1 to 3) II
   d. Musical Theatre Production (1 to 3) II
   h. Theatrical Design (1 to 3) [Rpt./3 units] I
   i. Period Design Style (1 to 3) II
   j. Special Topics in Directing (1 to 3) II

410. **Creative Drama** (3) GC I Principles and procedures of improvisation, role-playing, creative playwriting techniques, and program development in creative dramatics applicable to the elementary and secondary school levels. P, 12 units of drama or education.

412. **Theatre for Children** (3) GC II Principles and techniques of selecting plays, playwriting, directing, designing and producing theatre for children. 2R, 3L. P, 12 units of drama or education.

440a-440b. **History of the Modern Theatre** (3-3) GC Major developments in theatrical art from 19th-century realism to the theatre of the present.

460a-460b. **Writing for Stage and Screen I** (2-2) GC Preparation and analysis of brief scripts for stage and motion pictures; staged readings and lab. productions.

560a-560b. **Writing for Stage and Screen II** (3-3) Preparation and analysis of full-length scripts for stage and motion pictures. Production possible for selected scripts.

600. **Introduction to Graduate Study of Drama** (2) I Methods and materials for research in theatre and drama; introduction to the bibliography of these fields; organization and form of thesis.

640. **Dramatic Criticism: Tragedy** (3) I Comparative analysis of tragedy and theories of tragedy from antiquity to the present for stage and screen; writing of critical papers.

641. **Dramatic Criticism: Comedy** (3) II Comparative analysis of comedy and comic theory from antiquity to the present for stage and screen; writing of critical papers.

642a-642b. **Studies in Theatre History** (3-3) Concentrated study in theatre history, with major emphasis on the physical theatre, standard scholarly works, and source materials. 642a: Beginnings to circa 1660. 642b: Circa 1660 to 1975. 642a is not prerequisite to 642b.

644. **History of the American Theatre** (3) II Studies in the American theatre and drama. Directed and individual projects will be assigned.

696. **Seminar**
   a. Contemporary Trends (1 to 3) II
   b. Special Topics (1 to 3) II
   c. Period Design Style (1 to 3) II

**Cinema**


420. **Advanced Lighting Design** (3) GC II Special problems, practice and trends in designed light for theatrical productions. P, 220.

471. **Film/Video Production Financing** (3) GC I II Strategies for production financing for independent film/video projects and ways to position project in marketplace. Students will develop a prospectus for their own project. P, M.Ar. 215 or 310. (Identical with M.Ar. 471)

474a-474b. **Film Theory and Criticism** (3-3) GC Advanced studies in current cinematic theory and criticism. Historical examination of major film theories including formalism, realism, classical Hollywood, structuralist, semiotic and feminist film theories. P, M.Ar. 375.

496. **Proseminar**
   a. Portfolio (1 to 2) GC I II
   c. Advanced Topics in Film Studies (3) [Rpt./3] GC I II P, 109 or consult department before enrolling.

497. **Workshop**
   g. Cinema Production (1 to 6) [Rpt./20 units] GC I II S

696. **Seminar**
   c. Special Topics in Directing (1 to 3) I II
   d. Musical Theatre Production (1 to 3) I II
   f. Film Editing (1 to 3) I II
   g. Documentary and Educational Films (1 to 3) I II

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**ECOLOGY AND EVOLUTIONARY BIOLOGY**


Associate Professors Russell Davis, Robert S. Mellor, Richard E. Michod, Stephen M. Russell, David J. A. Vleck, Oscar G. Ward

Assistant Professors Michael J. Donoghue, Robert H. Robichaux, Richard E. Strauss, D. Lawrence Venable, J. Bruce Walsh

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in ecology and evolutionary biology and in botany. Concentrations are available in plant ecology, systematics and evolution; evolutionary theory; ecological and molecular genetics; environmental physiology; marine biology; animal behavior; population and community ecology; vertebrate biology and systematics; evolutionary morphology; and theoretical and mathematical biology. The department maintains excellent collections of fishes, amphibians, reptiles, birds, and mammals. An extensive herbarium is shared with the College of Agriculture. Field work is facilitated by a Marine Biology Station at Puerto Peñasco, Sonora, Mexico and by the availability of the Coronado Ranch in the Chiricahua Mountains, the Southwestern Research Station, Portal, Arizona, the Research Ranch, Elgin, Arizona, and the Desert Laboratory on Tumamoc Hill, Tucson, Arizona.

Applicants are required to furnish the department with completed departmental application forms, copies of scores on the Aptitude and Advanced (any discipline) tests of the Graduate Record Examination, copies of transcripts of all college work, copies of GRE scores (in addition to those required by the Graduate College), and three letters of recommendation from persons qualified to evaluate the applicant's scholarly potential. Applications should be submitted by January 15; admission is normally approved only for students beginning their graduate studies with the fall semester. Applicants are encouraged to seek external financial support from institutions such as the National Science Foundation and the Danforth Foundation. The department will make every effort to offer financial aid in the form of teaching or research assistantships.

Course work, while necessary, is no substitute for scholarship. Accordingly, particular emphasis is placed on the student's ability to formulate and pursue original research problems. One course, Research in Ecology and Evolution (610a-610b), is required of all new graduate students. The remainder of the program is designed to meet the individual needs of each student.

In addition to the courses listed below, the department offers courses in quantitative genetics, phylogenetic systematics, evolutionary morphology, plant physiological ecology, and approaches to problem solving in biology.
146 DEPARTMENTS AND COURSES OF INSTRUCTION


402. History of Biology (3) GC II (Identical with Hist. 402)

403R. Biology of Animal Parasites (3) GC I (Identical with V.Sc. 403R)

405. Aquatic Entomology (3) GC II 1988-89 (Identical with Ento. 405)

412. Plants Useful to Man (2) GC S Lecture-demonstration course for teachers and others wishing information on the uses of plants: foods and food plants, medicinal plants, plants and industry, plants in textiles and other manufactures.

413. The Plant Kingdom (3) GC S Designed for public school teachers and others wishing to become familiar with the major plant groups in our environment; collecting and growing plants. Field trip.

414. Plants of the Desert (2) GC S Designed for teachers and others wishing to become familiar with common native and cultivated plants; identification, ecology, and uses.

418a-418b. Scientific Illustration-Photography (2 to 4 - 2 to 4) [Rpt.] GC Individual basic training in the execution of thesis drawings and graphic art techniques. 418a: Illustration. 418b: Photography. Consult dept. before enrolling. (Identical with Anth. 418a-418b)

421. Philosophy of the Biological Sciences (3) GC 1987-88 (Identical with Phil. 421)

428R. Advanced Microbial Genetics (3) GC II (Identical with M.C.B. 428R)

428L. Advanced Microbial Genetics Laboratory (2) GC I (Identical with M.C.B. 428L)

431. Environmental Physiology (3) GC II 1987-88 Analysis and synthesis of recent studies of the physiological responses of animals to their environments. P, 468R.

433. Advanced Scientific Illustration (4) [Rpt./1] GC S Individualized advanced work in scientific illustration; lecture demonstrations on a variety of techniques. Field trips. P 418a. (Identical with Anth. 433)

434. Population Interactions (4) GC I Empirical and theoretical treatment of competition, cooperation, and mutualism within and between species, with emphasis on application of modern dynamics to ecological problems. Computer lab. 3R, 3L. P, 302, two semesters of calculus.

435. Evolution (3) GC I A balanced survey of the present-day concepts of the process and products of evolution, with emphasis on contrasting models and their consequences: recent techniques for the elucidation of phylogenetic pathways. P, 302, 320; Math. 125a, CR 125b. (Identical with Gene. 435)

436. Plant Ecology (4) GC II Dynamic processes giving rise to ecological patterns in plant populations and communities. 2R, 6L. Field trips. P, 302 and a basic ecology and a basic botany course.

438. Biogeography (3) GC II The role of historical events and ecological processes in determining the past and present geographic distribution of plants and animals. P, 302 or Geos. 225. (Identical with Geos. 438)

440R. Oceanography (2) GC II Introduction to the physical, chemical, geological, and biological dimensions of the oceans, with emphasis on their importance as biological environments.

440L. Oceanography Laboratory (2) GC II Field and lab. investigations of the Gulf of California, with emphasis on research techniques important to biological oceanography. Weekend field trips. P, 440R or CR.

441. Limnology (4) GC I (Identical with W.F.Sc. 441)

442. Marine Ecology (6) GC S A field introduction to basic concepts in marine ecology with emphasis on the behavior and ecology of invertebrates and fishes and the factors affecting the diversity and community structure of marine communities. The entire course is conducted at selected sites in the Gulf of California. Consult instructor before enrolling.

444. Insect Ecology (3) GC I (Identical with Ento. 444)

445. Ecology and Evolution of Insect/Host Plant Associations (1) GC II (Identical with Ento. 445)


458. Comparative Vertebrate Anatomy (4) GC I (Identical with V.Sc. 458)

459. Comparative Vertebrate Histology (4) GC II (Identical with V.Sc. 459)

460. Plant Physiology (4) GC I (Identical with M.C.B. 460)

463a-463b. Human Physiology Laboratory (1-1) GC Lab. for 464a-464b. P, CR 464a-464b. (Identical with M.C.B. 463a-463b and Tox. 463a-463b)
464a-464b. Human Physiology (3-3) GC Basic principles and concepts of physiology applied to humans. P, 304; Chem. 241b, 243b. (Identical with M.C.B. 464a-464b and Tox. 464a-464b)

468R. Comparative Physiology (3) GC I The responses of physiological systems to the environment; energy exchanges, respiration, thermal and osmotic regulation, locomotion, behavioral regulation, and integration of responses. P, 181, 182.

468L. Comparative Physiology Laboratory (1) GC I Physiological measurement techniques in laboratory and field studies. P, CR 468R.

470. Plant Diversity and Evolution (4) GC I Survey of the plant kingdom, with emphasis on comparative structure and evolution of major plant divisions. 2R, 6L. Field trips. P, 4 units of bio. or p.l.s.

472. Systematic Botany (4) GC II Evolutionary relationships of orders and families of spermatophytes; systems of classification; collection and identification of local flora. 2R, 6L.

473. Legumes, Grasses, and Composites (2) GC I 1988-89 Identification and classification of the three largest flowering plant families of the Southwest. 6L.

475. Freshwater Algae (4) GC II 1987-88 Systematics, ecology, and evolution of planktonic and benthic species; field techniques and lab. culture. 2R, 6L. Field trips. P, 4 units of bio. or p.l.s.

476. Marine Algae (4) GC II 1988-89 Systematics, ecology, and evolution of marine algae; field collection in marine environments and lab. culture. 2R, 6L. Field trips. P, 4 units of bio. or p.l.s.

477. Aquatic Plants (3) GC I Identification, ecology and economic importance of freshwater aquatic plants, as related to fisheries, wildlife management, limnology, plant ecology and aquatic biology. 2R, 3L. Field trips. P, 4 units of bio. or p.l.s.

480. Invertebrate Zoology (4) GC I Comparative morphology, physiology, and ecology of invertebrates. 2R, 6L. Field trips. P, 182.

482. Ichthyology (4) GC I Ecology, evolution and systematics of fishes, with field and lab. emphasis on Gulf of California and Arizona fishes. 2R, 6L. Weekend field trips. P, 182. (Identical with W.F.Sc. 482)

483. Herpetology (4) GC II Systematics, ecology, and evolution of the amphibians and reptiles. 2R, 6L or field work. P, 304.


512. Insect Behavior (3) II 1987-88 (Identical with Ento. 512)

523. Cytogenetics (3) II Investigation into the structure and function of chromosomes and their role in heredity and evolution. 2R, 3L. P, 320. (Identical with Gene. 523)

524. Theoretical Population Genetics (3) I Mathematical theory of modern population genetics developed from first principles, with emphasis on evolutionary implications and the historical development of ideas. P, 320, Math. 223. (Identical with Anth. 524 and Gene. 524)

525. Speciation (2) [Rpt.] II Mechanisms of evolution in the formation of races and species of animals and plants. P, 320. (Identical with Gene. 525)


580. Selected Studies in Malacology (2 to 4) [Rpt.] II Recent advances in malacology. 2R, 6L. Field trips. P, 480.

584. Selected Studies of Birds (2) [Rpt.] II Recent advances in ornithology. 1R, 3L or field trip. P, 484. (Identical with W.F.Sc. 584)

596. Seminar
   a. Evolutionary Ecology (1 to 2) [Rpt. /5] I, II
   b. Population Biology (1) [Rpt. 6] I, II Open to majors only.
   f. Sociology (2) [Rpt. /3] I
   j. Plant Population Ecology (1 to 3) [Rpt. /5] I

610a-610b. Research in Ecology and Evolution (1-1) I, II Introduction to the research currently being pursued by faculty and staff in the department. Open to majors only.

620. Applications and Techniques of Human Genetics (3) I (Identical with Gene. 620)

670. Recent Advances in Genetics (2) I (Identical with Gene. 670)

ECONOMICS

Professors Edward E. Zajac, Head, Gerald O. Bierwag, Phillip J. Bryson, John E. Buehler, James C. Cox, Helmut J. Frank (Emeritus), Bernard P. Herber, Jimmye S. Hillman (Agricultural Economics), Reka P. Hoff (Law), Philip G. Hudson (Emeritus), Gary D. Libecap, Robert H. Marshall, Leahmae McCoy (Emerita), Ronald L. Oaxaca, Kenneth R. Smith, Vernon L. Smith, Lester D. Taylor, Donald A. Wells

Associate Professors Michael K. Block (Management and Policy), David A. Conn, John Z. Drabicki, Donald G. Heckerman, R. Mark Isaac, James C. McBrearty, David E. Pingry, Gerald J. Swanson, Ronald J. Vogel (Management and Policy)

Assistant Professors Eskander Alvi, Kevin A. McCabe, Sharon B. Megdal, Michael R. Ransom, Stanley S. Reynolds, Fernando M. C. B. Saldanha, Barbara N. Sands

The department offers programs leading to the Master of Arts and Doctor of Philosophy degrees with a major in economics. The department also offers supporting work for the Master of Public Administration degree, the Master of Business Administration degree and Doctor of Philosophy degree with a major in business administration. For information concerning these degrees see Requirements for Master's Degrees/Master of Public Administration and Master of Business Administration as well as the Public Administration and Business Administration headnotes elsewhere in this catalog.

Applicants must have completed an undergraduate major or minor in economics and must submit scores on the aptitude test of the Graduate Record Examination.

Degrees

MASTER OF ARTS — All students must complete the core program consisting of 422, 501a, 501b, 521, and 597a, and a nine-unit field of specialization. (A minimum of thirty total units is required.) The field of specialization may be in economics or a related area and must be approved by an adviser. The student will be given a comprehensive exam over the core program and field. No thesis is required.

DOCTOR OF PHILOSOPHY — All students must complete the core program consisting of 501a-501b-501c, 502a-502b, 506, 520, 521, 522 and twelve units of 696 economics seminar courses. A minimum of 66 hours is required.

401. Studies in Microeconomics (3) GC II Studies in microeconomics, such as the economics of imperfect information and uncertainty, externalities and public goods, and imperfect competition. P, 361, Math. 125b.

405. Comparative Economic Systems (3) GC II Analysis of economic policy in market (capitalist) economies and of economic ideology and planning in command (Soviet-type) economies. P, 300 or 361.

406. Introduction to Experimental Economics (3) GC II Lab, experimental studies of economic behavior; applications to monopoly, bilateral bargaining, and competitive markets under various exchange rules; speculation, voting processes, public goods. 2R, 3L. P, 210 or 300 or 361.

409. Economic Anthropology (3) GC II (Identical with Anth. 409)

412. Agricultural Economic Development in Latin America (3) GC II (Identical with A.Ec. 412)

421. Introduction to Mathematical Economics (3) GC I Comparative statics, stability, classical optimization, the Kuhn-Tucker theory, calculus of variations, linear algebra, and game theory, and the application of these techniques in economic analysis. P, six upper-division units in econ.; Math. 125b.

422. Introduction to Econometrics (3) GC II Statistical methods in estimating and testing economic models; single and simultaneous equation estimation, identification, forecasting, and problems caused by violating classical regression model assumptions. P, 439 or M.A.P. 375.


436. Economics of Fiscal Federalism (3) GC II Study of the economics of intergovernmental fiscal relationships in a federal system inclusive of allocational, distributional, and aggregate economic effects. P, 201b or 210.

441. International Trade Theory (3) GC II General equilibrium analysis of product and input markets of international trade, tariffs, commercial policy, and growth and the welfare aspects of each. P, 300 or 361.

442. International Economics (3) GC I Financial aspects of international trade relations and commercial policy. P, 300 or 330.

460. Economic Organization and Governmental Policy (3) GC I Structure, conduct, and performance of American industry; governmental institutions and policies affecting business. P, 300 or 361; 439.

461. Economics of Regulated Industries (3) GC II Economic analysis of the regulated sector of the American economy, including communications, transportation and energy industries; impact of existing and alternative public policies. P, 300 or 361.

476. Natural Resource Economics (3) GC II (Identical with A.Ec. 476)

481. Economics of Wage Determination (3) GC I Applications of economic theory and empirical methods to labor supply and demand, investment in human capital, minimum wages, union effects on relative wages, and labor market discrimination. P, 300 or 361.

482. Labor and the Economy (3) GC II Macro aspects of labor economics: unemployment — causes and cures; unemployment and inflation; distribution of income. P, 300 or 361.

483. Urban Economics (3) GC II Problems of metropolitan areas; evaluation of alternative solutions. P, 201b or 210. (Identical with BLS. 483)

484. Regional Economics (3) GC I Location theory, regional growth, techniques of regional analysis. P, 300 or 361.

487. Health Economics (3) GC II A study of pricing, allocation, and distribution in the health-care industry, with particular emphasis on the economic effects of current governmental policy. P, 201b.

497. Workshop
   a. Economics Education Workshop (2) GC S Consult instructor before enrolling.
   b. Summer Institute on the American Economy (3) GC S Consult instructor before enrolling.
   c. Economic Issues for Teachers (3) GC S Consult instructor before enrolling.

500. Managerial Economics (3) I II S Microeconomic theory and applications. P, M.I.S. 400 or Math. 119 and 123. Advanced degree credit available for nonmajors only. Open only to students admitted to a BPA graduate program.


504. Production Economics (3) I (Identical with A.Ec. 504)


510. Macroeconomics (3) I II S Theory of income, employment, interest rates, and the price level. P, 500. Advanced degree credit available for nonmajors only. Open only to students admitted to a BPA graduate program.
150 DEPARTMENTS AND COURSES OF INSTRUCTION

511. **Microeconomic Theory and Behavior (3)** I Microeconomic theory with an emphasis on the use of experimental laboratory and field methods for testing the behavioral implications of the theory. P, 520, Math. 125a and 125b.

512. **International Agricultural Economic Development (3)** II (Identical with A.Ec. 512)

513. **Agricultural Price and Marketing Analysis (3)** II (Identical with A.Ec. 513)

514. **Cost-Benefit Analysis (3)** II (Identical with A.Ec. 514)

515. **Operations Research in Applied Economics (3)** I (Identical with A.Ec. 515)


534. **Public Finance (3)** I II The study of public fiscal economics, with emphasis on relevant topics for public administration and urban planning grad. students: public goods, tax and nontax revenues, intergovernmental issues, benefit-cost analysis. P, 500a.

536. **Innovation and Economic Growth (3)** I (Identical with Mktg. 536)

553. **Business and Economic Forecasting (3)** II Forecasting techniques used in business; assembly, interpretation and use of economic data; analysis of business conditions; examination of related environmental factors; construction of actual industry sales forecasts. P, 510, M.A.P. 552. Advanced degree credit available for nonmajors only.


568. **Environmental Scanning (3)** I Using information from the economy to develop a firm's competitive strategy. Multidisciplinary, with concepts from economics, marketing, and management. An MBA integrative course. Open only to students admitted to BPA graduate programs. P, 500, Fin. 511, Mktg. 500. (Identical with M.A.P. 568 and Mktg. 568)

570. **Management and Evaluation of Information Systems (3)** I II (Identical with M.I.S. 570)

576. **Advanced Natural Resource Economics (3)** I (Identical with A.Ec. 576)

577. **Natural Resource Economics and Public Policy (3)** I II (Identical with A.Ec. 577)

597. **Workshop**

696. **Seminar**
   a. Experimental Economics I (3) II
   b. Experimental Economics II (3) I
   c. Economic Analysis of Organizations I (3) II
   d. Economic Analysis of Organizations II (3) I
   e. Econometric Modeling I (3) II
   f. Econometric Modeling II (3) I
   g. Monetary Economics (3) I
   h. Labor Economics I (3) II
   i. Labor Economics II (3) I
   j. Public Policy Analysis I (3) II
   k. Public Policy Analysis II (3) I
   l. International Economics I (3) II
   m. International Economics II (3) I
   n. Advanced Macroeconomic Theory I (3) II
   o. Advanced Macroeconomic Theory II (3) I
   p. Industrial Organization and Regulation I (3) II
   q. Industrial Organization and Regulation II (3) I
   r. Advanced Microeconomic Theory I (3) II
   s. Advanced Microeconomic Theory II (3) I
   t. Mathematical Economics (3) I II
   u. Game Theory (3) I II

697. **Workshop**
   a. Experimental Economics (3) I P, 696b.
   b. Economic Analysis of Organizations (3) I P, 696d.
   d. Labor Economics (3) I P, 696i.
   e. Public Policy Analysis (3) I P, 696k.
f. International Economics (3) IP, 696m.
g. Advanced Macroeconomic Theory (3) IP, 696o.
h. Industrial Organization and Regulation (3) IP, 696q.
i. Advanced Microeconomic Theory (3) IP, 696s.

EDUCATION

Within the College of Education programs are offered leading to the Master of Arts (M.A.), Master of Education (M.Ed.), Master of Science (M.S.), Master of Teaching (M.T.), Educational Specialist (Ed.S.), Doctor of Philosophy (Ph.D.), and Doctor of Education (Ed.D.) degrees as indicated in the following list of departments and majors:

Division of Educational Foundations and Administration
- counseling and guidance ........................................... M.A./M.Ed./Ed.D./Ph.D.
- educational administration ........................................ M.A./M.Ed./Ed.S./Ed.D./Ph.D.
- educational psychology ........................................... M.A./M.Ed./Ed.S./Ed.D./Ph.D.
- foundations of education ........................................... M.A./M.Ed./Ed.D./Ph.D.
- higher education .................................................... M.A./M.Ed./Ed.D./Ph.D.

Division of Language, Reading and Culture
- bilingual/bicultural education .................................... M.A./M.Ed.
- reading ................................................................... M.A./M.Ed./Ed.S./Ed.D./Ph.D.

Division of Special Education and Rehabilitation
- rehabilitation .............................................................. M.S./Ed.D./Ph.D.
- special education ...................................................... M.A./M.Ed./Ed.S./Ed.D./Ph.D.

Division of Teaching and Teacher Education
- educational media ...................................................... M.Ed./Ed.S.
- elementary education ................................................ M.A./M.Ed./M.T./Ed.S./Ed.D./Ph.D.
- secondary education .................................................. M.A./M.Ed./M.T./Ed.S./Ed.D./Ph.D.

subject areas for secondary school teaching:
chemistry, communication, English, family
and consumer resources, French, general biology,
geography, German, health education, history,
journalism, Latin, mathematics, Oriental studies,
physics, political science, Russian, Spanish,
(and others by special approval of
the Graduate College) .............................................. M.Ed.

At the time the catalog was being edited, many programs in the College of Education were being redesigned. All current or prospective students should check with the Office of Student Services in the college or the appropriate division for information on current admissions and degree requirements.

EDUCATIONAL ADMINISTRATION

(See Educational Foundations and Administration)

EDUCATIONAL FOUNDATIONS AND ADMINISTRATION


Associate Professors Sheila Slaughter, Head, Harley D. Christiansen, Sarah M. Dinham, Lee A. Droegemueller, Fred Gullo (Emeritus), Stanley Pogrow, Donal M. Sacken

Assistant Professors Sharon Conley, Marcello Medina, Gary Rhoades, Richard Ruiz
The division offers programs leading to the Master of Arts and Master of Education degrees with majors in counseling and guidance, educational administration, educational psychology, foundations of education, and higher education. The Educational Specialist degree is offered with majors in educational administration and educational psychology. The Doctor of Education degree is offered with majors in counseling and guidance, educational administration, educational psychology, foundations of education, and higher education. The Doctor of Philosophy degree is offered with majors in counseling and guidance, educational administration, educational psychology, foundations of education, and higher education.

Concentrations are available within graduate majors offered in the division. Concentrations in educational psychology include school psychology and learning and development. The major in higher education is offered through the Center for the Study of Higher Education, with concentrations in academic administration, student personnel services administration, finance and business affairs administration, and institutional research.

The division also offers certification in educational administration and school psychology. Students seeking institutional recommendation for Arizona administrative certification should major in educational administration. Students seeking certification in school psychology should major in educational psychology. The school psychology training program is accredited by the American Psychological Association and leads to certification as a school psychologist. In the Center for the Study of Higher Education, master's degree programs may be designed to meet the requirements for the Arizona Community College Teaching Certificate (Type I) or for entry-level administrative service in institutions of higher education.

An undergraduate grade-point average of at least 3.00 is required for admission to full standing in a graduate degree program. However, applicants with undergraduate grade-point averages of 2.50 to 2.99 may be admitted on a provisional basis. A master's degree (in education or a related discipline) is a prerequisite for admission to a specialist or doctoral program. Beyond these minimal requirements, applicants must also meet the specific admission requirements for all majors offered in the division.

At the time the catalog was being edited, many programs in the College of Education were being redesigned. All current and prospective students should check with the Office of Student Services in the College of Education or the Division of Educational Foundations and Administration for current admission and degree requirements in each major.

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**Educational Administration**

476. **Philosophical Foundations of Education** (3) GC II Introduction to philosophy as general educational theory; logic for teachers, major philosophic thinkers, value theory, and epistemology.

487. **Microcomputers in Education** (3) GC I II S The microcomputer as object, medium, and manager of instruction; emphasis on computer literacy, classroom uses, and hands-on instruction.

488. **Microcomputer Application in Education** (3) GC I II S The microcomputer as the object and medium of instruction and as a management tool in the school setting; special emphasis on advanced programming techniques, Disk Basic, and Disk Operating Systems. P, 487.

567. **Law for Teachers and Student Personnel Workers** (3) II Law in the school and university setting; nature of the legal process; forces behind law and education; law and education as social processes and institutions; legal rights and responsibilities.

601. **Current Problems in Education** (3) I II The problems found in current educational literature, research studies, and school reports.

604. **Educational Administration in Anthropological Perspective** (3) I The application of anthropological field techniques and theory to specific educational problems associated with school administration.

605. **Social/Cultural Perspectives of School Administration** (3) II The use of social science theory and methodology in analyzing school administration problems and solutions.

606. **Comparative Education** (3) I II Emphasis on comparative education methodology; analysis of selected national education systems, with focus on sociocultural foundations; curriculum and instruction; administration; teacher education; contemporary trends and issues; implications for education in the United States.

607. **Pragmatic Philosophies of Education** (3) I Intensive analysis of modern philosophies and their relationships to American educational thought; the emergence of the "pragmatic" curriculum.

610. **Philosophy of Education** (3) I II Analysis of values and conflicts in American culture as these direct educational policy; critical examination of contending philosophies in the light of democratic ideals.
611. History of Western Education (3) I II The historical development of western educational thought from its origins to the present.

612. History of Education in the United States (3) I II The development of American educational thought from its colonial origin to the present.

614. State School Systems and School Law (3) I II Legal provisions for the government of state school systems; legal basis of local, state and federal relations in education; legal principles relating to pupils, teachers, and school administrators. P, 9 graduate units in education.

616. General School Administration (3) I Organization structures and purposes through which societal demands for education are met; administrative competencies and skills.

647. The Principalship (3) I S Functions and activities of building-level administrators, with emphasis on instruction, staff development, student services evaluation, and operational services.

648. The Superintendency (3) II Functions and responsibilities of the chief school executive and central office staff, with emphasis on external and internal system relationships in policy formation and decision-making.

664. Theory and Behavior in School Administration (3) II Theory in administration: patterns of theory classifications; relationships of theory to administrative function and organizational dynamics. P, 9 graduate units in educational administration.

670. Personnel Administration in Education (3) I Composition of school staffs and the functions of various personnel; patterns and practices in school personnel management; issues, trends, and prospects in personnel management. P, 15 graduate units in education or CR.

671. School Finance (3) I Historical background of the financing of education in the United States; economics and principles; sources and distribution of funds for education; budgeting, accounting, and reports.

672. School Business Management (3) II The general management of school business; administration and accounting of school funds; administration of equipment and supplies; other business operations. P, 9 graduate units in school administration.

675. The Law and American Education (3) I The analysis of educational questions as influenced by legal principles and the case law; effect of legal provisions upon administrative and other educational decisions and upon social policy.

676. Supervision of the Instructional Program (3) I II Purposes of instructional supervision: organization, techniques and skills for supervisory competency.

678. Educational Sociology (3) I II The school as a social institution; social functions of the school; social processes, socialization, and stratification in education; informal and formal systems and the bureaucratic structure of the school.

680. Administrative Leadership (3) I Explores the leadership process in education, including the use of power and authority in relation to existing social, organizational, and behavioral theories. P, 15 graduate units in educational administration.

684. Administration of Bilingual Education Programs (3) S Dynamics of the administration of educational programs for the bilingual learner including socio-political realities, mandated federal and state funded educational programs, and effective community participation.

694. Practicum
   a. Educational Administration (1 to 3) [Rpt./12 units] I II

695. Colloquium
   a. Issues in Educational Administration (1 to 3) [Rpt./12 units] I II

696. Seminar
   a. Topics in Educational Administration (1 to 3) [Rpt./12 units] I II

697. Workshop
   a. Problems in Educational Administration (1 to 3) [Rpt./12 units] I II

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**Educational Psychology**

500. Life Span Development (3) I II Dynamics of development, social integration and roles across the life span. Special emphasis on cognitive, emotional, and personality development with concentration on the antecedent events to adult life experiences. (Identical with C.D.F.R. 500)

501. Advanced Child Development (3) I II Aspects of growth and development which influence behavior of the school-age child; emphasis on current research findings. P, 301.

502. Advanced Preadolescent Development (3) I II Focus on ages 10 to 14. Emphasis on the physical, cognitive, and social development within multiple contexts.
Advanced Adolescent Development (3) II Major developmental issues within the adolescent years; emphasis on the importance and design of adolescent research. (Identical with C.D.F.R. 503)

Adult Learning and Development (3) I II Analysis of adult education and development; characteristics of adult learners and behavior and the consideration of life-long learning.

Learning Theory in Education (3) II Major theories of learning and motivation; emphasis on relationships between theory and practice in the schools.

Individual Differences (3) II Psychological, social, and biological factors producing human variation and their implications for education. P, 510.

Classroom Application of Behavior Modification Techniques (3) II Application of behavior principles and techniques to promote learning and social development of school-related behavior. 2R, 3L. P, 510 or CR.

School Psychology (3) I Roles of the school psychologist; implementing programs in the public schools; legal and ethical issues in school psychology. 2R, 3L.

Statistical Methods in Education (3) I II Descriptive, correlational, and inferential procedures for presenting and analyzing school and research data. For students in all fields.

Design of Questionnaires and Scales (3) I II Emphasis on theoretical and methodological issues related to the development of survey and rating scales, sampling procedures, and response bias.

Educational Tests and Measurements (3) I Theoretical and practical application of psychometric techniques to test construction, analysis, and interpretation of test results. P, 541.

Testing of Minorities (3) II Current theoretical, social, and practical issues in the use of norm-referenced tests with individuals from minority cultures.

Disciplined Inquiry in Education (3) I II Research techniques in education, interpretation of data and the reporting of results.

Theories of Human Development (3) I History and analysis of psychological theories of human development and a comprehensive overview of major theoretical systems. P, 500 or 501.

Psychological Theory in Educational Practice (3) I Major theories of psychological thought; strategies for utilizing such theories in educationally relevant research. P, 510.

Cognitive Development (3) II Cognitive theory and research as they bear upon developmental and educational processes. P, 500 or 501.

Design of Instruction (3) II Historical and theoretical bases for developing instructional design; emphasis on relationship between learning theory and instructional design. P, 510.

Behavioral Consultation in Educational Settings (3) II Principles and techniques of conducting behavioral consultation in educational settings to promote learning and development of children and youth. 2R, 3L. P, 517.

Advanced Statistical Methods in Education (3) I II Inferential procedures for analyzing educational data; includes nonparametric methods and introduction to multivariate and causal procedures. P, 541.

Multidimensional Methods in Educational Research (3) II Provides an understanding of and facility with research application of multivariate correlational techniques, such as multiple regression, discriminant function, canonical correlation, and factor analysis. P, 640.

Evaluating Standardized Tests (3) I Technical standards for evaluating standardized tests and manuals with emphasis on the contemporary state of the field. P, 541 and 558 or CR.

Theory of Measurement (3) II Advanced topics in theoretical and practical issues in psychometrics. P, 558; 640 or CR.

Research Design in Education (3) I Problems in the design of empirical studies in education; statistical adaptations to specific educational problems. P, 560, 640.

Theories of Intellectual Assessment (3) I II Various theories and models of human ability and their implications for intellectual assessment. P, 558 or CR.

Field Experience in Intellectual Assessment in Education (3) Supervised field experience in the administration, scoring and interpretation of various intellectual assessment devices. 674a: Wechsler Adult Intelligence Scale. 674b: Intellectual assessment techniques. 1R, 3L. Open to majors and minors only. Credit allowed for 674a or 674b, but not for both. P, 673 or CR.

Individual Assessment Techniques in the Schools (3) II Techniques for assessing personality and social behavior; practice in implementing programs derived from assessment techniques. 2R, 3L. Open to majors and minors only. P, 674b.

Psychoeducational Assessment in the Schools (3) II Psychoeducational assessment techniques; practice in prescribing remedial programs. 2R, 3L. Open to majors and minors only. P, 673, 674b.

Educational Program Evaluation Principles and Techniques (1 to 3) [Rpt./1] Development and current viewpoints, political context, illustrative cases, technical skills for determining merit or making decisions about educational and social programs. P, 541, 558.
685. **Child Behavior Disorders and Adjustment** (3) I II The diagnostic and assessment practices, theories, and research related to child behavior disorders. P, 530.


693. **Internship**  
b. School Psychology (1 to 3) [Rpt./12 units] I II

694. **Practicum**  
b. School Psychology (1 to 3) [Rpt./12 units] I II

695. **Colloquium**  
b. Issues in Educational Psychology (1 to 3) [Rpt./12 units] I II

696. **Seminar**  
b. Topics in Educational Psychology (1 to 3) [Rpt./12 units] I II

**Higher Education**

497. **Workshop**  
a. Fiscal Stress in Higher Education (3) GC 1

561. **The Community College** (3) I The scope, objectives, and educational functions of the community college, patterns of community college programs.

601. **Higher Education in the United States** (3) I The scope of higher education in the United States; brief survey of historical developments and philosophic bases; public policy issues at the state and federal level; types of institutions and their purposes; characteristics of faculty, students and curricula.

602. **Foundations of Student Personnel Work in Higher Education** (3) I Orientation to student personnel work in colleges and universities; interdisciplinary foundations; professional aspects; integrated lab. experience in selected campus settings.

608. **The College Student** (3) I History and characteristics of the college student; interactions with campus environmental influences; developmental and normative trends; major research findings.

609. **Organization and Administration in Higher Education** (3) I Organizational theory, structures, systems, and administrative procedures in varied higher education institutions; patterns of governance and policy development.

617. **Student Personnel Services in Higher Education** (3) I I Student personnel services, purposes, procedures, representative programs, current trends.

621. **Curriculum in Higher Education** (3) I II Early classical curriculum; development and administration of general education and professional studies; modern curriculum developments and innovations.

622. **Teaching in Higher Education** (3) I II Planning, organizing, and evaluating learning experiences for mature students.

641. **Institutional Research and Planning** (3) I I Development of institutional research programs for short-term and long-term planning; input and output measures.

650. **Higher Education Finance** (3) I Historical patterns of financing private and public higher education; current sources and types of financial support; alternative methods of financing; social benefits and consumer theories. Field trips.

651. **Higher Education Business Management** (3) I II Budget planning and execution; systems of resource allocation; personnel management; physical plant planning and construction; information systems and use in management.

661. **Higher Education and the Law** (3) I II Critical court decisions, past and present, affecting higher education; increasing role of the courts in decision making and policy development. Field trips. P, 601, 609, 621 or 650.

693. **Internship**  
c. Higher Education (1 to 3) [Rpt./12 units] I II

695. **Colloquium**  
c. Issues in Higher Education (1 to 3) [Rpt./12 units] I II

696. **Seminar**  
c. Topics in Higher Education (1 to 3) [Rpt./12 units] I II

**EDUCATIONAL MEDIA**

*(See Teaching and Teacher Education)*
EDUCATIONAL PSYCHOLOGY
(See Educational Foundations and Administration)

ELECTRICAL AND COMPUTER ENGINEERING


Assistant Professors Randall K. Bahr, Keith D. Paulsen, Jerzy Rozenblit, Ronald D. Schrimpf, Robin N. Strickland

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in electrical engineering. Master’s degree students may also select one of the following interdisciplinary options: biomedical engineering, clinical engineering, energy systems engineering, or materials engineering. For details concerning these options see Engineering elsewhere in this catalog.

Each applicant is required to submit scores on the general test of the Graduate Record Examination taken within the last five years. In addition, applicants for the Ph.D. program will be required to submit a detailed statement of professional goals, and three letters of recommendation from instructors who are in a position to predict the applicant’s potential for advanced work.

For the Master of Science degree, the required thirty units must include at least fifteen units (other than the thesis) in the major field, and no more than nine of these may be at the 400 level. Six units taken in another department are normally included. Under Plan "A," the student is required to submit a six-unit thesis as part of the 30 units and pass a final oral examination. Under Plan "B," the student is required to complete at least six units in electrical engineering in lieu of a thesis and to pass a comprehensive examination. Exceptions to these requirements are made for students selecting one of the interdisciplinary options identified above. Additional details concerning the requirements for the master’s or doctoral degrees may be obtained on request from the department.

A program for highly-qualified students with degrees in other fields is available. Under this program it is possible to remove undergraduate deficiencies and complete requirements for a master’s degree in as little as two and one-half years. Additional information concerning this program may be obtained on request from the department.

411. Electronic Instrumentation (1 to 3) GC II Individualized instructional units in specific areas: light, temperature, psychometry, reference electrodes, gas analysis, basic electric circuits, signal processing. P, college physics.

415. Medical Instrumentation (3) GC I Basic concepts of instrumentation and measurement; principles of transducers, operational amplifiers and instrument systems, with emphasis on biomedical measurements; lab. experiments with transducers and medical equipment. 2R, 3L. P sr. engineering.

417. Clinical Engineering (3) GC II Activities and responsibilities of clinical engineers; hospital facilities, medical equipment specifications and control, safety, management and health care. P, 208 or 351 b. (Identical with A.M.E. 417)

418. Physiology for Engineers (4) GC I (Identical with Psio. 418)

419. Physiology Laboratory (2) (Identical with Psio. 419)


426. Modern Filtering and Signal-Processing Techniques (3) GC II Operational amplifier circuits; basic active RC filter design; nonlinear wave shaping; analog switches; A/D and D/A conversion. P, 321b.

431. Principles of Communication Systems (3) GC I II Signal analysis techniques associated with modulation and demodulation in systems such as AM, FM, and PCM, with special emphasis on digital communication. P. 305. 351b.


434. Electrical and Optical Properties of Semiconducting Materials (3) GC I

436. Introduction to Coding Techniques (3) GC II Error-correcting codes used in modern digital communications systems, with emphasis on hardware implementations and performance on real channels. P. 271a and Stat. 361.

441. Automatic Control (3) GC II Linear control system representation in time and frequency domains, feedback control system characteristics, performance analysis and stability, design of control. P. 305. 321b.

442. Digital Control Systems (3) GC II Modeling, analysis, and design of digital control systems; A/D and D/A conversions, Z-transforms, time and frequency domain representations, stability, microprocessor-based designs. P. 441.

445. Direct Energy Conversion (3) GC II (Identical with N.E.E. 445)


452. Solid-State Device Design (3) GC II Properties of semiconductors, impurity behavior, solid-state effects; the operation of p-n junctions, transistors, phototransistors, tunnel diodes, surface devices. P. 381.

454. Electronic Packaging Principles (3) GC I II Introduction to problems encountered at all levels of packaging: thermal, mechanical, electrical, reliability, materials and system integration. Future trends in packaging. P. senior standing in engineering or science.

456. Optoelectronics (3) GC I Properties and applications of optoelectronic devices and systems. Topics include radiation sources, detector circuits, fiber optics, and electro-optical components. P. 351b and 381.

457. Integrated Circuit Technology Laboratory (3) GC I II Theory of and experiments in diffusion, oxidation, etc.; fabrication of an integrated circuit. (Identical with M.S.E. 457)

458. Solid-State Circuits (3) GC I Intermediate level circuitry and devices, with applications ranging from DC to the microwave and optical regions; consideration of discrete and integrated circuits. P. 321b. 351b.


461. Energy Conversion (3) GC I Principles and operating characteristics of rotating machinery and electromagnetic transducers, single-phase and polyphase transformer operation, laboratory demonstrations and tests of transformers and rotating machinery. P. 321b. 381.

462. Symmetrical Components (3) GC I Three-phase circuit analysis; analysis of fault conditions in power systems. Field trip. P. 321b.


465. Current Problems in Energy and Power (1 to 4) [Rpt./1] GC II (Identical with N.E.E. 465)

466. Power Plant Electrical Design (3) GC II Basic elements of power plant electrical design for both the generating system and the plant auxiliary system, including selection and sizing of major electrical equipment. P. 461 or 462. (Identical with N.E.E. 466)

467. Solar Energy Engineering (3) GC I (Identical with N.E.E. 467)

472. Continuous-System Simulation (3) GC I Interdisciplinary introduction to continuous-system simulation, mainly digital; modeling, state equations, languages, sensitivity and optimization. P. 305. (Identical with C.Sc. 472)

473. Software Engineering Concepts (3) GC II In-depth consideration of each of the phases of the software project life cycle. Includes a large-scale software development project involving groups of students. 2R, 3L. P. 371 or C.Sc. 227.
158 DEPARTMENTS AND COURSES OF INSTRUCTION

474. **Digital Logic Design (3)** GC I II Truth-functional calculus, Boolean algebra, map tabular minimization, coding, synthesis of sequential circuits, computer-aided engineering of digital circuits, selected laboratory exercises. 3R, 3L. P, 271b. (Identical with C.Sc. 474)

475. **Microcomputer-Based Design (3)** GC I II Design of microprocessor-based real-time test and control systems, use of development systems and emulators. 2R, 3L. P, 372. (Identical with C.Sc. 476)

476. **Computer Architecture (3)** GC I (Identical with C.Sc. 476)

477. **Environmental Impact of Energy-Related Systems (3)** GC II (Identical with C.E. 477)

478. **Data Communications Networks (3)** GC I Characteristics of ISO Open Systems Interconnection Reference Model; design of broad band and baseband network interfaces; features of network, transport, session, and presentation layers; Ethernet and IEEE 802 interface. P, 371, 372 or equivalent.

479. **Introduction to Knowledge Engineering (3)** GC I Heuristic search procedures, minimaxing, alpha-beta pruning. Knowledge acquisition, representation and utilization. Methodology of building expert systems. Introduction to Prolog and LISP. Each student is required to produce and implement a simple expert system. P, competence in some computer language.

481. **Microwave Measurements (3)** GC II Measurement techniques and the application of hardware and test equipment in the modern microwave laboratory. 2R, 3L. P, 381.

482. **Electromagnetics (3)** GC I Electrostatics and magnetostatics, review of Maxwell’s equations, plane waves, rectangular and circular waveguides, resonators, and antennas. P, 381 or Phys. 415a.


497. **Workshop**

501. **Linear Systems Theory (3)** I Mathematical descriptions of linear systems, state-variable models, analysis methods-stability, controllability and observability, state feedback techniques, design of feedback controllers and observers.


515. **Advanced Medical Instrumentation (3)** II Concepts and design of transducers, instrumentation and measurement systems, with emphasis on biomedical technology; research project on lab. computer. 2R, 3L.

521. **Network Synthesis (3)** I Synthesis of passive low-, high-, and band-pass network functions, time and frequency domain approximation, use of optimization techniques, properties of distributed elements.

522. **Active RC Filters (3)** II Modern techniques for realizing active RC filters, using lumped and distributed elements and operational amplifier gain blocks; determination of sensitivity.


531. **Image Processing Laboratory (3)** I Introduction to hardware and software used in image processing: image sampling and display systems, principles and applications; image processing software for image enhancement and information extraction; applied problems in natural resources, remote sensing. 3R, 3L. (Identical with Opti. 531)

532. **Pattern Recognition and Computer Vision (3)** II Computer pattern recognition and scene analysis. Theory, algorithms, and applications of computer vision and artificial intelligence. P, 531, 533. (Identical with Opti. 532)

533. **Image Processing: Devices, Systems and Applications (3)** II 1987-88 (Identical with Opti. 533)

534. **Electronic, Magnetic and Optical Materials (3)** II (Identical with M.S.E. 534)

539. **Algebraic Coding Theory (3)** II 1987-88 (Identical with Math. 539)


545. Decentralized Control and Large-Scale Systems (3) II 1987-88 Introduction to large-scale systems, definitions and special problems, modeling and model reduction, structural properties, decentralization of control and information, hierarchical and multi-level controllers. P, 501.


552. Linear Circuit Design (3) I Design of discrete and integrated solid-state circuits for small-signal applications; flow graph analysis; DC operational and wide-band amplifier design; power amplifier design.

553. Active Linear Circuit Design (3) II I.F. and R.F. band-pass amplifier design using solid-state devices; stagger-tuned I.F. amplifier and UHF band-pass amplifier design methods; fundamental concepts of design engineering. P, 552.


555. Layout Engineering for Integrated Circuits (3) I Development of layout ground rules; circuit design and layout methods for low sensitivity to parameter variations; use of SPICE and UAMASK programs for circuit simulation and layout. P, 457 or 458.

556. General Physical Electronics (3) I General overview of the physical principles of vacuum, plasma, solid-state and optical electronics. Topics include particle beams, magnetic properties of matter, holography.

558. Advanced Integrated Circuits Laboratory (3) II All phases of design and fabrication of a modern integrated circuit are considered and applied in the fabrication from concept to final test. 1R, 6L. P, 457, consult dept. before enrolling.


560. Aerosol Science (3) I II (Identical with Atmo. 560)

567. Advanced Solar Engineering (3) II (Identical with N.E.E. 567)

569. Energy Use: Analysis and Management (3) I (Identical with N.E.E. 569)

571. Digital Systems Design (3) III Computer organization, memory systems, AHPL, control unit design, microprogramming, input-output, computer arithmetic, features of large computers, time sharing. P, computer programming. (Identical with C.Sc. 571)


574. Distributed Discrete Event Simulation (3) I Introduction to simulation methodology and its implementation on multi-processors. Modular hierarchical discrete event model design and mapping onto distributed simulator architectures. Prior course in simulation recommended.


577. Computer Aided Engineering for Integrated Circuits (3) I Industrial CAD systems for integrated circuits; programs for process and device simulation; terminal models of bipolar and MOS devices, automated circuit analysis, methods, programs, use of computer graphics. P, 452, 455.
160 DEPARTMENTS AND COURSES OF INSTRUCTION

578. Advanced Topics in Computer Networks (3) II Analysis and design of computer networks using advanced protocols, data encryption, internet gateways, artificial intelligence-based filters, and mixed transmissions media. Applications to local area networks, long haul networks, and metropolitan area networks. Open to majors only. P, 478.


581. Electromagnetic Field Theory (3) II Methods used in solving electromagnetic problems of current importance such as appearing in IEEE transactions on microwave theory and techniques, antennas and propagation, and electromagnetic compatibility, and radio science. P, 502 or Math. 422b, E.C.E. 482 or Phys. 415b.

583. Remote Sensing Instrumentation and Techniques (3) II Development of instrumentation, measurement and signal processing techniques required for electromagnetic remote sensing applications with emphasis on atmospheric remote sensing. P, 482a or other introductory electro-magnetic course.

584. Advanced Antenna Theory and Design (3) II 1988-89 Electromagnetic radiation and diffraction; dipoles, slots, open wave guides, and horns; apertures, reflectors, and arrays; mechanical and electronic scanning; applications to practical radar and communications problems. P, 581.

585. Plasma Etching (3) II Practical methodology of basic etch processes in silicon, silicon oxide and nitride, and aluminum. Plasma physics and chemistry, computer simulation. P, 482, familiarity with processing techniques, or consult department before enrolling.

586. Geo-Electromagnetism (3) I 1987-88 Earth resistivity principles, induced polarization, electromagnetic induction and loop-loop coupling, earth conduction effects in power systems, well logging, geomagnetics, magnetotellurics and tunnel transmission. P, 482; 502 or Math. 422b; Phys. 415b. (Identical with Geos. 586)

589. Atmospheric Electricity (3) II 1987-88 (Identical with Atmo. 589)

636. Information Theory and Coding (3) II 1988-89 Definition of a measure of information and study of its properties; introduction to channel capacity and error-free communications over noisy channels; encoding and decoding systems, with emphasis on error correcting and error detecting codes for noisy binary channels. P, 503. (Identical with Math. 636)

639. Methods of Communication and Detection Theory and Signal Extraction (3) II 1987-88 Communication, detection and measurement as statistical decision problems; principles of communication in the presence of noise; discussion of AM, FM, and PCM; matched filter and correlation detection; coherent detection. P, 503.

652. Analysis and Design of Semiconductor Junction Devices (3) II Analysis of physical phenomena in semiconductors, including carrier transport, injection, and lifetime, with emphasis on how these phenomena affect design and operation of junction devices. P, 458 or 556.

653. Advanced Device Engineering (3) I Consideration of the design of devices: photoconduction, photovoltage, tunneling, surface effects, junction avalanche, solid-state microwave generation, thermoelectries and Hall effect.


674. Sequential Circuits and Automata (3) I Analysis and synthesis of sequential circuits, partitioning and state assignment, linear sequential circuits, iterative networks, fault test generation and design automation. P, 474. (Identical with C.Sc. 674)


685. Inertial Confinement Controlled Fusion (3) I (Identical with N.E.E. 685)

687. Magnetic Confinement Controlled Fusion (3) I (Identical with N.E.E. 687)


693. Internship c. Clinical Engineering (1 to 3) I II P, enrollment in clinical engineering option.

ELEMENTARY EDUCATION
(See Teaching and Teacher Education)
ENGINEERING

Within the colleges of Engineering and Mines, and Agriculture, programs are offered leading to the Master of Science (M.S.) and the Doctor of Philosophy (Ph.D.) degrees as indicated in the following list of departments and majors:

Aerospace and Mechanical Engineering
- aerospace engineering ........................................ M.S./Ph.D.
- mechanical engineering ..................................... M.S./Ph.D.

Agricultural Engineering
- agricultural engineering ...................................... M.S.
- irrigational engineering .................................... Ph.D.

Chemical Engineering
- chemical engineering ........................................ M.S./Ph.D.

Civil Engineering and Engineering Mechanics
- civil engineering ............................................. M.S./Ph.D.
- engineering mechanics .................................... M.S./Ph.D.

Electrical and Computer Engineering
- electrical engineering ....................................... M.S./Ph.D.

Hydrology and Water Resources
- hydrology ...................................................... M.S./Ph.D.
- water resources administration ........................... M.S./Ph.D.

Materials Science and Engineering
- materials science and engineering ....................... M.S./Ph.D.

Mining and Geological Engineering
- mining engineering .......................................... M.S./Ph.D.
- geological engineering .................................... M.S./Ph.D.
- mineral economics .......................................... M.S./Ph.D.

Nuclear and Energy Engineering
- nuclear engineering .......................................... M.S./Ph.D.

Systems and Industrial Engineering
- systems engineering ......................................... M.S./Ph.D.
- industrial engineering .................................... M.S.
- reliability engineering ..................................... M.S.

Qualified students working toward an advanced degree in various engineering programs may select certain options which are interdisciplinary or interdepartmental in nature. The programs in which these options are available and descriptions of the option follow:

BIOMEDICAL ENGINEERING — This option is available in the departments of Aerospace and Mechanical Engineering, Chemical Engineering, Electrical and Computer Engineering, Nuclear and Energy Engineering, and Systems and Industrial Engineering. Biomedical engineering is a multidiscipline in which physical scientists and engineers interact with life scientists and physicians to solve problems ranging from basic investigations to applications in clinics and related health service facilities. The work is coordinated by the Committee on Biomedical Engineering.

CLINICAL ENGINEERING — This option is available in the departments of Electrical and Computer Engineering and Aerospace and Mechanical Engineering. Clinical engineering can be defined as the application of engineering methods and technologies to the problems and needs of medicine and health care delivery. Clinical engineering implies bedside or patient-related engineering and involves the use of the engineer's background and skills as a part of the total health care team. The option includes specific and elective course work, laboratories, a thesis project, and a nine- to twelve-month clinical engineering internship in a hospital.
ENGLISH SYSTEMS ENGINEERING — This option is available in the departments of Aerospace and Mechanical Engineering, Chemical Engineering, Civil Engineering and Engineering Mechanics, Electrical and Computer Engineering, and Nuclear and Energy Engineering. The program is designed to encourage engineering study and research efforts directed toward society's energy needs. The scope of interest includes energy sources (fossil, geothermal, hydro, nuclear, and solar); systems to convert and transfer energy and power; efficient energy utilization; and environmental controls. Applied research and industrial interaction are stressed. The program is coordinated by a committee representing the departments in which the option is available.

ENGINEERING MECHANICS
(See Civil Engineering and Engineering Mechanics)

ENGLISH

Professors Gerald Monsman, Head, Barbara Babcock, J. Douglas Canfield, L. D. Clark (Emeritus), Mary Jane Cook (Emerita), Roger Dahood, Edgar Dryden, Sigmund Eisner, Lawrence J. Evers, Dorothy V. Fuller (Emerita), Albert F. Gegenheimer, Frances Gillmor (Emerita), Byrd H. Granger (Emerita), Nils Hasselmo, Richard Hosley, Robert W. Houston, Billie Jo Andrew Inman, Carl F. Keppler (Emeritus), Carl H. Ketcham, John H. McElroy, Gerald M. McNiece, N. Scott Momaday, A. Laurence Muir (Emeritus), Steve L. Oren, Charles E. Poverman, Suresh Raval, Harry F. Robins (Emeritus), Paul Rosenblatt, Herbert Schneidau, Charles W. Scruggs, Richard Shelton, Oliver F. Sigworth (Emeritus), Melvin T. Solve (Emeritus), John C. Ulreich, J.P. Wearing, Peter Wild


Assistant Professors Donna Johnson, Dhira Mahoney, Tenney Nathanson, Duane Roen, Alice M. Senob (Emerita), Charlotte Thompson, Thomas Willard, Lynda Zwinger

The department offers programs leading to the Master of Arts degree with a major in English or in English as a second language, the Master of Fine Arts degree with a major in creative writing, and the Doctor of Philosophy degree with a major in English. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in English and the Doctor of Philosophy degree with a major in English education.

Degrees

MASTER OF ARTS (Major in English) — To be admissible, applicants must have completed the equivalent of the undergraduate major in English with a grade-point average of at least 3.50 in courses in English. Applicants must submit scores on the aptitude and advanced literature in English tests of the Graduate Record Examination and a short sample of their scholarly or critical writing. Applicants must also arrange to have the department receive three letters of recommendation. These materials should be addressed to the Director of Graduate Study of the Department of English.*

MASTER OF ARTS (Major in English as a second language) — General Graduate Record Examination scores are required for students whose GPAs are below 3.0. Applicants must present evidence of the completion of two years of college study in a foreign language or demonstrate equivalent proficiency by examination.** Applicants must also present proof of some prior teaching or tutoring experience.
MASTER OF FINE ARTS — For information concerning this degree see Requirements for Master's Degrees/Master of Fine Arts elsewhere in this catalog.*

MASTER OF EDUCATION — Applicants must have completed an undergraduate major or minor in English, including a minimum of twenty units in English with a year's survey of English literature, a course in the history of the English language, and a course in modern grammar. Graduate Record Examination scores may be required of applicants whose undergraduate preparation seems weak. For further information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.*

DOCTOR OF PHILOSOPHY — The admission requirements for this degree program are the same as those set forth for the Master of Arts with a major in English above. At least 30 units of 500-level work (beyond the requirements for the Master of Arts degree) must be completed in addition to the dissertation. All students must pass a qualifying examination in English and American literature equivalent to the final examination for the Master of Arts degree with high pass performance. The dissertation for students with English majors may take the form of three extended essays. The dissertation for students with English education majors will normally take that form.*

*Details of specific departmental requirements for the various degree programs should be obtained from the Director of Graduate Study of the Department of English.

401. Advanced Nonfiction Writing (1 to 4) [Rpt./2] GC I II P, 301.
403. Advanced Scientific Writing (3) GC I II Preparation of professional literature for publication.
404. Advanced Fiction Writing (1 to 4) [Rpt./2] GC I II P, 304.
405. History of the English Language (3) GC I II The evolution of English sounds, inflections, and vocabulary from earliest times to the present, with attention to historical conditions. (Identical with Ger. 405)
406. Modern Grammar and Usage (3) GC I II Current American English structure according to major types of grammar and current American English usage, both with reference to standard British English.
408. English as a Second Language in Bilingual Education (3) GC I II Methodology for the teaching of English as a component of bilingual education; grammar, phonology, and syntax as they apply to the teaching of language skills. (Identical with T.T.E. 408)
409. Advanced Poetry Writing (1 to 4) [Rpt./2] GC I II P, 309.
411. Teaching of Literature (3) GC I II Theory and practice of teaching literature, with intensive study of genres and works commonly taught in secondary schools. P, nine units of lit. (Identical with T.T.E. 411)
413. Poetry in Forms (1 to 4) [Rpt.] GC I II Explores prosody through discussing and writing of forms and types, research paper. P, 309.
419a-419b. Non-fiction Prose (3-3) GC 419a: The essay in English. 419b: Other prose forms. P, Freshman Composition; upper division or graduate standing
420. Contemporary American Usage (3) GC I II S Consideration of the varieties of contemporary American language usage, social and regional, written and oral. P, upper division or graduate standing.
445. Introduction to TESL: An Overview (2) GC I The development of English as a second language with emphasis on current trends, the influence of linguistic theory, and the international role of English.
449a-449b. Folklore (3-3) GC 449a: Forms of Verbal Folklore: myth, legend, folktale, riddle, proverb, jokes, folksong, ballad, etc. 449b: Non-verbal Folklore: custom, belief, folk art and craft, food, medicine, dress, festival, and drama. (Identical with A.In.S. 449a-449b and Anth. 449a-449b)
461. Linguistics and the Study of Literature (3) GC II 1988-89 (Identical with Ling. 461)
469a-469b. Germanic Folklore: An Introduction to Nonliterary Forms (3-3) GC (Identical with Ger. 469a-469b)
477. Ethnic Literature
   a. North American Indian Literature. (3) GC (Identical with A.In.S. 477a)
164 DEPARTMENTS AND COURSES OF INSTRUCTION

483. American Realism (3) GC I The development of realism and naturalism in American literature; Twain, James, Crane, Dreiser, and other writers.


503a. Introduction to Comparative Literature and Literary Theory (3) I (Identical with C.P.L.T. 503a)

515a-515b. History of Criticism (3-3) 515a: Plato through the 19th century. 515b: Modern criticism.

516a-516b. Theories of Linguistic Structure (3-3) 516a: The American tradition in linguistics. 516b: The European tradition in linguistics. 516a is not prerequisite to 516b.

520. History of the German Language (3) II 1987-88 (Identical with Ger. 520)

525. Beowulf (3) II (Identical with Ger. 525)

526. Advanced Studies in Chaucer (3) II


531. Advanced Studies in Shakespeare (3) II

533. Studies in the Renaissance (3) I

534. Advanced Studies in Milton (3) I

541. Studies in the Restoration and Eighteenth Century (3) II


561. History of Children's Literature (3) II (Identical with Li.S. 561)


591. Preceptorship
   a. Methodology of Essay Writing (1) I II Designed for graduate teaching assistants in English.
   b. Methodology in Critical Reading and Writing (1) I II Designed for graduate teaching assistants in English.

595. Colloquium
   a. Rhetoric of Exposition (1) I II Designed for graduate teaching assistants in English.
   b. Rhetoric of Literature and Critical Writing (1) I II Designed for graduate teaching assistants in English.

596. Seminar
   a. Medieval Literature (3) [Rpt.] I II
   b. Renaissance Literature (3) [Rpt.] I II
   c. Restoration and Eighteenth-Century Literature (3) [Rpt.] I II
   d. Nineteenth-Century British Literature (3) [Rpt.] I II
   e. Twentieth-Century British Literature (3) [Rpt.] I II
   f. American Literature (3) [Rpt.] I II
   g. Comparative Literature (3) [Rpt.] I II
   h. Modern Literature (3) [Rpt.] I II Open to creative writing majors only.
   i. Germanic Linguistics (3) [Rpt.] I II (Identical with Ger. 596i)
   j. Linguistics for ESL (3) [Rpt.] I II
   k. Methods and Materials of Literary Research (3) [Rpt.] I II
   l. Theories of Criticism (3) [Rpt.] I II
   m. Studies in the Oral Tradition (3) [Rpt./9 units] I II (Identical with A.In.S. 596m)

597. Workshop
   a. Southern Arizona Writing Project (3-9) [Rpt./12 units] I II S (Identical with L.R.C. 597a, which is home)
   o. The Teaching of English (3) I II S [Rpt.] (Identical with L.R.C. 597o)

604. Writing Project in Fiction (1 to 6) [Rpt.] I II For M.F.A. candidates working on the book-length writing project in fiction.

609. Writing Project in Poetry (1 to 6) [Rpt.] I II For M.F.A. candidates working on the book-length writing project in poetry.

613. Teaching of ESL (3) I Basic approaches to the teaching of English as a second language, with emphasis on the aural-oral method. P, 612 or CR. (Identical with L.R.C. 613)

693. Internship

696. Seminar
b. Linguistics (2 to 4) I II (Identical with Ger. 696b, which is home)
c. Folklore (2 to 4) I II (Identical with Ger. 696c, which is home)

ENGLISH AS A SECOND LANGUAGE
(See English)

ENGLISH EDUCATION
(See English)

ENTOMOLOGY

Professors William S. Bowers, Head, Paul D. Gerhardt (Emeritus), John G. Hildebrand (Neurobiology), Roger T. Huber, Leon Moore, William L. Nutting (Emeritus), Donald M. Tuttle (Emeritus), George W. Ware, Theo F. Watson, Floyd G. Werner
Associate Professor Robert L. Smith
Assistant Professors David N. Byrne, Nancy A. Moran, L. Irene Terry

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees in entomology. Disciplinary specializations are available in agricultural entomology, aquatic entomology, apiculture, behavior, biological control, bionomics, ecology, host plant resistance, insect pest management, medical and veterinary entomology, morphology, physiology, taxonomy and toxicology. Entomological research opportunities also exist in the Department of Biochemistry and the Division of Neurobiology.

Admission requirements include the completion of an undergraduate major in entomology or equivalent degree in the biological sciences. The undergraduate program should include course work in the biological sciences, physics, organic chemistry, and mathematics. Applicants must submit scores on the general and subject tests of the Graduate Record Examination and three letters of recommendation from persons in a position to assess the applicant's potential as a graduate student. Inquiries concerning financial aid should be addressed to the department.

Graduate study programs are individually planned and approved by the guidance committee. Master's degree candidates, regardless of the area of concentration, will be required to have completed courses in systematics, morphology and physiology. A thesis is ordinarily required. The doctoral program requires, in addition to the requirements for the master's degree, courses in biochemistry, computer programming, advanced statistics, and the equivalent of one semester of teaching experience.

402. Introduction to Pesticides and Their Use (2) GC II (Identical with Pl.P. 402)
403R. Biology of Animal Parasites (3) GC I (Identical with V.Sc. 403R)
404. Insect Morphology (4) GC I 1988-89 External and internal anatomy as related to identification, function and phylogeny of insects and other arthropods; modifications in development and habits peculiar to the insects. 2R, 6L. P, 3 units of entomology or invertebrate zoo.
407. Insect Physiology (4) GC II 1988-89 Principles of the physiological systems of insects and lab. methods for their study, with emphasis on the functioning of these systems in the environment. 2R, 6L. P, 3 units of organic chemistry or biochemistry.
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Department</th>
<th>Units</th>
<th>Prerequisites</th>
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</thead>
<tbody>
<tr>
<td>412</td>
<td>Cultural Control and Host Plant Resistance (1) GC I Analysis of cultural practices used for insect management in crop systems. Principles of insect-plant relationships pertaining to resistance in crop plants, and the methods used to develop resistant crop varieties. 2R. P, one unit in entomology. Terry.</td>
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<tr>
<td>416</td>
<td>Biological Control (2) GC II Principles of the biological control of arthropod pests, with emphasis on their application to agricultural entomology. 2R. P, 444 or a course in population ecology. Watson</td>
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<tr>
<td>418</td>
<td>Insect Vectors of Plant Pathogens (1) GC II Examination of the relationships between insect vectors, plant pathogens, and host crops. 2R. P, one unit in entomology. Byrne</td>
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<tr>
<td>420</td>
<td>Urban Entomology (3) GC II 1987-88 Biology of insects, other arthropods and vertebrates, beneficial and pestiferous, that impact humans in the urban ecosystem. Identification of species and management of pests. 2R, 3L. Field trips. Smith</td>
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<tr>
<td>422</td>
<td>Insect Population Sampling (1) GC I Development of sampling methods for both research purposes and pest management decision making. Comparison of the efficiency of sampling methods and programs for sampling data analysis. 1R, 3L. Field trips. P, 3 units of statistics. Terry</td>
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<tr>
<td>424</td>
<td>Biorational Strategies for Insect Control (1) GC I History, current status, and methods for the discovery of intrinsically non-toxic chemicals targeted to interfere with processes unique to insects including growth, development, reproduction, diapause, and behavior. 2R. P, one unit in entomology. 3 units of organic chemistry or biochemistry. Bowers</td>
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<tr>
<td>426</td>
<td>Insect Population Sampling (3) GC I Examination of the history, methods, externalities and benefits of the use of insecticides and acaricides. 2R. P, one unit in entomology. Byrne</td>
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<tr>
<td>430</td>
<td>Principles of Insect Pest Management (1) GC I Principles, concepts, and methods of insect pest management. 2R. P, 412, 422, 430. Watson</td>
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<tr>
<td>444</td>
<td>Insect Ecology (3) GC I Determinants of population size and distribution, including processes occurring within and between populations, abiotic factors. Techniques for evaluating population parameters. 2R, 3L. Field trips. P, one course in entomology or Ecol. 182. (Identical with Ecol. 444) Moran</td>
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<tr>
<td>445</td>
<td>Ecology and Evolution of Insect/Host Plant Associations (1) GC II Theoretical and empirical evidence on the role of hosts in insect radiation, the evolution of defenses in plants, insect adaptations to plants, the evolution of host specificity. P, one course in entomology or Ecol. 182. (Identical with Ecol. 445) Moran</td>
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<tr>
<td>449</td>
<td>Crop Insect Biology (1) GC I The biology and recognition of both pestiferous and beneficial arthropods found in Arizona's principal agricultural crops. Analysis of methods used to manage their populations. 1R, 3L. Field trips. P, 151 or 201R. Byrne</td>
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<tr>
<td>508</td>
<td>Insecticide Toxicology (3) II 1987-88 Insecticides and related chemicals; their modes of action, detoxication, resistance in arthropods, and environmental distribution and effects. P, 3 units of organic chemistry or biochemistry. (Identical with Tox. 508)</td>
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<tr>
<td>512</td>
<td>Insect Behavior (3) II 1987-88 The evolution of arthropod behavior in ecological context. Ultimate causation with some consideration of physiological and morphological constructs. 2R, 3L. Field trips. (Identical with Ecol. 512) Smith</td>
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<tr>
<td>516</td>
<td>Applied Insect Taxonomy (4) I 1987-88 Principles and methods in the classification of animals. Practice in developing practical classifications of insects that are of significance to crop protection in local areas. Classification of immature stages of terrestrial insects. 3R, 3L. Field trips. Werner</td>
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<tr>
<td>576</td>
<td>Environmental Toxicology (3) I (Identical with Tox. 576)</td>
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<tr>
<td>659</td>
<td>Electron Microscopy (4) I (Identical with Pl.P. 659, Micr. 659, and V.Sc. 659)</td>
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<tr>
<td>696</td>
<td>Seminar</td>
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<tr>
<td>a.</td>
<td>Entomology (1) [Rpt./6] II</td>
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</tbody>
</table>

**ENVIRONMENT AND BEHAVIOR**

*Committee on Environment and Behavior (Graduate)*

Professors Robert Bechtel, Chairperson (Psychology), Charles Albanese (Architecture), Terry Daniel (Psychology), William Havens (Renewable Natural Resources), Helen Ingram (Political Science), William Ittelson (Psychology), David King (Renewable Natural Resources), Kirby Lockard (Architecture), William Rathje (Anthropology), Thomas F. Saarinen (Geography), Lawrence Wheeler (Psychology), Ervin H. Zube (Renewable Natural Resources)

Associate Professors Dennis Doxtater (Architecture), William Shaw (Renewable Natural Resources)

Assistant Professors Robert Itami (Renewable Natural Resources), Chet Ross (Family and Consumer Resources)
The Committee on Environment and Behavior functions to coordinate and further develop study of the relationship between physical settings and human activities. This multidisciplinary group of teachers and researchers will assist students interested in combining an environment and behavior emphasis into majors such as psychology, architecture, landscape architecture, interior design, geography, renewable natural resources, political science, and water resources administration. Students should consult their department advisers and appropriate members of the Committee on Environment and Behavior.

While no graduate major is offered, the committee does offer a doctoral minor. A minimum of fifteen units from environment and behavior courses approved by the committee is required.

Current information on studies in environment and behavior can be obtained from the Chairperson, Committee on Environment and Behavior, Department of Psychology. Courses identified as having content which deals specifically with environment and behavior include: Arch. 287, 429, 474, 497; Art. 434; Geog. 275, 360, 407, 561, 563; Ids. 596u; L.Ar. 533, 595a; N.R.R. 470; Pol. 481; Psyc. 371, 428, 520, 560; R.N.R. 595c.

### ETHNIC STUDIES

*(See American Indian Studies)*

### EXERCISE AND SPORT SCIENCES

Professors Charles M. Tipton, *Head*, Anne E. Atwater, Timothy G. Lohman, Donna Mae Miller, Frederick B. Roby, Mary P. Roby, David H. Strack


Assistant Professors Theresa E. Boggess, Joy C. Bunt, Roger M. Enoka, Douglas R. Seals, Roy A. Tatum

The Department of Exercise and Sport Sciences is concerned with advancing the body of knowledge in the exercise and sport sciences and preparing professionals for careers in applied exercise science, teaching, coaching and research. The department offers programs leading to the Master of Science and Master of Arts degrees with a major in exercise and sport sciences. A minor in exercise and sport sciences is available for doctoral students with majors in other disciplines. Students wishing to specialize in exercise physiology at the doctoral level may do so through an interdisciplinary Animal Physiology program (see that entry elsewhere in this catalog). Additional information concerning these programs may be obtained on request from the department.

Applicants must have completed human anatomy and human physiology. In addition, each applicant is required to submit scores on the Graduate Record Examination General Test, a detailed statement of professional goals, and three letters of recommendation from persons in a position to evaluate the applicant's potential as a graduate student. These materials should be sent to the Graduate Program Director, Department of Exercise and Sport Sciences.

Study programs for both the Master of Science and Master of Arts degrees are individually planned, in consultation with an advisor, around a principal area of interest. At least 20 units must be completed in exercise and sport sciences, but students are encouraged to take work in related fields, outside the department, if it is directed toward research interests. A thesis is optional, but a student who chooses to write one may earn as many as 6 units for its preparation. In the thesis option, the student must complete a minimum of 30 units of approved graduate work. Students who do not elect to write a thesis must complete 32 units of approved graduate work. Excellent research facilities are available.

402. *Principles of Neuroanatomy* (4) GC II (Identical with Anat. 402)
**168 DEPARTMENTS AND COURSES OF INSTRUCTION**

470. **Biomechanics of Human Movement** (3) GC I Analysis of human motion focusing on the mechanical interaction between the human body and the external environment. 2R, 3L. P, 370, Ecol. 159a-159b. Atwater/Enoka

485. **Sport in Contemporary Society** (3) GC I Study of contemporary sport from the perspectives of its personal, social, cultural, economic and educational dimensions. Miller


496. **Proseminar**
   - Analysis of Data in Human Motion Studies (1) GC II Atwater

515. **Philosophy of Physical Education and Sport** (3) GC I Designed to help the student examine philosophic foundations, to explore the philosophic process, and to analyze, formulate, and apply principles as guides to action. P, 12 upper-division units of ex.s.s. Miller

525. **Motor Learning and Human Performance** (3) GC I Neuropsychological approach to the study of motor skill acquisition and learning variables affecting human potential for physical performance. Fairchild

526. **Neural and Perceptual Foundations of Motor Learning and Performance** (3) GC I Examines the neural basis of motor behavior and the role and influence of perceptual modalities in motor learning and sports performance; topics include sensory coding, perceptual processing and motor control. Russell

527. **Psychology of Sport and Exercise** (3) GC I Examines the effects of motivation, personality, attitudes, competition and group dynamics on sport performance as well as the psychological effects of exercise, exercise adherence and exercise addiction. Williams

528. **Stress Management for Performance and Health** (3) GC I Examines within a biopsychosocial framework the concept of stress as it relates to performance and the etiology of stress-related health disorders. Also examines and applies stress management interventions to enhance performance and promote health. Williams

529. **Psychological Interventions and Ergogenic Aids for Peak Performance** (3) GC II The application and effectiveness of ergogenic aid mechanisms, particularly psychological interventions, in enhancing performance. P, 528. Williams

530. **Advanced Physiology of Exercise** (4) GC I Metabolic, cardiopulmonary, thermoregulatory, fluid-electrolyte, neuroendocrine, neuromuscular and various environmental factors which influence physiologic adjustments to acute exercise and the physiological adaptations to chronic exercise. P, 373. Tipton/Seals/Enoka/Lohman


535. **Issues and Trends in Physical Education and Sport** (3) GC II Designed to aid the student in identifying, analyzing, and evaluating recent developments and basic issues in physical education and sport. P, 12 upper-division units of ex.s.s. Miller

536. **Administration of Sports Programs** (3) GC II Designed to provide a theoretical framework for students pursuing sports management careers and others interested in various functions involved in the conduct of sport programs. Miller

545. **Evaluation and Regulation of Body Build and Composition** (3) GC I Laboratory and field assessment of body fat, lean body mass and somatotype; anthropometry; body build and composition of the athlete; morphology of fat and lean tissue; exercise and dietary regulation of obesity and chronic underweight. P, 373, 374, Math. 117e. Bunt

548. **Nutrition in Sport and Exercise** (3) GC II A critical analysis of research in the role of nutrition in physical performance. Emphasis on both nutritional deficiencies and supplements and their relation to performance, the assessment of nutritional status, the interaction of exercise and nutrition in fitness and weight control programs. N.F.S. 310 or N.F.S. 410. (Identical with N.F.S. 548) Lohman

550. **Advanced Exercise Physiology Laboratory** (3) GC II Experiments designed to demonstrate basic concepts of physiological responses to exercise with emphasis on development of skills in laboratory instrumentation and techniques of research. Roby/Seals/Tipton

555. **Cinematographic Techniques for Analyzing Human Movement** (3) GC II High-speed motion picture photography applied to the study of human motion; techniques of data collection, reduction, analysis and interpretation. P, 520. Atwater

565. **Physical Activity in Aging and Chronic Diseases: Physiological Aspects** (3) GC II The etiology and pathophysiological processes involved in coronary heart disease, hypertension, diabetes, and aging; role of exercise in prevention as a potential therapeutic intervention. Seals
566. **Physical Activity in Aging and Chronic Diseases: Psychosocial Aspects** (3) I Psychosocial dimensions of exercise programs designed for populations with chronic diseases as well as for older populations. P or CR 565. *Fairchild*

570. **Research Design in Exercise and Sport Sciences** (2) I II Study of research designs, methodologies and data analysis procedures pertinent to the exercise and sport sciences; emphasis is on the selection of research problems and interpretation of research articles. *Lohman*

571. **Laboratory in Research Design for Exercise and Sport Sciences** (1) I II Laboratory experiences in literature retrieval systems; data analysis procedures by calculator, microcomputer, and mainframe computer; critical analysis procedures of research articles, and participation in a research project. CR, 570. *Lohman*

575. **Statistical Analysis in Exercise and Sport Sciences** (3) II Analysis of research designs and data analysis procedures in the field of exercise and sport sciences with emphasis on appropriateness of selected designs and interpretation of various data analysis procedures. Statistical power, reliability, covariance and multiple regression techniques and uses of micro- and mainframe data analysis software. P, 570 and 571. *Lohman*

580. **Evaluation of Athletic Injuries** (3) I Advanced study of the etiology, pathology, and clinical signs of common athletic injuries. Emphasis on clinical evaluation of athletic injuries by the athletic trainer. P, 377; 800 hrs. of clinical experience in athletic training. *Delforge*

581. **Therapeutic Modalities** (2) II Advanced study of the role of hydrotherapeutic and electrotherapeutic agents in the rehabilitation of athletic injuries. P, 580. *Delforge*

582. **Anatomical Basis of Sport Injuries** (3) I Comprehensive survey of bones, ligaments, muscles, nerves, and vessels of the trunk and upper and lower extremities, with emphasis on their relationship to sport injuries. 2R, 3L. P, CR 580. *Hillman*

584. **Rehabilitation of Athletic Injuries** (3) II Principles in the planning and implementation of rehabilitation programs for injured athletes with emphasis on application of contemporary therapeutic exercise techniques. P, 580. *Delforge*

585. **Issues in Athletic Training and Sports Medicine** (3) S Current issues and trends in athletic training and sports medicine with emphasis on the professional preparation of athletic trainers and the role of the certified athletic trainer in athletic health care delivery systems. P, 580. *Delforge*

586. **Physical Education and the Law** (3) I Investigation and analysis of legal parameters within which the physical educator and coach operate; negligence theory; common defenses; product liability; insurance; legal implications for program development and methodology. *Baker*

588. **Legal Aspects of Sports Administration** (3) II Development of administrative and coaching techniques from the legal perspective. Analysis of personnel procedures, purchase of equipment, athletic associations, certification, transportation, medical procedures, officiating, and the handicapped athlete as influenced by litigation. P, 586. *Baker*

594. **Practicum** b. Exercise Technician/Exercise Prescription (2) I II P, 374, 394d. *Roby*

695. **Colloquium** a. Motor Control (2) [Rpt./8 units] II P, Psio. 480 and consult department before enrolling. (Identical with Psio. 695a, Psyc. 695a, Sp.H. 695a, S.I.E. 695a)

791. **Preceptorship** a. Laboratory Rotations (2) I II 6L. Open to majors only. P, 550.

795. **Colloquium** a. Motor Control (1) [Rpt./1] I II P, 530.
   b. Environment (1) [Rpt./1] I II P, 530.
   c. Aging and Disease (1) [Rpt./1] I II P, 530.
   d. Metabolism (1) [Rpt./1] I II P, 530.

**FAMILY AND CONSUMER RESOURCES**

Professors Robert R. Rice, *Director*, Oscar C. Christensen, Victor A. Christopherson, Roger J. Daldrup, Kathryn L. Hatch, Theodore Jacob, Jean Ruley Kearn, Amy Jean Knorr (*Emerita*), Doris E. Manning (*Emerita*), Naomi A. Reich, Carl A. Ridley, George B. Sproles, Mary Adele Wood (*Emerita*)

Associate Professors Richard L. Erickson, Donna R. Iams, Roger M. Kramer, Philip J. Lauver, Mary H. Marion, Betty J. Newlon, Joel Rudd

Assistant Professors Oscar A. Blazquez, Brenda M. Brandt, Maureen E. Kelly, Elizabeth Kendall Sproles, Molly Longstreth, Chet J. Ross, Mari S. Wilhelm
The School of Family and Consumer Resources offers programs leading to the Master of Science degree with majors in family and consumer resources and home economics education. For the Master of Science degree with a major in family and consumer resources, concentrations are available in child development and family relations; clothing, textiles and interior design; consumer studies and home management; counseling and guidance; home economics education; human development; and interpersonal relations. The school also offers programs leading to the Master of Home Economics Education degree with a major in home economics education and, in cooperation with the College of Education, the Master of Education degree with a major in family and consumer resources. For information concerning these degrees see Requirements for Master’s Degrees/Master of Home Economics Education and Master of Education elsewhere in this catalog.

All applicants are required to submit scores on the aptitude test of the Graduate Record Examination. Additional admission requirements, if any, are given in the notes under each division below.

Requirements to be included in the graduate study program of each student are two units of seminar, an appropriate course in statistics, a course in research methods, and a thesis of four to six units. Modification of these requirements may be made, with the approval of the student's graduate committee and the director of the school, after consideration of the student's preparation and professional objectives. Special degree requirements, if any, are given in the notes under each division below. Opportunities to participate in current research programs, such as those at the Agricultural Experiment Station, are available.

Divisions

CHILD DEVELOPMENT AND FAMILY RELATIONS — For the Master of Science degree with a major in family and consumer resources, concentrations are available in (1) human development, which provides training in scientific theory and research across the individual lifespan and family life cycle, as well as the opportunity to gain practicum experience in adult development; and (2) interpersonal relationships, which provides training in personal development and interpersonal competence. Students are required to complete 36 units, including four to six units for the thesis or two units for the master's report.

CLOTHING, TEXTILES, AND INTERIOR DESIGN — For the Master of Science degree with a major in family and consumer resources, a concentration is available in clothing, textiles, and interior design. Students are required to complete 34 units including four to six units for the thesis. This program prepares students for employment in teaching at the secondary-school, community-college, or university level; for promotional and educational or testing and research positions with industrial and commercial companies; or for design and development of furniture and accessories.

COUNSELING AND GUIDANCE — The division offers programs leading to the Master of Science degree. Concentrations are available in career counseling, marriage, family and agency counseling. A minor program of fifteen units minimum is available for doctoral students majoring in other fields.

Forms and statements regarding application procedures for master's programs with a major in counseling and guidance are obtainable on request from the department. Master's degree applicants must submit a personal data blank, a candidate's statement, letters of recommendation and scores of the Graduate Record Examination. All application materials for fall admission must be received by March 1.

Individual master's programs will be planned with and approved by an advisor. These may vary both in course work and in total units, depending upon the area of concentration and upon past experience and training.

HOME ECONOMICS EDUCATION/CONSUMER STUDIES — Programs leading to the Master of Science degree and the Master of Home Economics Education degree with a major in home economics education are available. A minor in home economics education is also available for doctoral students with majors in other disciplines. The Master of Science degree program requires a thesis and no fewer than twenty units in home economics education, family and consumer resources, or education, or a combination. A total of thirty units is required. These
programs prepare students for employment in the Cooperative Extension Service at county or specialist levels; for teaching at secondary, community-college, or university levels; for supervision at local and state levels; or for educational positions in business.

For the Master of Science degree with a major in family and consumer resources, concentrations are available in family economics, consumer studies and home management, consumer economics, and consumer education. Because of the interdisciplinary nature of the program, allied subjects such as economics, education, management, sociology, and other fields of family and consumer resources may be selected to give the desired emphasis. These programs prepare students for career opportunities in college and university teaching, the Cooperative Extension Service, business, and research.

NUTRITION AND FOOD SCIENCE — See Nutrition and Food Science elsewhere in this catalog.

Family and Consumer Resources

465. Women in International Development (3) GC II (Identical with Anth. 465)

696. Seminar z. Family and Consumer Resources (1 to 3) [Rpt./1] I II

Child Development and Family Relations

Professor Jacob, Chairperson of the Division

407. Problems in Child Development (3) GC II 1988-89 Special child-rearing contexts in contemporary society; poverty, minority group membership, social change, and special developmental considerations.

413. Issues in Aging (3) GC II Introductory course in gerontology, with emphasis upon contemporary issues. (Identical with Gero. 413)

417. Advanced Human Development and Relations (3) GC II Behavioral science approaches to interpersonal competence within various societal contexts. P, 117.

427. Problems in Marriage and the Family (3) GC II Identification and analysis of major problem areas in marriage and the family, including economic, sexual, role conflict, emotional disorders, and childrearing.


457. Bio-Social Determinants of Socialization (3) GC II Bio-social factors related to socialization and the influence of various subcultures and contexts upon child-rearing practices. P, 223; 6 units of child dev. or soc. or pyc. (Identical with Soc. 457)


487. Readings in Family Relations (3) GC II Critical analysis of selected studies and research. P, 137, or 337, or Soc. 321.

500. Life Span Development (3) II (Identical with Ed.P. 500)

503. Advanced Adolescent Development (3) II (Identical with Ed.P. 503)

507a-507b. Research Methods in Social Science (3-3) I II 507a: Problem selection, literature review, research design, data analysis, and other related topics, leading to the development of a research prospectus. 507b: Introduction to computer usage in social sci.; critical review of thesis writing by faculty and peers, including literature review, problem formulation, and research design.

517. Program Development and Evaluation in Micro-level Human Services (3) I Comprehensive review of human and family intervention projects and the procedures involved in developing, implementing, and evaluating these projects. All-day field trips. P, 507b.

547. Theories of Human and Family Development (3) I Analysis and integration of the major theories of individual and family development within a social context; evaluation of theoretical formulations in selected content areas of human relations and individual growth. P, 9 units of child dev., family relations, pyc. or soc.
172 DEPARTMENTS AND COURSES OF INSTRUCTION

557. **Methods in Marital Therapy (3)** I Theories and principles of counseling for premarital, marital, and group counseling situations. (Identical with Coun. 557)

573. **Family Development (3)** I Internal development of families over the life cycle, with emphasis on family goals, structure and functioning in the context of American society. P, 223, Soc. 100, or Psyc. 101.

607. **Topics in Child Development and Family Relations. (1 to 3) [Rpt./1]** II Variable content: cognitive development, biological theories of development, role theory, middle childhood, and others.

637. **Trends in Human Relations (3)** I Philosophy, content, and resources for understanding, teaching and working in the field of human relations.

### Clothing, Textiles, and Interior Design

**Professor Hatch, Chairperson of the Division**

**Clothing and Textiles**

434. **The Fashion Industry (3) GC II** Operations of the fashion business including producers of fibers, fabrics, apparel and fashion retailers. P, 304 or consult department before enrolling.

444. **Dimensions of Clothing Behavior (3) GC II** Analysis of psychological, social, cultural, historical, economic and aesthetic dimensions of clothing reported in literature. P, 145, Soc. 100, Psyc. 101, Econ. 201a.

445. **Clothing for Special Needs (3) GC I** Clothing and accessories for special needs; based upon research. (Identical with Gero. 445)

454. **New Developments in the Textile Field (3) GC I** Fabric finishes, new fiber development, textured yarns, knits, and fabric use and care problems. P, 284R.

464. **Aspects of Clothing Design (3) GC [Rpt./9 units]** I Projects in the analysis and manipulation of design media to produce garments to meet selected needs and populations. 1R, 6L. P, 145, 344.

484. **Textile Analysis (3) GC 11987-88** Physical and chemical testing, dyes, microscopic analysis and use of textile testing equipment for fabric analysis. 2R, 3L. P, 454.

**Interior Design**

405. **Barrier Free Design (3) GC II** Current research in architecture, interior design, product design, physical therapy, behavioral science and rehabilitation reviewed and applied in design problem-solving.

455. **Visual Merchandising and Display (3) GC S** All aspects of displaying merchandise, including window display, interior display, color and lighting techniques, line and composition, three-dimensional presentation, fixtures and systems, planning and layout, scheduling and promotion. P, 115 or Art 101.

475. **Contract Design (3) GC I** Design problems, presentations and purchasing. P, 265b, 355, L.Ar. 345.

485. **Ethics and Practice for Interior Design (3) GC II** Readings in the interior fields, with emphasis on individual professionalism. P, 375.

488. **Advanced Studio Project: Interior Design (3) GC II** Detailed studio-based design projects applying previously acquired design and graphic skills demonstrating high level of competence in problem solving. 1R, 6L. P, 375, 475.

### Counseling and Guidance

**Associate Professor Erickson, Chairperson of the Division**

401. **Basic Skills in Counseling (3) GC I** Selected counseling skills and their applications to noncounseling settings. Designed for nonmajors needing basic skills in counseling as an adjunct to other primary occupational functions.

403. **Principles of Adlerian Psychology (3) GC I II** Techniques for the study of human behavior; implications for improving adult-child relationships, with emphasis on Adlerian principles.

445. **Psychosocial Aspects of the Drug Use Process (3) GC I** (Identical with Ph.Pr. 445)

521. **Techniques of Interviewing (3) I II** Types and functions, process, and application of the interview in various settings.
Counseling and Guidance Laboratory (1 to 3) [Rpt.] I II Supervised observation and participation in selected counseling and guidance activities: campus, public school, and community settings.

Methods in Marital Therapy (3) I (Identical with C.D.F.R. 557)

Counseling the Adult (3) I Adult crisis, midlife changes and developmental patterns; counseling techniques and intervention strategies.

Counseling Women (3) II Examination of the counseling needs of contemporary women and current types of intervention designed to meet these needs. (Identical with W.S. 571)

Human Relations Training (3) I II Interdisciplinary human relations training lab. for assessment and development of communication and interpersonal skills. Applications in the home, business, educational and community settings.

Workshop
- Self-Management Techniques (3) S
- Anger, Depression and Guilt (3) S
- Family Systems and Psychodrama (3) S

Foundations of Counseling (3) I II Relationship and contributions of various fields to the work of the counselor at all levels, in current and historical perspective; derivation of principles and objectives; integrated lab. experience in selected settings. Open to majors only.

Appraisal of the Individual (3) I II Methods of appraising and reporting individual behavior, with emphasis on nonpsychometric data. Open to majors only.

Testing in Counseling (3) I II Evaluation and selection of psychological tests for guidance; use of psychometric data in counseling. Open to majors only.

Career Counseling (3) I II Theories of vocational development; types, sources, and use of occupational and educational information in career counseling and decision making. P, 601 or CR.

The Counseling Process (3) I II Introduction to theories of counseling; collation and interpretation of counseling data; the counseling process; study of cases. P, 601, 622.

Theories of Counseling (3) I II Rationale, development, and research underlying major counseling theories. P, 631, 644.

Premarriage and Marriage Counseling (3) I II Contemporary issues, concepts, and procedures in premarriage and marriage counseling. P, 581, 622.

Procedures in Family Counseling (1 to 3) I II Theory and process in family counseling; problem solving techniques applied to parent-child conflict; lab. experience. P, 403.

Procedures in Marriage Counseling (3) I II Application of counseling theory and techniques to the diagnosis of marital relationship and strategies for behavior change. P, 403, 601, 622.

Group Counseling (3) I Theory and process in group counseling; applications in school, college, and community settings; lab. experience. P, 644.

Internship
- Counseling (1 to 9) [Rpt.] I II
- Practicum P, 24 units of counseling courses. Supervised practice is offered on the basis of need and demand in the following areas:
  - Agency Counseling (1 to 9) [Rpt.] I II
  - Family Counseling (1 to 9) [Rpt.] I II
  - Group Counseling (1 to 9) [Rpt.] I II
  - Marriage Counseling (1 to 9) [Rpt.] I II

Colloquium
- Professional Practice (1 to 3) [Rpt.] I II
- Counselor Education and Supervision (1 to 3) [Rpt.] I II
- Counseling Theory (Theory varies) (1 to 3) [Rpt.] I II
- Career Development (1 to 3) I II

Home Economics Education/Consumer Studies

Associate Professor Rudd, Chairperson of the Division

Consumer Studies

Consumer Fraud in Nutrition (3) GC S (Identical with N.F.S. 411)

Management of Family Finances (3) GC I II Management of family finances throughout the family life cycle to achieve financial well being. P, Econ. 201a.
436. **Economics of Aging** (3) GC II Economic issues as they affect the aging individual, family and society; economic demographics, consumer problems, and retirement financial planning. (Identical with Gero. 436)

446. **Consumer Economics** (3) GC I II Study and application of consumer economics under existing market conditions. P, Econ. 201a.

466. **Family Economics** (3) GC I Analysis of the family as an economic-decision-making unit within the larger economic system. P, Econ. 201b.


### Home Economics Education

409. **Occupational Home Economics Programs** (3) GC II Purposes and methods of teaching home economics-related occupations, with emphasis on cooperative home economics vocational education. P, T.T.E. 338g; CR H.E.E. 408 and 489 or teaching experience.

411. **Consumer Fraud in Nutrition** (3) GC S (Identical N.F.S. 411)

428. **Professional Presentations and Techniques** (3) GC I Theory and practice of educational techniques in non-formal settings in positions in business, government and human services. 2R, 3L.

448. **Extension Program Planning and Evaluation** (3) GC II Bases and procedures for program planning, implementation and evaluation in non-formal education programs such as the Cooperative Extension Service. Examination of issues and trends, observation and individual projects. P, A.Ed. 338, and H.E.E. 428 or A.Ed. 409. (Identical with A.Ed. 448)

497. **Workshop**

  i. * Extension Communications (1 to 2) [Rpt./2] GC (Identical with A.Ed. 497i, which is home)

  r. * Public Relations in Extension (1 to 2) [Rpt./2] GC (Identical with A.Ed. 497r, which is home)

538. **Philosophy and Principles of Extension Education** (3) I (Identical with A.Ed. 538)

539. **Extension Education Methods** (3) II (Identical with A.Ed. 539)

597. **Workshop**

  c. * Extension Credibility and Accountability (1 to 2) [Rpt./2] (Identical with A.Ed. 597c, which is home)

  d. * Extension Supervision and Administration (1 to 3) [Rpt./2] (Identical with A.Ed. 597d, which is home)

  g. * Microcomputers-Extension (1 to 2) [Rpt./2] (Identical with A.Ed. 597g, which is home)

  h. * Family Development through Home Economic Programs (1 to 2)

  t. Principles of Extension Training (1 to 3) I (Identical with A.Ed. 597t, which is home)

  u. Evaluation in Extension Education (1 to 3) I (Identical with A.Ed. 597u, which is home)

  v. Volunteer Staff Development in Extension (3) II 2R, 3L. (Identical with A.Ed. 597v)

  w. Administration of Extension Programs (1 to 3) I (Identical with A.Ed. 597w, which is home)

*Offered only through the Cooperative Extension Service Winter School.

607. **Topics in Home Economics Education** (1 to 3) [Rpt./12 units] II S Philosophy, content, and resources for understanding, teaching, and working in home economics education.

609. **Supervision in Vocational Education and Extension** (3) I 1987-88 Theory, principles and techniques of supervision in vocational and extension education.

610. **Investigation and Studies in Home Economics** (3) I Study and analysis of research literature, methods, techniques, and procedures for conducting investigations, selecting and developing plans for research problems.

618. **Evaluation in Home Economics Education** (3) II 1988-89 Application of theory to the selection and construction of evaluation instruments, their use and interpretation in home economics programs.

628. **Curriculum Theory in Home Economics** (3) I 1988-89 Theoretical bases and processes of curriculum building in home economics; current issues in home economics education.
FINANCE AND REAL ESTATE

Professors Edward A. Dyl, Head, Gerald O. Bierwag, Willard T. Carleton, Nestor R. Roos (Emeritus)
Associate Professors Erich K. Bleck, Joseph S. Gerber (Emeritus)
Assistant Professors Prabir Datta, William V. Harlow, Ill, John D. Schatzberg, Howard S. Stern, Gerry Suchanek

The department offers programs leading to the Master of Science degree with a major in finance. Concentrations are available in finance or real estate. The department also participates in the programs leading to the Master of Business Administration and the Doctor of Philosophy degrees with a major in business administration. For information concerning these degrees see Requirements for Master's Degrees/Master of Business Administration and the headnotes of Business Administration elsewhere in this catalog.

For admission, the applicant is expected to have completed undergraduate work in managerial accounting, economics, finance, marketing, organizational behavior, production, business policy, statistics, and mathematics through calculus (Math. 119 and 123). A score on the Graduate Management Admissions Test in the sixtieth percentile or above and an academic average of approximately "B" or better are required for admission consideration.

The program for the Master of Science degree with a major in finance includes a minimum of sixteen units at the 500 level and either a thesis or a research report.

421. Investments (3) GC I II Operation and analysis of the stock, bond, and commodity markets; theory and practice in construction and management of investment alternatives. P, Fin. 311.
422. Securities Analysis (3) GC I II Current practices and techniques of evaluating common stocks, bonds, stock options and warrants. P, Fin. 421.
431. Financial Intermediaries (3) GC I II Financial markets and institutions; effects of economic conditions and government policy on financial institutions, the flow of funds, and interest rates; term structure of interest rates; financial institution management. P, Fin. 311, Econ. 330.
465. Advanced Real Estate Appraisal (3) GC II Valuation of income-producing property; the capitalization process, discounted cash flow, concepts of investment analysis. P, Fin. 361, 362.
486. Fundamentals of Industrial Hygiene (3) GC I (Identical with O.S.H. 486)
487. Advanced Industrial Hygiene and Safety (3) GC II (Identical with O.S.H. 487)
511. Business Finance (3) I II Integration of the basic principles and theory of business finance, with emphasis on analytical financial management of the firm. Students with credit in Fin. 412 should take Fin. 512. Open only to students admitted to a BPA graduate program. P, Acct. 550.
512. Advanced Corporation Finance (3) II Financial theory applied to capital structure; investment decisions; corporate valuation; and corporate financial policies. P, Fin. 412 or 511.
513. **Theory of Finance (3)** I Theoretical models pertaining to financial decisions. P, Fin. 412 or 511.

521. **Portfolio Management (3)** I Portfolio theory and applications; equity markets, fixed income, and option markets; risk analysis and investment strategies. P, Fin. 421.

522. **Advanced Securities Analysis (3)** II Examination of securities risk, return, and price behavior in competitive markets. P, Fin. 421 or 521.

531. **Money and Capital Markets (3)** I Analysis of the theoretical and practical problems facing individuals and financial institutions managing money and fixed-income portfolios. P, Fin. 421 or 431.

532. **Financial Futures and Options (3)** II Design and trading of interest rate futures and options. Examination of their use in hedging, speculating, arbitraging, and their regulation. P, Fin. 421 or 521.

537. **Finance for New Ventures (3)** I Value maximization; simulation of value distribution; sources of venture capital; timing of initial public offering; new venture ownership structuring. Open only to students in the entrepreneurship program. P, Fin. 511, Econ. 500a-500b, Mktg. 500. (Identical with M.A.P. 537)

539. **Planning of New Ventures (3)** II (Identical with M.A.P. 539)


696. **Seminar**
   a. Investment Analysis (1 to 3) [Rpt./1] I II
   b. Financial Markets (1 to 3) [Rpt./1] I II
   c. Corporation Finance (1 to 3) [Rpt./1] I II
   d. Capital Budgeting (1 to 3) I II
   e. Research Methods (1 to 3) [Rpt./1] I II

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**FOOD SCIENCE**
(See Nutrition and Food Science)

**FOOD SERVICE MANAGEMENT**
(See Nutrition and Food Science)

**FOUNDATIONS OF EDUCATION**
(See Educational Foundations and Administration)

**FRENCH AND ITALIAN**

Professors Guido Capponi (Emeritus), Frank M. Chambers (Emeritus), Jean-Jacques Demorest, Charles I. Rosenberg


Assistant Professor Lise Leibacher

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in French. In cooperation with the College of Education, the department also offers courses leading to the Master of Education degree with a major in French. For information regarding this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog. A doctoral minor is available in French and in Italian.

The department participates in the offering of the M.A. with a major in Romance languages through the Committee on Romance Languages. For information, see Romance Lan-
The department cooperates with the Arizona Center for Medieval and Renaissance Studies.

Admission to graduate programs in French requires the completion of a bachelor degree with a major in French. Applicants must submit scores on the aptitude and advanced French tests of the Graduate Record Examination. Admission to a doctoral program is dependent upon the completion of a Master of Arts degree with a major in French. Students with a master's degree from another institution must take a qualifying examination during the first two weeks of residence.

**Degrees**

**MASTER OF ARTS** (Major in French) — Students must complete at least 32 units of course work. A thesis is not required. Concentrations are available in the literature of France and Francophone literature. Candidates must pass a final written and oral examination.

**DOCTOR OF PHILOSOPHY** — The major in French consists of a minimum of 50 units of graduate course work in the department in addition to the dissertation. The minor, consisting of 15 or more units, may be taken within the department or in a field approved by the department. All students are required to demonstrate knowledge in two other foreign languages. After successful completion of the written and oral preliminary examination, each candidate will write and defend a doctoral dissertation.

### French

- **403a-403b.** *Literature of the 16th Century* (3-3) GC 1987-88 403a: Early Renaissance, Reformation, Rabelais, the Pleiade. 403b: The Humanists, Montaigne, D'Aubigne, the drama. P, 201b. 403a is not prerequisite to 403b.
- **404a-404b.** *Literature of the 17th Century* (3-3) GC 1988-89 404a: Human condition, as seen by the epoch of Louis XIII and the Fronde. 404b: Classical ideal. P, 201b. 404a is not prerequisite to 404b.
- **405a-405b.** *Literature of the 18th Century* (3-3) GC 1987-88 Study of ideas in the French Enlightenment. 405a: Rationalist currents. 405b: Sensibility. P, 201b. 405a is not prerequisite to 405b.
- **414.** *Teaching of Modern Languages* (3) GC II (Identical with T.T.E. 414)
- **415.** *Stylistics* (3) GC I Principles of stylistics, with exercises in literary translation and original writing. P, 375b.
- **416.** *Translation* (3) GC II Theory and practice of translation (French/English; English/French). Literary and technical. P, 375b or 370b.
- **422.** *Introduction to Romance Philology* (3) GC I 1988-89 (Identical with Span. 422)
- **430a-430b.** *French Civilization* (3-3) GC Historical, social, economic, literary, and artistic elements in the development of the French nation. P, 201b. 430a is not prerequisite to 430b.
- **431.** *Contemporary French Philosophy* (3) GC II 1987-88 Discussion course, conducted in English with readings in French; Bergson, Camus, Simone Weil, Teilhard de Chardin, Sartre, Levi-Strauss.
- **450a-450b.** *French Literature of Black Africa and the West Indies* (3-3) GC 1987-88 450a: Up to 1960. 450b: 1960 to present. P, 201b. 450a is not prerequisite to 450b. (Identical with BLS. 450a-450b)
- **452.** *French Literature of Quebec* (3) GC II 1988-89 Comprehensive study of the most significant literary expression in Quebec. P, 201b.


470. Advanced Grammar and Usage (3) GC II Structural analysis of spoken and written French, with emphasis on structural patterns and attention to contrasts with English. Graduate students will do additional work in composition and stylistics. P. 201b.

500. Intensive Reading Course for Graduate Nonmajors (3 hrs/wk., no credit) I II Rapid acquisition of reading proficiency in French. No prior knowledge of the language necessary. Proficiency certification obtained from this course fulfills graduate foreign language requirement in some departments (consult department for information).

510. Materials and Methods of Research (2) I 1987-88 Problems and methods of advanced research in French language and literature. Use of specialized library resources and computerized data bases. Style and presentation conventions for preparation of scholarly research.

511. Contemporary French Literary Theory (3) II 1987-88 Methods of criticism and techniques of literary analysis.


557. Rousseau (3) II 1988-89 Rousseau's political thought; his ideas concerning education; The Confessions; the beginning of Romanticism.

558. Realism and Naturalism in the Novel (3) I 1987-88 Flaubert, Zola, Maupassant, etc.

559. Contemporary Theatre (3) II 1988-89 Theatre from 1950 to the present time; Ionesco, Beckett, Genet, Arrabal, Obaldia, Tardieu, Dubillard, etc.


579. Problems in Teaching College French (1 to 3) I II Methodology course in lower-division college pedagogy. Discussion of broader issues of language, pedagogy, academe, the history of foreign language education, college teaching as a career.

696. Seminar
   a. Romance Philology (3) I II
   b. Topics in French Literature (3) [Rpt./2] I II
   c. Old French Literature (3) I II
   d. 16th Century (3) I II
   e. 17th Century (3) I II
   f. 18th Century (3) I II
   g. 19th Century (3) I II
   h. 20th Century (3) I II

Italian

402a-402b. II Trecento: Introduction to Dante, Petrarch, and Boccaccio (3-3) GC 402a: Emphasis on La Divina Commedia. 402b: Petrarch and Boccaccio. P. 201b.

404a-404b. Literature of the Renaissance (3-3) GC 404a: Humanism and Early Renaissance. 404b: High and Late Renaissance. P. 201b.

405a-405b. Lingua e Stile (3-3) GC Practice in formal writing and formal oral communication. Principles of stylistics. P. 305b or consult department before enrolling.


420a-420b. Italian Civilization. (3-3) GC S Historical, geographical, social, and artistic aspects of the development of the culture of Italy. Offered only in Florence, Italy. P. 201b. 420a is not prerequisite to 420b.

422. Introduction to Romance Philology (3) GC I 1988-89 (Identical with Span. 422)

696. Seminar
   a. Italian Literature (3) [Rpt.] I II
GENETICS

Committee on Genetics (Graduate)

Professors William P. Bemis (*Emeritus*, Plant Sciences), Harris Bernstein (Microbiology and Immunology), John R. Davis (Pathology), John E. Endrizzi (Plant Sciences), Robert M. Harris (*Emeritus*, Ecology and Evolutionary Biology), William B. Heed (Ecology and Evolutionary Biology), Frank R.H. Katterman (Plant Sciences), Robert G. McDaniel (Plant Sciences), Neil H. Mendelson (Molecular and Cellular Biology), David W. Mount (Molecular and Cellular Biology), Robert T. Ramage (Plant Sciences), Donald Ray (Animal Sciences), Nobuyoshi Shimizu (Molecular and Cellular Biology)

Associate Professors Oscar G. Ward (Ecology and Evolutionary Biology), Chairperson, Richard E. Michod (Ecology and Evolutionary Biology), Jeffrey Trent (Radiation Oncology), Stephen Zegura (Anthropology)

Assistant Professor Sue DeNise (Animal Sciences)

Geneticists from various departments comprise the interdepartmental Committee on Genetics, which offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in genetics. The areas of study emphasized by the committee are molecular and cellular genetics, cytogenetics and population genetics. Research opportunities include bacterial and bacteriophage genetics, gene regulation, developmental plant genetics, plant and animal cytogenetics, somatic cell genetics, cancer and clinical cytogenetics, quantitative genetics and animal breeding, ecological and evolutionary genetics, population genetics, human genetics and biometrical principles as applied to individuals and populations.

Admission requirements include: completion of bachelor's degree with one year of biology, courses in genetics, ecology, physiology and developmental biology, chemistry through organic, mathematics through integral calculus, introductory physics and statistics. In addition to materials required by the Graduate College, applicants are required to furnish the committee with completed Committee on Genetics application forms, GRE scores on quantitative and verbal tests, and three letters of recommendation from persons qualified to evaluate the applicant's scholarly potential. The deadline for receipt of application forms for fall admission is April 1 and for spring admission, November 1.

All students are required to complete 16 units of core courses specified by the committee and which include: three semester units of molecular or microbial genetics, three units of cytogenetics, two units of population genetics, three units of statistics, one unit of the history of genetics and two units each of colloquium and recent advances in genetics. Doctoral programs include those courses deemed necessary to proper training in the major and minor areas as determined by the student's guidance committee. A minor may be selected from various areas including animal sciences, anthropology, biochemistry, ecology and evolutionary biology, microbiology and immunology, molecular and cellular biology, and plant sciences. The master's degree program is designed to provide the student with a broad background in genetics. The course of study for the M.S. degree requires a minimum of 30 units of graduate work. A thesis is required.

413. Principles of Animal Breeding (3) GC II (Identical with An.S. 413)
414. Animal Breeding Systems (2) GC I (Identical with An.S. 414)
415. Somatic Cell Genetics (2) GC I (Identical with M.C.B. 415)
428R. Advanced Microbial Genetics (3) GC II (Identical with M.C.B. 428R)
435. Evolution (3) GC I (Identical with Ecol. 435)
GEOGRAPHY AND REGIONAL DEVELOPMENT

Professors Terence Burke, Robert D. Carpenter (Emeritus), Lay J. Gibson, Lawrence D. Mann, Leland R. Pederson, Richard W. Reeves, Thomas F. Saarinen, Dan Stanislawski (Emeritus), Andrew Wilson (Emeritus), Ervin H. Zube (Renewable Natural Resources)

Associate Professors Gordon F. Mulligan, Head, D. Robert Altschul, Michael E. Bonine (Oriental Studies), David A. Plane

Assistant Professor Sallie A. Marston

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in geography. In cooperation with the College of Education, the department offers work leading to the Master of Education degree with a major in geography. The department also offers work in regional planning leading to the Master of Science degree with a major in planning.

Geography

All applicants are required to submit scores on the aptitude section of the Graduate Record Examination. Admission to the Doctor of Philosophy degree program requires the recommendation of the committee administering the final examination for the Master of Arts degree or, if the master's degree was earned elsewhere, admission is subject to passing a qualifying examination during the first semester of resident graduate study.
All students working toward the Master of Arts degree are required to complete 485, 500, 557 and 589 during the first year in residence. In addition, students will normally enroll in 696f each semester they are in residence, up to a maximum of 9 units. The 30 units required for the degree must include at least 18 units of geography at the 500 or 600 level; 696f may be used to meet this requirement. The remainder of the program is selected, with the approval of an adviser, from geography and supporting disciplines. Courses may include geography courses at the 400, 500, or 600 level or courses outside the department. Students may, with the consent of an adviser, elect to write a thesis. Students electing the thesis option must pass a final oral examination; those electing the non-thesis option must pass a written and oral comprehensive examination.

No thesis is required for the Master of Education degree program. For further information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

The Master of Science with a major in planning (regional planning concentration) is offered through the Graduate College for students seeking professional preparation for careers in planning for urban and rural regions. For further information see Planning elsewhere in this catalog.

Students working toward the Doctor of Philosophy degree must, in addition to the requirements for the Master of Arts degree, complete a minimum of 18 units in geography (exclusive of the dissertation) of which no fewer than 15 units must be at the 500-level or above. Doctoral students are required to enroll in 796a each semester they are in residence, up to a maximum of 9 units. Students must also achieve high-level competence in two fields of concentration, one topical and one regional, and will ordinarily complete six units of work in each. Topical concentrations available are behavioral, cultural, economic, historical, physical, and urban geography, and regional development. Regional concentrations available are Anglo-America (or United States), arid lands, and Latin America. Doctoral language requirements may be met by one of three options: a reading knowledge of French or German and one other approved language; high proficiency in the use of one approved language; or a reading knowledge of an approved language and completion of an eleven-unit sequence in statistics/computer science to be prescribed by the departmental faculty. The minor or minors must be complementary to the student's program of specialization. The dissertation should incorporate aspects of both the topical and regional concentrations chosen. More detailed information may be obtained by writing to the head of the department.

401. Introduction to Water Resources Policy (3) GC II (Identical with W.R.A. 401)
407. The American Landscape (3) GC II Origin and character of the visual aspects of places viewed individually and regionally; changes in habitat, vernacular structures, landscaping, townscapes, countrysides and special features. Field trips. (Identical with L.Ar. 407) Zube
408. Arizona and the Southwest (3) GC II The changing character of the land and man's occupation of it, with emphasis on Arizona; historically and problem oriented. Field trip. Duffett
411. Middle America (3) GC II Land, man, and culture in the major natural and cultural regions of Mexico, Central America, and West Indies. Pederson
412. South America (3) GC I Physical and cultural bases of South America's geographic patterns, with emphasis on human settlement and problems of resource development. Pederson
413. Africa (3) GC II Physical and human bases of regional contrasts, with emphasis on tropical environmental systems and changing patterns of resource utilization and development. Altschul
414. Rural Area Development (3) GC I (Identical with A.Ec. 414)
417. Introduction to Geographic Information Systems (3) GC II (Identical with R.N.R. 417)
444. Site Planning (2) GC II (Identical with Arch. 444)
453. Locational Analysis (3) GC II Industrial location theory, location factors, and case studies; consumer behavior and shopping models; geography of economic impacts; geographic inequalities and spatial welfare; location of public facilities. (Identical with Ping. 453) Mulligan
456. Urban Geography (3) GC I An integrated approach to the built environment with special emphasis on the historical, social and political aspects of American urban development. (Identical with Ping. 456) Marston/Mulligan
457. **Statistical Techniques in Geography and Planning** (3) GC I Methods of gathering and analyzing data for the solution of geographical, urban, and regional planning problems, with emphasis on quantitative and statistical techniques used in spatial analysis and cartography, on the one hand, and program planning, on the other. (Identical with Ping. 457) Silvers/Plane

459. **Topics in Economic Geography of the Middle East** (3) GC II (Identical with Or.S. 459)

461. **Population and Resources** (3) GC I Estimates of present and potential world population; distribution and methods of conserving important resources. Field trips. (Identical with Ping. 461 and W.R.A. 461) Marston

463. **Physical Aspects of Arid Lands** (3) GC II Landforms, climate, hydrology, soils, vegetation, and animal life of deserts, with particular emphasis on the interaction of these phenomena in southern Arizona. Altschul

464. **The Arid and Semiarid Lands** (3) GC I Past, present and future of settlement and resource utilization in the world's arid lands; spatial interrelationships of environmental, demographic, socioeconomic and political systems. Altschul

469. **Geography of the Middle East** (3) GC I (Identical with Or.S. 469)

471. **Problems in Regional Development** (3) GC I II Regional inventories and methods of analysis; development problems, policies and strategies; generation, implementation, and evaluation of development of programs; case studies. (Identical with A.Ec. 471 and Ping. 471) Plane

476. **Metropolitan Land Development** (3) [Rpt./1] GC I II S A case-oriented approach to site selection, rezoning, financing, architectural design, economic feasibility, and other facets of the land development process. Field trip. Consult with department before repeating course. (Identical with Ping. 476)

481. **Computer Cartography** (3) GC II Introduction to the use of computers for map production, with emphasis on cartographic principles and practical experience with several user-oriented mapping programs. (Identical with Ping. 481)

483. **Geographic Applications of Remote Sensing** (3) GC II Use of aircraft and satellite imagery for monitoring and analyzing landforms, soils, vegetation and land use, with the focus on problems of land-use planning, resource management and related topics. 2R, 3L. Field trip, P, two units of remote sensing or equivalent experience. (Identical with Ping. 483)

485. **Geography Summer Field Camp** (3) [Rpt./2] GC S Physical and cultural problems in geography studied at first hand. Fee $250. P, 3 units of geography. Reeves/Gibson

500. **Current Geographical Research** (3) I Major trends and issues in human and physical geography. Field trips.

510. **Development of Regional Planning** (3) I Survey of the historical development of the planning profession; the evolution of American planning as a response to urbanization. Open to majors only. Credit allowed for this course or 301, but not for both. (Identical with Ping. 510)

511. **Metropolitan and Regional Planning** (3) I Survey and evaluation of concepts and examples, including metropolitan, economic development, state and national, and environmental plans in the U.S. and abroad. (Identical with Ping. 511) Mann

556. **Urban Systems Analysis** (3) II Theoretical and applied analysis of urban growth models, gradients of urban influence, residential and facility decisions, and urban transportation. (Identical with Ping. 556) Mulligan

557. **Spatial Analysis** (3) II Formal analysis and modeling of spatial structures and processes; conceptual evaluation of point patterns, networks, surfaces and interaction. P, 457. (Identical with Ping. 557) Reeves

561. **Resource Management** (3) I Examination and critical appraisal of social and behavioral science aspects of resource management, with special emphasis on factors affecting decision making. (Identical with Ping. 561) Saarinen

562. **Paleoecology and Man** (3) I (Identical with Geos. 562)

563. **Perception of Environment** (3) II Examination of interdisciplinary research on environmental perception; consideration of social and behavioral variables at all scales of environmental perception and planning. (Identical with Ping. 563) Saarinen

589. **History of Geographic Thought** (3) I History of geographic philosophy and methodology. P, 15 units of geography. Pederson

596. **Seminar**
   a. Economic Geography (3) I II
   b. Cultural Geography (3) I II
   c. Physical Geography (3) I II
   d. Historical Geography (3) I II
e. Area Study (3) I II
f. Doctoral Research Seminar (3) [Rpt./3] I II
u. Interdisciplinary Environment-Behavior-Design (3) I (Identical with Idis. 596u, which is home)

605. Planning Theories and Perspectives (3) I A critical examination of normative and methodological assumptions of alternative planning models, with emphasis on developing a perspective on contemporary planning issues. (Identical with Ping. 605) Mann

608. Planning Law (3) II Land-use controls, the law of zoning, exclusionary zoning, restrictive covenants, comprehensive plan, environmental protection, eminent domain, nuisance. (Identical with Ping. 608)

609. Policy Problems in Structure and Change (3) II (Identical with M.A.P. 609)

611. Projects in Regional Planning (1 to 5) [Rpt./5 units] II Lectures, laboratory, and field projects covering various aspects of professional practice. P 605, 24 units toward a graduate degree in planning. Field trips. (Identical with Ping. 611)

659. Growth Controls (3) II Current legal and planning techniques to regulate the rate of growth, the sequence of growth, and the eventual total size of towns, regions, and states; concentration on case studies. (Identical with Law 659 and Ping. 659)

696. Seminar
f. Master's Research Seminar (3) [Rpt./9 units] I II
o. The General Plan (3) [Rpt./6 units] I II (Identical with Ping. 696o)
p. The Land Development Process (3) [Rpt./6 units] I II (Identical with Ping. 696p)

796. Seminar
a. Doctoral Research Seminar (3) [Rpt./3] I II

GEOLOGICAL ENGINEERING
(See Mining and Geological Engineering)

GEOLOGY
(See Geosciences)

GEOSCIENCES

Professors William R. Dickinson, Head, John W. Anthony (Emeritus), Victor R. Baker, Bryant Bannister (Laboratory of Tree-Ring Research), William B. Bull, Robert F. Butler, Clement G. Chase, Peter J. Coney, Paul E. Damon, George H. Davis, Jeffrey S. Dean (Laboratory of Tree-Ring Research), Harold C. Fritts (Laboratory of Tree-Ring Research) (Emeritus), Jibamitra Ganguly, Laurence M. Gould (Emeritus), Jibamitra Ganguly, Laurence M. Gould (Emeritus), John M. Guilbert, C. Vance Haynes (Anthropology), Malcolm K. Hughes (Laboratory of Tree-Ring Research), Gerhard O. W. Kremp (Emeritus), Valmore C. LaMarche (Laboratory of Tree-Ring Research), Everett H. Lindsay, Paul S. Martin, Edgar J. McCullough, Jr., H. J. Melosh (Planetary Sciences), Bartholomew S. Nagy, Denis L. Norton, William J. Robinson (Laboratory of Tree-Ring Research), Joseph F. Schreiber, Jr., Terah L. Smiley (Emeritus), Charles W. Stockton (Laboratory of Tree-Ring Research), Marvin A. Stokes (Laboratory of Tree-Ring Research), John S. Sumner (Emeritus), Spencer R. Titley, James R. Wait (Electrical and Computer Engineering)

Associate Professors Karl W. Flessa, Austin Long, P. Jonathan Patchett, Randall M. Richardson
Assistant Professors Andrew S. Cohen, Owen K. Davis, Christopher J. Eastoe, George E. Gehrels, Joaquin Ruiz, Frank W. Telewski (Laboratory of Tree-Ring Research), Terry C. Wallace

The department offers graduate studies leading to the Master of Science and the Doctor of Philosophy degrees with a major in geosciences.

Applicants for graduate degrees must have completed the bachelor's degree with a major in geosciences or in an allied discipline. All applicants must submit directly to the department
their scores on the general and subject tests of the Graduate Record Examination, and provide
three letters of recommendation and a personal resume including a statement of proposed
academic and research activities.

Degrees

MASTER OF SCIENCE — Designed to train students committed to working in industry, in local,
state or federal government programs, or as teachers in a junior college setting. The program
also serves as a foundation for graduate studies continued beyond the M.S. level, especially for
those students whose M.S. research experiences are vital to their professional growth and for
those who develop strong research interests and abilities.

DOCTOR OF PHILOSOPHY — Designed for students who plan to work as professional geo-
scientists in research-oriented capacities in the academic community, industry, or government.
Qualified students with a master's degree or a bachelor's degree may be accepted into the Ph.D.
program.

Students working toward an advanced degree in geosciences should concentrate in one
or more of the following curriculum options:

Economic Geology — Ore deposits petrology; hydrothermal ore deposits; fluid inclusion studies;
sulfur isotope analysis; alteration petrology/geochemistry; plate tectonics and ore deposits;
mathematical theory of magma-hydrothermal systems; dynamic models of intrusion; vol-
canogenic ore systems.

Geophysics — Seismology; inverse theory; potential fields; plate-dynamics; geoelectromagnetism (a joint effort with the Department of Electrical and Computer Engineering); paleomagnetism; electrical geophysics.

Mineralogy-Petrology-Geochemistry — Morphology and structure of crystals; crystal chemistry;
experimental petrology; thermodynamics and kinetics of the mineralogical evolution of rocks;
thermal evolution of of rocks; crystal growth in igneous and metamorphic processes; trace
element geochemistry; isotope geochemistry; geochemistry of the mantle; composition of the
earth's core; organic geochemistry and history of early life.

Planetary Geology — A concentration through the Departments of Geosciences and Planetary
Sciences. Geomorphology of planetary surfaces; geochemical evolution of planetary bodies;
geochemistry/cosmochemistry of meteorites; stress modeling in planetary bodies; organic geo-
chemistry of the solar system; planetary geophysics; cratering.

Quaternary-Paleoenvironmental Studies — Paleoecology; paleoclimatology; environmental
geology; palynology; dendrochronology; radiocarbon dating; stable isotope geochemistry;
quaternary geology-stratigraphy.

Stratigraphy-Paleontology — Sedimentary petrology; depositional sedimentary environments;
basin analysis; stratigraphy; biostratigraphy; invertebrate and vertebrate paleontology; pa-
leoecology and evolution.

Tectonics — Structural geology; regional tectonics; tectonic geomorphology; sedimentary tec-
tonics; tectonophysics; geochronology; tectonic implications of paleomagnetism.

401. Environmental Education (3) GC I II Nature of ecosystems; relationships of people and their en-
virnment; major conservation problems; discussion of proposed solutions; the experiential approach.
Field trips, including three days in Sonoran wilderness.

403. Introduction to the Solar System (3) GC I (Identical with Pty.S. 403)

407. Photogeology (3) GC II (Identical with G.En. 407)

409. Introductory Vertebrate Paleontology (3) GC I Survey of the vertebrate fossil record, with emphasis
on morphological characters relating the major groups of vertebrates. P. 101b, 102b or Ecol. 102.
Lindsay
<table>
<thead>
<tr>
<th>Course Number</th>
<th>Course Name</th>
<th>Prerequisites/Comments</th>
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</thead>
<tbody>
<tr>
<td>410</td>
<td>Mammalian Phylogeny and Evolution (3) GC II 1988-89</td>
<td>A study of the mammalian fossil record, with emphasis on taxonomy and morphological evolution of selected mammal orders. 2R, 3L. Field trips. P, 409. Lindsay</td>
</tr>
<tr>
<td>414</td>
<td>Sedimentary Geology (3) GC I</td>
<td>Sedimentary processes and depositional systems; sedimentary textures and structures; nonmarine, transitional, and marine deposition. 2R, 3L. Field trips. P, 109.</td>
</tr>
<tr>
<td>416</td>
<td>Field Studies in Geophysics (3) GC S (Identical with G.En. 416)</td>
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<tr>
<td>419</td>
<td>Sedimentary Processes (3) GC II</td>
<td>Plate tectonics; thermal properties and processes in the Earth; mechanical behavior of lithosphere and mantle; global gravity and geoid. P, Math. 254; Phys. 121. (Identical with Pty.S. 419) Richardson/Chase</td>
</tr>
<tr>
<td>420</td>
<td>Geophysical Exploration: Potential Field Methods (4) GC I</td>
<td>Principles of gravity, magnetic, and electrical exploration; acquisition and interpretation of data to define geologic structure and evaluate resources. 3R, 2L. P, Phys. 110, 116, Math. 223 (Identical with G.En. 420) Chase/Sternberg</td>
</tr>
<tr>
<td>422</td>
<td>Petroleum Geology (3) GC I</td>
<td>Origin, migration, chemistry, and accumulation of petroleum; reservoir mechanics, types of traps; recovery of petroleum; oil shales and tar sands. 2R, 3L. Nagy</td>
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<tr>
<td>424</td>
<td>Paleomagnetism: Principles and Applications (3) GC II</td>
<td>Physical basis for remanent magnetism in rocks, techniques of sample collection, measurements, and statistical treatment; review of polarity time scale, apparent polar wander, plate tectonics. P, Phys. 103b or 116. Butler</td>
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<tr>
<td>435</td>
<td>Hydrogeology (3) GC II I</td>
<td>(Identical with Hydr. 435)</td>
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<tr>
<td>438</td>
<td>Biogeography (3) GC II</td>
<td>(Identical with Ecol. 438)</td>
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<tr>
<td>440</td>
<td>Introduction to Geodynamics (3) [Rpt./1] GC II 1987-88</td>
<td>Large scale tectonic problems approached through geophysical with combined with geological analysis, both in regional tectonic context. P, 20 units of geology, incl. 221, Math. 254, and 3 units geophysics.</td>
</tr>
<tr>
<td>441</td>
<td>Industrial Minerals and Rocks (3) GC I</td>
<td>1988-89 Geology, origin, mode of occurrence, and methods of evaluation of nonmetallic mineral deposits. 2R, 3L. P, 303. Guilbert</td>
</tr>
<tr>
<td>445</td>
<td>Geomorphology (4) GC I</td>
<td>Concepts of landform development, with emphasis on fluvial processes and environmental applications. 3R, 3L. Field trips. P, 101a, 102a. Bull</td>
</tr>
<tr>
<td>450</td>
<td>Glacial and Quaternary Geology (3) GC II</td>
<td>Glacial processes, landforms, and deposits. Physical aspects of Quaternary paleoenvironmental change and effects on fluvial, eolian, lacustrine, weathering, and mass movement processes. P, 101b, 102b. Baker</td>
</tr>
<tr>
<td>455</td>
<td>Introduction to Geochemistry (3) GC I</td>
<td>Nuclear systematics and thermodynamics with applications to geologic processes. P, 101a, 102a; Chem. 103b, 104b.</td>
</tr>
<tr>
<td>457</td>
<td>Low Temperature Geochemistry (3) GC II</td>
<td>Equilibrium and kinetic chemical processes producing soils, natural waters, and chemical sediments. P, 101a, 102a, 455 or Chem. 480a; Chem. 103b, 104b. (Identical with Hydr. 457) Long</td>
</tr>
<tr>
<td>462</td>
<td>Introduction to Quaternary Ecology (3) GC II</td>
<td>Survey of methods and theories used in reconstructing vegetation and climate. Ocean cores, palynology, dendroclimatology. Field trip. (Identical with Anth. 462)</td>
</tr>
<tr>
<td>464a-464b</td>
<td>Introduction to Dendrochronology (3-3) GC I</td>
<td>Survey of dendrochronological theory and methods. Applications to archaeological, geological, and biological dating problems and paleo-environmental reconstruction. Emphasis on dating methods, developing tree-ring chronologies, and evaluating tree-ring dates from various contexts. 2R,3L. Field trips. (Identical with Anth. 464a-464b and Ws.M. 464a-464b) LaMarche</td>
</tr>
<tr>
<td>470</td>
<td>Introduction to Paleoecology (3) GC II</td>
<td>Paleontologic approaches to the reconstruction of ancient environments, populations and communities. Evolution of communities through geologic time. 2R, 3L. Field trips. P, 225, 302. Flessa</td>
</tr>
<tr>
<td>473</td>
<td>Geology and the Urban Environment (3) GC II</td>
<td>Geologic processes that result in loss of life and/or property damage; emphasis on case studies of urban areas in the Southwest. Implications for public policy. 2R, 3L. All-day field trips. (Identical with PIng. 473)</td>
</tr>
<tr>
<td>475</td>
<td>Cenozoic Mammalian Faunas (3) GC II 1987-88</td>
<td>Continental Cenozoic stratigraphy and mammalian biochronology of North America and other continents. 2R, 3L. Field trips. P, 408. Lindsay</td>
</tr>
<tr>
<td>504</td>
<td>Geology of Arizona (3 to 4) I</td>
<td>Systematic coverage of Basin and Range province and Colorado Plateau geology as part of the Southern Cordillera, with emphasis on significant problems. Field trips. Consult dept. before enrolling for three unit option. Damon</td>
</tr>
</tbody>
</table>
506. **Analytical Techniques in Geology** (4) II Strengths and limitations of methods and analysis of geologic material including XRF, XRD, microprobe, AA theory/experience, INAA, and mass spectrometry theory. 3R, 3L. Open to majors only. P, Chem 103a-103b, Phys. 110, 116, 121 or 103a-103b and 180a-180b.

507. **Applied Multispectral Imagery** (3) II (Identical with G.En. 507)

509a-509b. **Petrology** (3-3) Earth composition; spatial and temporal distribution of rock types; application of physicochemical principles to magmatic and metamorphic processes. P, 405, Chem. 480a or CR.


512. **Petrology of Sandstones** (3) I Origin, deposition, and diagenesis of sandstones and other terrigenous sedimentary rocks; classification in hand specimens, detrital grains, and thin sections. 2R, 3L. Field trips. P, 405. Schreiber

514. **Late Quaternary Geology** (3) I Paleoenvironment and geochronology of Late Quaternary alluvium as read from the stratigraphic records and geomorphology at key localities in North America. The interaction of fluvial and aeolian processes in the eastern Sahara will be evaluated using enhanced LANDSAT and Shuttle Imaging Radar. Domestic field trips. Enrollment limited to 10 students. P, 101b, 102b. (Identical with Anth. 514) Haynes

520. **Meteorites** (3) II 1988-89 (Identical with Pty.S. 520)

521. **Analysis of Regional Geologic Structure** (3) II Geometric, kinematic, and dynamic analyses of deformational structures; stereographic and computer treatment of fabric data; experimental deformation; structural analysis in field; report writing. All day field trips every Friday. P, 412.

522. **Well Logging Interpretation** (3) II (Identical with G.En. 522)

523. **Advanced Geologic Mapping** (3) [Rpt./3] I Geologic mapping in a variety of rock types and structural regimes, with emphasis on the recognition and solution of regionally significant structural problems. Field trips. P, 413. G. Gehrels

525. **Regional Tectonics** (3) I Methods of tectonic regionalization and integration based on litho-tectonic assemblages, tectono-stratigraphic terranes, and regional structural analysis. Discussion of types of orogenic systems, plate regimes and their kinematics, economic aspects of regional tectonics. Coney

526. **Cordilleran Tectonics** (3) II Geologic and tectonic evolution of the North American Cordillera based on analysis of geologic, paleomagnetic, and paleobiogeographic constraints and tectonic models. G. Gehrels

528. **Nuclear Geology** (3) II 1988-89 Nuclear phenomena applied to the solution of geologic problems, with emphasis on radioisotope dating and isotope petrology. (Identical with Pty.S. 528) Damon

535. **Aquifer Mechanics** (3) I (Identical with Hydr. 535)

536. **Development of Groundwater Resources** (3) II (Identical with Hydr. 536)

540. **Topics in Geodynamics** (3) [Rpt./1] II 1988-89 Large-scale tectonic problems approached through combined geophysical and geological analysis, both in regional tectonic context. P. 20 units of geology, including 221; 3 units of geophysics; Math. 254.

541. **Soil Genesis** (3) II (Identical with S.W. 541)

542. **Ore Deposit Petrology** (3) II 1988-89 Orthomagmatic, porphyry base metal, skarn, and leached capping lithologic-mineralogic studies by petrographic microscope, electron probe, and advanced techniques. 1R, 6L. P, 425 or CR, 546a. Guilbert

543. **Mathematical Theory of Magma-Hydrothermal Systems** (3) I Dynamics and chronology of natural systems are reconstructed using mathematical systems and computer models to represent the redistribution of thermal and mechanical energy around magma chambers. Norton

544. **Principles of Techniques of Hydrothermal Geochemistry** (3) II Application of physical chemistry and allied laboratory techniques to the problems of hydrothermal ore formation. P, Chem. 480a. Eastoe

545. **Geochemical Processes in Magma-Hydrothermal Systems** (3) II Migration of chemical components in natural fluid-rock systems are analyzed using the geochemical theory that represents irreversible, equilibrium, advection mass transfer. Norton

546a-546b. **Advanced Ore Deposit Geology** (4-4) Geology, characteristics and origins of ore deposits in igneous, sedimentary, and metamorphic rocks. Labs. include field trips, analytical techniques, problem solving. 2R, 6L. P, 303, 405, Chem. 480a or CR. Tilley/Guilbert

554. **Evolution of Planetary Surfaces** (3) II 1988-89 (Identical with Pty.S. 554)


560. **Electrical Exploration Methods** (3) I (Identical with G.En. 560)
561. Paleoindian Origins (3) I (Identical with Anth. 561)

564. Isotope Hydrology (3) I Theory and application of light stable and cosmogenic isotopes to hydrological and paleoenvironmental problems. Radiometric dating of ground water. (Identical with Hydr. 564) Long

565. Isotope Geology (3) II Theory and application of light stable isotopes to petrological, ore deposition, and geothermal problems. Long/Eastoe

566. Botanical Basis of Dendrochronology (3) II 1987-88 Examination of the environmentally modified processes of developmental tree physiology and wood anatomy and their application to tree-ring analysis. Field trip. (Identical with Ws.M. 566) Telewski


568. Advanced Seismology (3) II 1987-88 Computational techniques in seismology. The application of synthetic seismograms to model source processes and complex structure. P, 432; Math. 422b. Wallace


579. Introduction to Quaternary Macrofossil Analysis (4) [Rpt./1] II 1988-89 Literature and techniques of identification of plant remains including leaves, seeds, and wood of gymnosperms and angiosperms. 2R, 6L. Field Trips. P, Ecol. 472 O. Davis


581. Quaternary Palynology (4) II 1987-88 Theory and application of pollen to geology, biology, archaeology, and paleoecology; definition of information pollen sample record; experience in pollen extraction and identification. 3R, 4L. O. Davis (Identical with Anth. 581)

584. Sedimentary Basins (3) II Sedimentologic, stratigraphic, structural, subsidence, thermal, and diagenetic evolution of sedimentary basins in relation to plate tectonic settings. 2R, 3L.

585. Petrology of Carbonate Rocks (3) II Origin, depositional environments, and diagenesis of carbonate and associated chemical and biochemical sedimentary rocks. 2R, 3L. Field trips. P, 405. Schreiber


596. Seminar
  a. Petrography-Petrology (1 to 4) I II
  b. Structural Geology (1 to 4) I II
  c. Mineral Deposits (1 to 4) I II
  d. Petroleum Geology (1 to 4) I II
  e. Tectonics (1 to 4) I II
  f. Mineralogy-Crystallography (1 to 4) I II
  g. Vertebrate Paleontology (1 to 4) I II
  h. Paleontology (1 to 4) I II
  i. Paleooecology-Paleoenvironments (1 to 4) I II
  j. Geomorphology (1 to 4) I II
  k. Geophysics (1 to 4) I II
  l. Geomathematics (1 to 4) I II
  m. Sedimentology (1 to 4) I II
  n. Stratigraphy (1 to 4) I II
  o. Regional Tectonics (1 to 4) I II
  p. Hydrogeology (1 to 3) [Rpt./2] I II (Identical with Hydr. 596p, which is home)
  q. General Geochronology (1 to 4) I II
  r. Quaternary Geochronology (1 to 4) I II (Identical with Anth. 596r)
  s. Sedimentary Petrography (1 to 4) I II
  t. Organic Geochemistry (1 to 4) I II
  u. Inorganic Geochemistry (1 to 4) I II
  v. Dendrochronology (1 to 4) I II
  w. Palynology (1 to 4) I II
  x. Paleobotany (1 to 4) I II
  y. Role of Water in Geologic Processes (1 to 4) I II
  z. Topics in Geophysics (1 to 4) I II


651. Tectonic and Climatic Geomorphology (3) II 1988-89 Effects of tectonic movements and climatic changes on geomorphic processes, landforms, and soils; paleoclimatic and earthquake-hazards interpretations. 2R, 3L. Field trips (includes spring break field trip). Bull

**GERMAN**

Professors Renate A. Schulz, *Head*, Jean R. Beck (*Emeritus*), David H. Chisholm, Max Dufner, David J. Woloshin (*Emeritus*)

Associate Professors Dennis I. Greene, Richard C. Helt, Babette Luz (*Emerita*), Roland Richter

Assistant Professor Mary Wildner-Bassett

The department offers a program leading to the Master of Arts degree with a major in German. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in German. For information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog. Studies are available in the various areas of German language, literature, and culture in their more modern and contemporary aspects as well as in earlier historical and linguistic developments. Courses are also available in second language teaching methodology, theory of second language acquisition and testing for a minor option in the M.A. degree in German.

Prerequisite for admission to the graduate program is the completion of at least sixteen acceptable units of upper-division, undergraduate course work in German.

Students working toward the Master of Arts degree must complete a minimum of 32 units of graduate work, including at least 24 units in courses offered by the Department of German. Ger. 601 is required of all master's candidates; Ger. 479 is required of all teaching assistants. No thesis is required.

The student must pass both a written and an oral comprehensive examination. Prior to this examination each student must either have passed 475a or 475b successfully or give evidence of an equivalent proficiency in the use of written German and must rate Superior on the ACTFL/ETS Oral Interview Test or an equivalent test.

400a-400b. **History of German Literature** (3-3) GC GRD Historical survey of German literary development from the beginning to the modern period; lectures in German, alternating with conferences in Engl. P, 6 units of upper-division German. 400a is not prerequisite to 400b. Greene

405. **History of the English Language** (3) GC III (Identical with Engl. 405)

410a-410b. **Cultural Development of Germany** (3-3) GC GRD Social, political, religious, and artistic elements entering into the growth and development of Germany; lectures in English. 410a is not prerequisite to 410b. Dufner/Richter

469a-469b. **Germanic Folklore: An Introduction to Nonliterary Forms** (3-3) GC Tales, balladry, folk speech, customs and lore of the Germanic people. Readings and lectures in Engl. Readings in German for German majors. 469a is not prerequisite to 469b. (Identical with Engl. 469a-469b)

475a-475b. **Advanced Grammar and Stylistics** (3-3) GC GRD Practical training in written German through the study of the more complex refinements of German grammar and style, as found in representative documents. P, 315b. 475a is not prerequisite to 475b. Richter

479. **Issues in Foreign Language Teaching** (3) GC I Modern methods of language teaching with emphasis on German as a foreign language. Schulz/Wildner-Bassett

480. **Applied Linguistics for Foreign Language Teaching** (3) GC II 1988-89 Issues in and methods of applied linguistics with emphasis on Germanic languages. Schulz/Wildner-Bassett

496. **Proseminar**

a. Translation (3) [Rpt./2] GC I II P, 315b.

501. **German Lyric Verse from the Reformation through Classicism** (3) II 1988-89 Introduction to the principles and forms of poetry; analysis and interpretation of outstanding examples of German lyric verse from the 16th through the 18th centuries. P, 6 units of upper-division German. Chisholm

502. **German Lyric Verse from Romanticism to the Present** (3) I 1989-90 Introduction to the principles and forms of poetry; analysis and interpretation of outstanding examples of German lyric verse of the 19th and 20th centuries. P, 6 units of upper-division German. Chisholm
503. Eighteenth-Century German Literature (3) II 1987-88 Klopstock, Lessing, Wieland, Goethe, Schiller, Hölderlin and other authors. P, 6 units of upper-division German. Duhm

505. German Romanticism and Realism (3) I 1988-89 Readings and discussions of representative works from 1797 to 1848. P, 6 units of upper-division German. Richter

506. German Literature from 1848 through Naturalism (3) I 1987-88 Readings of major prose and dramatic works of the second half of the 19th century, in German. P, 6 units of upper-division German. Heit

507. Goethe's Faust (3) II 1988-89 A close reading of the poem and an introduction to some of the critical secondary literature. P, 6 units of upper-division German. Duhm

509. German Literature from 1900 through the Weimar Republic (3) II 1987-88 Readings of major prose and dramatic works between 1900 and 1933, in German. P, 6 units of upper-division German. Heit

510. German Literature from 1933 to the Present (3) I 1988-89 Readings of major prose and dramatic works after 1933, in German. P, 6 units of upper-division German. Heit

511. Middle High German (3) GRD II 1988-89 Introduction to Middle High German language and literature; selective readings from representative literary works of the period. P, 302b, 315b.

520. History of the German Language (3) GRD II 1987-88 Introduction to Germanic philology; an overview of the development of the German language from its roots in the Indo-European language family to New High German. P, 8 units of upper-division German. (Identical with Engl. 520)

525. Beowulf (3) II (Identical with Engl. 525, which is home)

527a. Studies in Medieval Language and Literature (3) (Identical with Engl. 527a)

594. Practicum
   a. Translation (2 to 5) [Rpt./3] P, 496a or departmental proficiency exam.

596. Seminar
   i. Germanic Linguistics (3) [Rpt.] I II (Identical with Engl. 596i, which is home)

597. Workshop
   a. Translation (3) [Rpt./3] I II P, competency at third-year undergraduate level or pass departmental placement test.

601. Materials and Methods of Research (3) I 1987-88 Survey of the tools and methods of literary and linguistic research and introduction to principles of literary analysis. Chisholm

696. Seminar
   a. Literature (2 to 4) [Rpt.] II
   b. Linguistics (2 to 4) I II (Identical with Engl. 696b)
   c. Folklore (2 to 4) I II (Identical with Engl. 696c)
   d. Pedagogy (2 to 4) [Rpt.] II
   e. Translation (2 to 4) [Rpt.] II

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GERONTOLOGY

Committee on Gerontology

Professors William A. Stini (Anthropology), Chairperson, Daniel R. Boone (Speech and Hearing Sciences), John T. Boyer (Internal Medicine), Herbert E. Carter (Biochemistry), Theodore H. Koff (Management and Policy), Fred B. Roby, Jr. (Exercise and Sport Science), Roy G. Spece, Jr. (Law), Charles W. Weber (Nutrition and Food Science)

Associate Professors J. Lyle Bootman (Pharmacy Practice), Alfred W. Kaszniaik (Psychology), Jessie V. Pergrin (Nursing)

Assistant Professor Evan W. Kligman (Family and Community Medicine)

Because of its multidisciplinary nature, study in gerontology is located in a number of departments. The Committee on Gerontology plays a facilitating role in the coordination and development of aging studies and will guide students interested in incorporating a gerontological emphasis into their chosen field. Although no graduate major is offered, the Committee does offer a doctoral minor appropriate for students in areas such as education, administration, health, nutrition, and the social and behavioral sciences. A minimum of fifteen units selected
from required and elective courses is required. It is also possible for students to pursue gerontological study in the Gerontology Certificate Program which offers formal recognition through an eighteen-unit structured course of graduate study. The program is similar to that of many other colleges and universities in this country and is designed primarily for individuals planning to enter or to continue in a profession which involves provision of services and/or administration of programs for the aging.

Students should consult with the major department about developing a gerontological emphasis within the major field through course work, research, thesis and dissertation. This most commonly occurs in the departments of Management and Policy, Psychology, Speech and Hearing Sciences, the Division of Special Education and Rehabilitation, the School of Family and Consumer Resources, and the colleges of Nursing and Pharmacy. In addition, graduate work with a strong gerontological focus is available in long term care administration (M.P.A.) and gerontological nursing (M.S.). Courses in other departments identified as having content which deals specifically with elderly and aging processes include: Coun. 570; I.D. 405; Psyc. 421 and 428; M.A.P. 457, 595d, 662, S.E.R. 482.

Further information on gerontology study and Committee programs can be obtained from the Coordinator, Committee on Gerontology, Anthropology 214.

406. Social Gerontology (3) GC II (Identical with Soc. 406)
413. Issues in Aging (3) GC II (Identical with C.D.F.R. 413)
435. Psychological Problems of the Aged (3) GC I (Identical with Psyc. 435)
436. Economics of Aging (3) GC II (Identical with C.S. 436)
445. Clothing for Special Needs (3) GC I (Identical with C.T. 445)
447. Perspectives in Geriatrics Laboratory (1) GC II (Identical with Ph.Pr. 447)
448. Perspectives in Geriatrics (2) GC II (Identical with Ph.Pr. 448)
457. Law of the Elderly (2) GC II (Identical with M.A.P. 457)
470a. Human Adaptability (3) GC I (Identical with Anth. 470a)
576. Communicative Aspects of Aging (2) I (Identical with Sp.H. 576)
589. Health of the Older Adult (3) I (Identical with Nurs. 589)
695. Colloquium
   a. Research in Gerontology (1) II (Identical with Ph.Pr. 695a)

GOVERNMENT
(See Political Science)

GRADUATE LIBRARY SCHOOL
(See Library Science)

GREEK
(See Classics)

HEALTH EDUCATION
(See Health-Related Professions)
HEALTH-RELATED PROFESSIONS

Professor William H. King
Associate Professors Sue Criswell, Kam Nasser
Assistant Professors Jae O. Kang, Harold Potter, Jr.

The School of Health-Related Professions presently offers the Master of Education degree with a major in health education.

MASTER OF EDUCATION — For the major in health education, applicants must have bachelor's degrees from approved colleges or universities with a cumulative grade-point average of 2.50.

The major requires a minimum of 32 units, including 17 units of health education (from Hlth. 430, 431, 432, 433, 434, 435, 436, 437, 440, 475, 496a, 499, 599, and 699) and twelve units of education courses, including Ed.P. 560. A thesis is not required. The candidate must pass a final examination in both health education and education. Depending upon the student's background, electives may be taken with the approval of the student's major adviser.

Specializations are available in secondary education, higher education, or special education. For further information on courses required for each of these specializations, contact the School of Health-Related Professions.

Health-Related Professions

460. Introduction to Epidemiology (3) GC I II Introduction to the purposes, principles, and methods of epidemiology.

564. Principles and Methods of Epidemiology (3) II Study of chronic diseases and mortality; indices of health, factor-disease associations; measures of disease frequency, study design, data analysis, and interpretation of results; discussion of basic biostatistical procedures.

Health Education

430. Critical Analysis of Health Education (3) GC I Analysis and evaluation of curriculum, new teaching techniques and administrative trends in health science education; critical discussion of issues, research publications, and current periodicals in the area of health education. P, 180 or 181.

431. Field Work in Health Education (3) GC I II On the job participation and observation in health programs of public and voluntary health organizations. Open to health education majors only.

432. Organization and Administration of School Health Education (3) GC I Principles and techniques for organizing and administering school health programs; discussion of curriculum, facilities, personnel, school health legislation, administrative problems.

433. International Health Problems (3) GC I Interprets the major health problems not only of the developed and emerging nations, but also the situations in underdeveloped countries; includes assistance programs by international health groups.

434. Sex Education (3) GC II Critical analysis of the current philosophy, principles, programs, problems, trends and basic issues in sex education on the elementary, junior high and high school levels.

435. Safety Education and Accident Prevention (3) GC II Analysis of accident prevention programs in schools, colleges, communities, and industry, with emphasis on specific protective measures pertaining to athletics, physical education, recreation, highway safety, and vocational training.

436. Traffic Safety Education (3) GC I II Principles of accident prevention and traffic survival education, with emphasis on the certification of secondary school teachers preparing to teach driver education and training.

437. Contemporary Community Health Problems (3) GC II Analysis of the concept of community health services, human ecology, and conservation of human resources, with emphasis on modern miasmas such as air, water, and noise pollution; sociological problems of alcohol, alcoholism, and drug abuse. P, 178.

440. Survey of Health Education Literature (3) GC II Examination of health education literature from ancient societies to present, including an analysis of current health literature from various professional, community, voluntary, public and international health organizations.

475. Alcohol Abuse and Alcoholism (1) GC S Review of the nature and ramifications of alcohol problems, as well as analysis of physical, psychological and social implications.

496. Proseminar
a. Tobacco, Alcohol, and Narcotics (3) GC I II
DEPARTMENTS AND COURSES OF INSTRUCTION

Medical Technology

Director Sue Criswell

481a-481b. Clinical Laboratory: Hematology (6-4) GC [Rpt./1] S Basic hematology and hematological procedures including cell structure and function, inherited and acquired anomalies, hemostasis, cell enumeration and differentiation, cytogenetics. P, committee permission.

482a-482b. Clinical Laboratory: Immunology and Immunohematology (4-4) GC [Rpt./1] Serological methods used in the clinical laboratory and interpretation of results; blood banking procedures. P, committee permission.

483a-483b. Clinical Laboratory: Chemistry (6-6) GC [Rpt./1] Fundamental concepts of clinical laboratory chemistry including pathophysiology and clinical correlations. P, committee permission.

484a-484b. Clinical Laboratory: Microbiology and Parasitology (6-6) GC [Rpt./1] Clinical laboratory techniques to safely and accurately culture or isolate and identify pathogenic organisms; physiological consequences of parasitism and the role of the laboratory in treatment. P, committee permission.

485. Clinical Laboratory: Sciences (2) GC [Rpt./1] I II Basic principles of instrumentation, laboratory mathematics, biostatistics, quality control, toxicology, nuclear medicine, laboratory management and laboratory safety. P, committee permission.

Occupational Safety and Health

Director M. Van Ert

402. Industrial Hygiene Instrumentation and Analysis (3) GC II Introduction to field sampling instruments, concepts, quality control, and statistical analysis, with emphasis on instrument selection and calibration. 2R, 3L. P, O.S.H. 486, Chem. 322, 323, and CR Chem. 324.

410. Physical Exposures (3) GC II Recognition, evaluation, and control of physical exposures, including radiation, noise, vibration, and heat stress. Student is required to recognize potential exposures, use correct instrumentation to collect and evaluate data, and develop controls. 2R, 3L. P, O.S.H. 486.


486. Fundamentals of Industrial Hygiene (3) GC I Introduction to the principles of occupational safety and health, with emphasis on industrial hygiene aspects including recognition, evaluation, and control of environmental and industrial health hazards. (Identical with C.E. 486 and Tox. 486)

487. Advanced Industrial Hygiene and Safety (3) GC II An in-depth coverage of the industrial hygiene and safety professions emphasizing the principles of contaminant generation and behavior, the design of industrial hygiene/safety programs, and survey of industrial plants. P, O.S.H. 486. (Identical with C.E. 487 and Tox. 487)

488. Applied Industrial Safety (3) GC II Thorough study of technical safety topics such as fire technology, systems safety, manual materials handling; selected topics in construction and manufacturing safety. P, O.S.H. 486b.

495. Colloquium

HEALTH SERVICES ADMINISTRATION

(See Management and Policy)

HEBREW

(See Oriental Studies)

HIGHER EDUCATION

(See Educational Foundations and Administration)
HISTORY

Professors Michael Schaller, Head, Herman E. Bateman (Emeritus), Gail Bernstein, Robert P. Browder (Emeritus), Paul A. Carter, Leonard Dinnerstein, James Donohoe, Robert M. Gimello (Oriental Studies), Harwood Hinton, Ursula Lamb (Emerita), John V. Mering, Michael C. Meyer, Roger L. Nichols, Heiko A. Oberman, J. Gregory Oswald, Thomas W. Parker (Emeritus), Boyd Shafer (Emeritus), Jing-shen Tao (Oriental Studies), Robert Vignery, Donald Weinstein


Assistant Professors Kevin Gosner, Tessie Liu

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in history. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in history.

Applicants for the graduate program must have completed the equivalent of the bachelor’s degree with a major in history or related subject and are required to submit scores on the aptitude tests of the Graduate Record Examination, a statement of purpose, and three letters of recommendation. Unless a master’s degree was earned at the University of Arizona, students will be required to take a qualifying examination during the first year of doctoral studies.

Degrees

MASTER OF ARTS — At least 24 units must be completed in history including nine units (at least three of which are at the 500 level) in each of two of the following areas: Ancient; Europe, 300–1648; Europe, 1648–1945; Latin America; United States; Applied History; Women’s History. The student who elects to submit a thesis (six units) is required to complete at least twelve units at the 500 level in history other than independent study. The student who elects to present two research seminar papers (six units) in lieu of thesis is required to complete at least eighteen units at the 500 level in history other than independent study. Each student must demonstrate reading knowledge of one foreign language. In special cases computer programming or statistics may be substituted for the foreign language requirement. Each student must pass a final examination covering one of the two areas selected for concentration. A total of 30 units is required for the degree.

MASTER OF EDUCATION — All students must complete at least eighteen units in history, not fewer than six of which are at the 500 level. An oral or written examination covering the work in history as well as an examination by the College of Education must be passed, but no thesis is required. For further information concerning this degree see Requirements for Master’s Degrees/Master of Education elsewhere in this catalog.

DOCTOR OF PHILOSOPHY — In consultation with an adviser, each beginning student will select a major field and two special fields of study. One special field may be outside the department. Each student must demonstrate a reading knowledge of two foreign languages. In United States history, a reading knowledge of one foreign language and possibly other skills will be required. Preliminary to admission to formal candidacy, each student must pass an examination covering the fields chosen. Following this examination, the candidate must prepare and defend a dissertation displaying mature research in original sources, competence in assembling and presenting historical data, and critical scholarship. MAJOR FIELDS: Ancient Greece, Ancient Rome, Europe — 300–800, Europe — 800–1300, Europe — 1300–1648, Europe — 1648–1815, Europe — 1815 to the Present, Latin America, United States, Women’s History, Asian History, Comparative History.
194 DEPARTMENTS AND COURSES OF INSTRUCTION

401. Ancient Mesopotamia (3) GC I 1988-89 (Identical with Anth. 401)

402. History of Biology (3) GC II Great writings in biology and medicine. (Identical with Ecol. 402) Lenior

403a-403b. History of Greece (3-3) GC 403a: From prehistoric times to the outbreak of the Peloponnesian War. 403b: From the outbreak of the Peloponnesian War to the end of the Hellenistic Age. 403a is not prerequisite to 403b. (Identical with Clas. 403a-403b) deLaix

404a-404b. History of Rome (3-3) GC 404a: The Republic to the death of Caesar. 404b: The Empire through the reign of Constantine the Great. 404a is not prerequisite to 404b. (Identical with Clas. 404a-404b) deLaix

405a-405b. Medieval Europe (3-3) GC Major institutions and trends in Europe from the breakup of the Roman World to the 15th century. 405a is not prerequisite to 405b. (Identical with Reli. 405a-405b) A. Bernstein

406. Medieval England (3) GC I From the Roman conquest to the War of the Roses, with emphasis on political, economic, and cultural developments. A. Bernstein

407. Intellectual History of Medieval Europe (3) GC II Fusion of the Greco-Roman, Christian, and German traditions and analysis of major medieval cultural and intellectual achievements. (Identical with Reli. 407) A. Bernstein

408. The Renaissance (3) GC I Social, economic, cultural, and religious history of the 14th and 15th centuries; humanism, artistic revolution, and new world discoveries. (Identical with Reli. 408) Weinsein

409. The Reformation (3) GC II The Reformation in thought and action both from the perspective of its religious origins and of the political and social conditions. Analysis of its impact on sixteenth century Europe including the spread of Protestant reformation and its companion movement, counter-reformation. (Identical with Reli. 409) Oberman

410. History of Hell in Early Europe (3) GC II The concept of punishment after death in Western Europe from the Bible to Dante. Includes the Hebrew, Greco-Roman, Germanic, and Christian traditions. (Identical with Reli. 410) A. Bernstein

411. European Intellectual History to 1750 (3) GC I Dominant themes in European intellectual history from the end of the Middle Ages to the period of the Enlightenment. Reading and discussions of texts from Petrarsh to Locke. Donohoe

412. European Intellectual History: 1750 to 20th Century (3) GC II Dominant themes in European intellectual history from about 1750 to the 20th century. Reading and discussions of texts from David Hume to Friedrich Nietzsche. Donohoe

413. War and Peace in Europe (3) GC II European background to contemporary international relations from the Congress of Vienna through the outbreak of World War II.

414. Medieval and Early Modern Germany (3) GC I The political, social, economic and cultural history of Germany from the late Middle Ages to about 1800. Donohoe/Rebel

415. Modern Germany (3) GC II The political, social, economic and cultural history of Germany from the period of the French Revolution to the present. Donohoe/Rebel

416. Tudor-Stuart England (3) GC I An intensive study of English history from the accession of Edward IV to the Hanoverian dynasty. (Identical with Reli. 416) Cosgrove

417. History of Modern Britain (3) GC II An intensive study of English history from the accession of George III to the present. Cosgrove

418. France under the Old Regime, 1589-1789 (3) GC I French political development, institutions, and culture from Henry IV to the eve of the French Revolution. Vignery

419. The French Enlightenment (3) GC I Cultural history of France in the 18th century, with emphasis on the works of the philosophes. Vignery

420. The French Revolution and Napoleon (3) GC II The origins and progress of the Revolution in France. Vignery

421. History of Russia: Early Period (3) GC I Political, socio-economic, and cultural history of Russia in medieval and early modern times. Kellogg

422. History of Russia: Modern Period (3) GC II Political, socio-economic, and cultural history of Russia in the modern era until the Bolshevik Revolution. Kellogg

423. Intellectual History of Russia (3) GC II The historical significance of social, political, and revolutionary thought in 19th- and 20th-century Russia.

424. The Russian Revolutions (3) GC I The era of reform and revolutions in Russia from 1890 to 1921, culminating in the formation of the Soviet regime.

425. History of the Soviet Union (3) GC I The Bolshevik Revolution and problems of Soviet Russian history from 1917 to the present.

427. Russian-American Relations: 1781 to the Present (3) GC II Diplomatic, social, economic and cultural relations between Russia and the United States.

431. Colonial America (3) GC I The experience and evolving institutions of the North Atlantic colonists from the first landings to the end of the French and Indian War. Marietta

432. The Era of the American Revolution (3) GC II Origins, progress, and character of the struggle against Great Britain; internal political, constitutional, social, and economic developments; the problems of the ‘Critical Period’ and the making of the Constitution. Marietta

433. Jefferson and the New Nation, 1790-1825 (3) GC I The Federalists and the rise of the Republican party; a biographical, political, economic, and social history of the early North, South and expanding West. Campbell

434. The Jacksonian Era, 1825-1850 (3) GC I II Political, social and economic developments in the United States from the adoption of the Monroe Doctrine through the Mexican War. Campbell/Mering

435. The Coming of the Civil War, U.S. 1845-1861 (3) GC I Political, constitutional, social and economic developments in the U.S. from the Mexican War through the Civil War. (Identical with BLS. 435) Mering

436. Civil War and Reconstruction, U.S. 1861-1878 (3) GC II Political, constitutional, economic, and military developments in the U.S. and the Confederacy during and after the Civil War. (Identical with BLS. 436) Mering

437. U.S. 1876-1919 The Gilded Age and Progressive Era (3) GC Examination of economic, social and political developments in years of rapid industrialization from the end of Reconstruction through World War I. Carter

438. U.S. 1918-1945 From World War I through World War II (3) GC Prosperity. Depression and the New Deal in peace and war: Carter/Garcia

440. United States: 1945 to Present (3) GC I II American society and the role of the United States in world affairs from the Yalta Conference to the present. Dinnerstein/Schaller

442. History of American Society and Thought: Pre-Civil War (3) GC I American political, religious, cultural and philosophical ideas as expressed in colonial, revolutionary, and pre-Civil War society. Carter

443. History of American Society and Thought Since the Civil War (3) GC II The transformation of American minds since the Civil War as expressed in literary, philosophic, religious, and other cultural forms. Carter

446. History of Arizona (3) GC I II The history of Arizona from the entrance of the Spaniards in 1539 to its emergence as a modern state in the Southwest. Hinton

449. History of American Foreign Relations to 1914 (3) GC I Examines the rise of America from a struggling colony to a world class power, including its relations with Europe, Latin America and Asia. Schaller

450. History of American Foreign Relations since 1914 (3) GC II Examines the pivotal role played by the United States in world affairs since WWI, focusing on America's struggle with revolutionary movements in Europe, Asia and Latin America. Schaller

451. The United States and East Asia: 1840 to the Present (3) GC II 1888-89 An examination of American interaction with Japan and China since the Opium Wars, with special attention given to economic, cultural, and military relations and conflicts. (Identical with Or.S. 451) Schaller

452. American Ethnic History (3) GC II A history of the various ethnic minorities in America from Colonial times to the present, with emphasis on adjustment, acculturation and degrees of assimilation. (Identical with BLS. 452) Dinnerstein/Garcia

453. History of Women and Work (3) GC I History of women and work in western and non-western nations from prehistoric times to the present. (Identical with W.S. 453) Anderson

454. Spanish Inquisition (3) GC I 1988-89 The Inquisition in Spanish, European, and ethnic history; its bureaucracy and procedures; its festivities, its victims; New and Old Christians, and witches. (Identical with Or.S. 454 and Reli. 454) Swetschinski

458. Feminism: A Comparative History (3) GC II International history of feminism as an ideology and a political movement from the 17th century to the present. (Identical with W.S. 458) Anderson

460. History of the Hispanic Borderlands (3) GC II The Spanish and Mexican experience in the Southwest from the 16th century to 1848. (Identical with M.A.S. 460)

461. The Iberian Empires (3) GC II European background to, and results of, Iberian expansion from the 15th through 17th centuries. Spanish colonialism in the New World is contrasted with Portuguese systems in the East.
462. Intellectual History of Latin America since 1810 (3) GC II 1988-89 Latin American thought from
Independence to the 20th century; major Latin American thinkers and writers, and influences from
Europe and the United States. Brubaker

463. Marxism in East Asia (3) GC I (Identical with Or.S. 463)

464. History of Argentina (3) GC I Survey of Argentine history and culture from the colonial era to the
present. Guy

465. History of Spain (3) GC I II S History of Spain from remote times to the present; emphasis on the
period from 1492, Spain's role in the world and the Spanish Civil War, Spain's cultural contributions.
Brubaker

466. History of Brazil (3) GC II Brazil's political, economic, social and intellectual development. Guy

467. Contemporary Latin America (3) GC II Revolution, social change and reaction in Latin America from
1930 to the present. Guy

468-486b. Asia and the West (3-3) GC 1987-88 (Identical with Or.S. 468a-468b)

469. History of Women in Latin America (3) GC II Women's history in Latin America from the Conquest
to the present. (Identical with W.S. 469) Guy

471. Introduction to Indic Civilization (3) GC I (Identical with Or.S. 471)

472. History of Medieval India (3) GC I 1987-88 (Identical with Or.S. 472)

473. History of Modern India and Pakistan: 1750-Present (3) GC II 1987-88 (Identical with Or.S. 473)

474a-474b-474c. History of Japan (3-3-3) GC (Identical with Or.S. 474a-474b-474c)

475a-475b-475c-475d-475e. Periods in Chinese History (3-3-3-3-3) GC (Identical with Or.S.
475a-475b-475c-475d-475e)

476. Modern Chinese History (3) GC (Identical with Or.S. 476)

477a-477b. History of the Middle East (3-3) GC (Identical with Or.S. 477a-477b)

478. Modern History of the Middle East (3) GC I (Identical with Or.S. 478)

479. The Ottoman Empire to 1800 (3) GC II 1988-89 (Identical with Or.S. 479)

480a-480b. History of Iran and Central Asia (3-3) GC (Identical with Or.S. 480a-480b)

482. Social History of China (3) GC (Identical with Or.S. 482)

488. History of Byzantium (3) GC II Political, social, and cultural history of Byzantium from A.D. 325 to
1453, including the Byzantine legacy in Europe and the Middle East. (Identical with Clas. 488 and Reli.
488) Kellogg

489. Women in East Asia (3) GC I (Identical with Or.S. 489)

490. Philosophy of History (3) GC I Introduction to historical thinking from antiquity to the present, with
emphasis on ideas in European and North American historical writings during the modern and con-
temporary eras.

495. Colloquium
a. Revolution in Chinese History (3) GC II (Identical with Or.S. 495a, which is home)
b. Studies in Black America (3) GC I II (Identical with Bl.S. 495b)
c. The Mexican American (3) GC I II (Identical with M.A.S. 495c)
d. Modern Chinese Frontier Areas (3) GC I 1987-88 (Identical with Or.S. 495d) Hedtke

496. Proseminar
a. Historical Research and Writing (3) GC I II

595. Colloquium
Certain colloquia in Oriental studies may be used for history graduate credit.
a. Advanced Studies in United States History (3) I II
b. Advanced Studies in Latin American History (3) I II
c. Advanced Studies in European History (3) I II
d. Applied History (3) I Field trips. (Identical with La.S. 595d)
e. Advanced Studies in the History of Women (3) I II GRD (Identical with W.S. 595e)
f. Advanced Studies in Ancient History (3) I II Consult department before enrolling. (Identical with Clas.
595f)

596. Seminar
Certain seminars in Oriental studies may be used for history graduate credit.
a. Colonial U. S. History (3) I II
b. Nineteenth-Century U. S. History (3) I II
c. Twentieth-Century U. S. History (3) I II
d. Ancient History (3) I II
e. Medieval Europe (3) I II
Hydrology and Water Resources

Professors Nathan Buras, Head, Donald R. Davis, Stanley N. Davis, Lucien Duckstein, Daniel D. Evans, Martin M. Fogel (Watershed Management), John W. Harshbarger (Emeritus), Simon Ince, William B. Lord (Water Resources Research Center), Thomas Maddock, III, Shlomo P. Neuman, Eugene S. Simpson (Emeritus)

Associate Professors Michael D. Bradley, Soroosh Sorooshian

Assistant Professors Roger C. Bales, Susan C. Nunn, T.-C. Jim Yeh

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in hydrology and in water resources administration. The faculty offers competence in hydrogeology, hydrogeochemistry, ground-water hydrology, surface-water hydrology, mathematical and statistical methods in hydrology (including numerical modeling), and in water resource planning, management, and administration.

Applicants need not have completed an undergraduate major in hydrology. The programs have been developed to enable graduates from the basic sciences and from related fields such as geology, engineering, agriculture, meteorology, economics, and political science to enter directly. It is recommended that applicants submit scores on the Graduate Record Examination.

Graduate study programs are individually planned to meet the student's special interests and professional objectives. Certain basic courses in hydrology and water resources are required of each master's candidate unless equivalent courses were taken elsewhere. A thesis based on individual research is required for the master's degree, and all students are expected to acquire a capability for computer programming.

Applicants for admission to the Doctor of Philosophy degree program should have completed the Master of Science degree with a major in hydrology, water resources, or a related field. Where gaps exist in background knowledge of relevant subject matter, the student may be required to take additional course work.
HYDROLOGY — The program is designed for students with special interest in the physical, chemical, and biological aspects of the hydrologic cycle as it relates to water resources. Students may concentrate in one or in a combination of these fields but should acquire some proficiency in all aspects of hydrology and water resources administration.

WATER RESOURCES ADMINISTRATION — The Master of Science and the Doctor of Philosophy degrees are offered with major in water resources administration. This interdisciplinary program is for students with special interests in operations research, management, or the social sciences as related to water resources. Students majoring in the program are expected to have or acquire a basic knowledge in hydrology. Courses and research provide learning experience in both quantitative and nonquantitative methodologies. Three areas of concentration are currently defined: water policy and planning, water resources systems, and water quality management.

Hydrology

402. Fundamentals of Water Quality (3) GC I Introduction to chemical processes affecting the behavior of major and minor chemical species in the aquatic environment. Physical, equilibrium, organic, and analytical principles as applied to natural waters. Open to majors only. P, Chem. 103b, Phys. 103b, and Math. 125b.

403. Subsurface Hydrology (3) GC I Physical, mathematical, geologic, and engineering fundamentals to subsurface hydrologic processes. Open to majors only. P, A.M.E. 331a or C.E. 321; Math. 125b; Geos. 101a.


405. Hydrology of Unsaturated Media (3) GC I Physical properties and processes of unsaturated media related to storage and movement of water and transport of contaminants. P, Phys. 103b, Math. 125b. (Identical with S.W. 405)

414a-414b. Field Hydrology (Summer Camp) (3-3) GC S Field methods of collection, compilation, and interpretation of data in surface and ground-water hydrology; investigation of a small water resources project; preparation of hydrologic reports. Daily field work. Fee. P, 405, 423, 435.

423. Hydrology (3) GC I (Identical with C.E. 423)


450. Environmental Hydrology (3) GC II Chemical and physical properties of water in relation to man's use; transport and dispersion of pollutants in surface and subsurface water; chemical and transport models. 2R, 3L. Field trips. P, 150, Chem. 103a-103b, Math. 125b, S.I.E. 170.

457. Low Temperature Geochemistry (3) GC II (Identical with Geos. 457)

460. Watershed Hydrology (3) GC I (Identical with Ws.M. 460)

471. Water Quality Control (3) GC II (Identical with C.E. 471)

480. Hydrologic Systems (3) GC I Major aspects of the hydrologic cycle are studied quantitatively, with emphasis on model construction and simulation. 2R, 3L. Field trips. P, 423 or 460.

481. Physical Oceanology and Limnology for Hydrologists (2) GC II 1987-88 Origin, distribution, and characteristics of oceanic water; advective and convective processes; estuarine and shoreline processes; effect on coastal aquifers; classification and hydrologic regimen of lakes. P, Math. 125b.

502. Snow Hydrology (2) I 1988-89 (Identical with Ws.M. 502)

503. Subsurface Fluid Dynamics (3) I Kinematics and dynamics of fluids in saturated porous and fractured media; introduction to free surface, unsaturated, and multiphase flows. P, A.M.E. 331a or C.E. 321, Math. 422a. (Identical with C.E. 503)

504. Numerical Methods in Subsurface Hydrology (4) II Finite difference and finite element methods for subsurface fluid flow and mass or energy transport; applications to aquifers, unsaturated soils, seepage through earth dams, geothermal systems. 3R, 3L. P, Math. 422a. (Identical with C.E. 504)
506. **Water Quality Dynamics** (3) II Chemical and physical methods are used to study the quality of ground and surface waters with emphasis on electrolyte chemistry, heterogeneous processes, colloids, and surface processes including sorption phenomena. Equilibrium and dynamic models of water chemistry. P. Chem. 480a or 450.


536. **Development of Ground-Water Resources** (3) II Analytic techniques to evaluate geohydrologic systems; case histories used to study management of ground- and surface-water resources; planning and design of regional water resource investigations. Field trips. 2R. 3L. P. 535. (Identical with Geos. 536)

540a-540b. **Advanced Surface Water Hydrology** (3-3) Fluvial dynamics and flood routing; flood hydrology; hydrology of water supply; classical and numerical methods. P. 423.

545. **Advanced Statistical Hydrology** (3) I 1987-88 Advanced application of statistics and probability to hydrology and water resources; multivariate modeling, choice of models and parameters, simulation, Bayesian decision theory. P. 445.

564. **Isotope Hydrology** (3) (Identical with Geos. 564)

565. **Hydrochemistry** (3) I II 1987-88 (Identical with S.W. 565)

596. **Seminar**
   - Hydrogeology (1 to 3) [Rpt./2] II (Identical with Geos. 596p)

603. **Well Hydraulics and Pumping Test Analysis** (2) II 1988-89 Flow to wells in aquifers, with emphasis on design and interpretation of pumping tests; confined, unconfined, and leaky aquifer systems; fractured rocks; automatic curve matching. P. 503 or 535, Math. 422a.

605. **Soil Water Dynamics** (3) II 1988-89 (Identical with S.W. 605)


695. **Colloquium**
   - Hydrology (1 to 3) [Rpt./1] II

696. **Seminar**
   - Unsaturated Flow (2 to 3) I II
   - Regional Hydrologic Analysis (1 to 3) II P. 423, 435.
   - Desert Hydrology (1 to 3) [Rpt./2] I II 1988-89
   - Pollutants in the Hydrologic Environment (1 to 3) I II
   - Aquatic Chemistry of Surfaces (1 to 3) I 1987-88 P. 506.

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**Water Resources Administration**

401. **Introduction to Water Resources Policy** (3) GC II Water resources policy including the identification of regional problems of water use, the elements of water planning, water rights, and a consideration of institutional structures and processes. P. Math. 125a. (Identical with Geog. 401)

408. **Water Resources Management, Planning, and Rights: A Policy Approach** (3) GC II An introduction to basic concepts and issues of water resources management and administration, emphasizing water law and rights, water resources planning, institutional and organizational arrangements, and policy processes such as adjudication and rule-making. Open to majors only.

443. **Quantitative Planning Methods in Water Resources Administration** (3) GC I Applications of quantitative methods to water resources management; benefit-cost analysis; optimization; structure and basis of planning process; principles and guidelines. P. microeconomics, Math. 125a.

444. **Quantitative Design Methods in Water Resources Administration** (3) GC II Applications of quantitative methods to water resources management; benefit-cost analysis; optimization; operations research methods (linear, quadratic, and dynamic programming). P. FORTRAN, microeconomics, Math. 125a.

461. **Population and Resources** (3) GC I (Identical with Geog. 461)

476. **Natural Resource Economics** (3) GC II (Identical with A.Ec. 476)

480. **Forest Policy and Administration** (3) GC II (Identical with Ws.M. 480)

481. **Environmental Policy** (3) GC II (Identical with Pol. 481)
200 DEPARTMENTS AND COURSES OF INSTRUCTION

501a-501b. Water Resources Policy and Administration (3-3) Institutional and policy aspects of water resources administration; management, organizational theory, and international problems of water use and development; ground-water management and policy. 501a is not prerequisite to 501b.


525. Water Quality Modeling (3) (Identical with C.E. 525)

526. Water Quality Management (3) Optimization and systems analysis techniques used in modeling; current models used in formulation and implementation of water quality policy. P, 525. (Identical with C.E. 526)

556. Finite State Methods in Water Resources Management (3) Finite state methods; applications to natural resource systems as arise in hydrology, ecology, and earth sciences, including the modeling of interfaces such as socioeconomic processes. P, Math. 254, S.I.E. 170. (Identical with S.I.E. 556)


576. Advanced Natural Resource Economics (3) (Identical with A.Ec. 576)

577. Natural Resource Economics and Public Policy (3) (Identical with A.Ec. 577)

643. Water Resources Systems Analysis (3) Applications of mathematical programming to the analysis of interactions of hydrology, engineering, economics, and socio-institutional environment in regional water resources systems. P, 544b or consult department before enrolling.

695. Colloquium
b. Water Resources Administration (1 to 3) [Rpt./1] II

696. Seminar
h. Long-Range Resource Planning (1 to 3) [Rpt./2] I
i. International Water Resource Management (1 to 3) [Rpt./2] I
m. Water Storage Systems (1 to 3) [Rpt./1] II P, consult department before enrolling.

INDUSTRIAL ENGINEERING
(See Systems and Industrial Engineering)

INTERDISCIPLINARY PROGRAMS

The Office of Interdisciplinary Programs is the agency responsible for furthering the development of interdisciplinary activities. The Coordinator of Interdisciplinary Programs works with the Graduate College and with the Vice President for Research in fostering educational and research projects.

In most cases, interdisciplinary courses are listed under a "home" department and crosslisted in a variety of other departments. These appear under the appropriate headings elsewhere in this catalog.

596. Seminar
u. Interdisciplinary Environment-Behavior-Design (3) (Identical with Arch. 596u, Geog. 596u, L.Ar. 596u, Psyc. 596u, and Ping. 596u)

INTERIOR DESIGN
(See Family and Consumer Resources)

IRRIGATION
(See Agricultural Engineering)

ITALIAN
(See French and Italian)
The department offers a program leading to the Master of Arts degree with a major in journalism. The program is designed for students dedicated to developing or improving professional skills while attaining an academic background in one or more specializations.

An undergraduate major in journalism is not necessary for admission. Students are required to complete 205, 206, and 320 as deficiencies without graduate credit. A minimum of thirty units is required for the master's degree. Electives are chosen from journalism or related fields with the approval of the adviser. A complete program of study must be approved by the graduate adviser in the first semester, and the adviser must approve any subsequent changes. No foreign language proficiency is required, although for those interested in Latin America, the department has an exchange program in Guadalajara.

Students are required to work on two departmental newspapers and to demonstrate a high level of skill in reporting and writing courses. The program of study must include 411, 413, 502, 509, 596, and 909. Advanced-degree credit will not be given for a grade lower than "B" in any professional, photojournalism, or editing course.

The graduate program has been accredited by the American Council for Education in Journalism and Mass Communications.

**403. Advanced Photojournalism (3)** GC I II Open to majors only. P, 301, 302.

**405. The Study of News (3)** GC I II Critical study and problem analysis of the media. Field work may include publication of conclusions.

**411. News Features (3)** GC I II Writing the basic news feature article; specialized reporting and rewriting techniques. P 206.


**413. Reporting Public Affairs (3)** GC I II Study and practice of newsgathering on executive, legislative, and judicial levels in city, county, state and federal governments, with emphasis on news sources and interpretive writing. P 206, 208.

**414. The News Agency: Arizona News Service (1)** GC [Rpt.] I II Role and operations of the news agency, wire service or syndicate. Class members will form staff of Arizona News Service to supply client newspapers from bureaus in Tucson and Phoenix. Field trips. P or CR, 411 or 413.

**415. The Editorial Page (3)** GC I II Critical study of opinion-makers, with emphasis on editors and public-affairs columnists; analysis of editorial pages in a changing society; writing of editorials. P 206.

**416. The Weekly Newspaper (3)** GC I II Community and suburban weeklies, including problems of news coverage, production, advertising and circulation. Integration of electronic text systems. Field trips.

**417. Sports News Writing (3)** GC I Students will cover sports events and write sports features. Interview and rewriting techniques. P 206.

**419. Public Information Writing (3)** GC I I S The history, principles and techniques of public information, the relation between news media and government, and the responsibilities of government and other public information specialists.


**425. The Electronic Newspaper: Tucson News and Sports (3)** GC I II Reporting and writing Tucson news stories suitable for use on local cable television station. Students produce copy on a character generator and send it by modem to a public access channel. P, 205, 206 or CR.
202 DEPARTMENTS AND COURSES OF INSTRUCTION

450. **Community Journalism: The Tombstone Epitaph** (3) GC [Rpt.] I II Class members work as editorial staff to produce the local newspaper for Tombstone, Arizona. Intensive study of problems and responsibilities of community newspapers. P, 206, 208, 301, 320, discussion of preparation with instructor.

451. **Community Journalism: El Independiente** (3) GC [Rpt.] I II Class members work as editorial staff to produce a publication for the city of South Tucson. Intensive study of problems and responsibilities of journalism. P, 206, 208, 301, 320, discussion of preparation with instructor.

452. **Press Criticism: The Pretentious Idea** (3) GC I II Study of press criticism, including the publication of a press review. Open to majors only. P, 206, 208, 320, discussion of preparation with instructor.

470. **The Press and Society** (3) GC I II Critical study of press performance in current affairs; changing requirements for socially responsible and professional journalism in a democracy. (Identical with M.Ar. 470)

471. **International Communications** (3) GC I II Study of world news systems, including news-gathering agencies, role of the foreign correspondent, the foreign press, and factors influencing international news flow.

497. **Workshop**
   a. Color Photography (2) [Rpt./1] GC S Two-week field trip with fee.

502. **Freedom of Expression** (3) I II Analysis of access and barriers to information and communication at local, state, national and international levels; intensive study of the legal relationship between mass media and society. Open to majors only.

509. **Media in the Twentieth Century** (3) I The social, cultural, and economic role of a free press in American society. Interaction of press and government at judicial, executive, and legislative levels.

596. **Seminar**
   a. History of Mass Media (3) I II
   b. International Communications (3) I II
   c. Reporting Governmental Affairs (3) I II
   d. Magazines (3) I II
   e. Electronic Media (3) I II
   f. Community Journalism (3) I II
   g. Journalism Education (3) I II
   h. Latin-American Press (3) I II
   i. News Analysis (3) I II
   j. Media Organization (3) I II

LANDSCAPE ARCHITECTURE
(See Renewable Natural Resources)

LANGUAGE, READING AND CULTURE

Professors Kenneth S. Goodman, Yetta M. Goodman, Amelia Melnik, Kenneth J. Smith, William J. Valmont

Associate Professors Adela A. Allen, Head, Patricia L. Anders, John M. Bradley, Margaret B. Fleming, Judy N. Mitchell, Luis C. Moll, James R. Rankin

Assistant Professor Arminda Fuentevilla

The division offers programs leading to the Master of Arts and Master of Education degrees with majors in bilingual/bicultural education and reading. The division offers programs leading to the Educational Specialist, Doctor of Education, and Doctor of Philosophy degrees with a major in reading.

An undergraduate grade-point average of at least 3.00 is required for admission to full standing in a graduate degree program. However, applicants with undergraduate grade-point averages of 2.50 to 2.99 may be admitted on a provisional basis. A master's degree (in education or a related discipline) is a prerequisite for admission to a specialist or doctoral program. Beyond these minimal requirements, applicants must also meet the specific admission requirements for all majors offered in the division.

At the time the catalog was being edited, many programs in the College of Education were being redesigned. All current and prospective students should check with the Office of Student Services in the College of Education or the Division of Language, Reading and Culture for current admission and degree requirements in each major.
406. **Foundations of Reading Instruction in Spanish** (2) GC II Introduction to the theoretical and practical aspects of the reading process, with attention to essential decoding and comprehension skills; special application for teaching Spanish-speaking children to read. Taught in Span. P, Span. fluency. (Identical with M.A.S. 406)

420. **Education and the Culturally Diverse** (3) GC I II Analysis of the interaction of school, community, and family factors in the education of diverse populations.

427. **Bilingual Curriculum Development** (3) GC I II Theory and application of curriculum development to bilingual instructional program: designs, organizational patterns, materials and media, change strategies, and evaluation.

430. **Computer Literacy for Teachers** (3) GC I II Microcomputer operation; software evaluation; use of author systems and word processors in the classroom; computer managed instruction; organization for computer use.

435. **Secondary School Reading in the Classroom** (3) GC I II Provisions and procedures for evaluating and developing reading skills needed in content areas.

481. **Children's Literature in the Classroom** (3) GC I II S Strategies for teachers to promote literary appreciation and analysis of classic and contemporary children's literature of all genres.

504. **Language and Culture in Education** (3) I II Theory and research concerning language acquisition in first and second languages and relationships to reading and writing; impact of linguistic and cultural background on education; pedagogical implications.

505. **Essentials of Reading and Writing Instruction** (3) I II Theories and principles underlying reading instruction, approaches to teaching, basic analysis of research.

507. **Analysis of Decoding** (3) I II Phoneme theory; prerequisites for learning phoneme-grapheme associations; teaching word identification skills; examination and analysis of instructional materials and related research. P, 505 or CR.

508. **Bilingual Reading and Writing** (3) I Analysis of reading situations encountered by bilingual students; phonological, semantic and syntactic aspects of instruction; methods and materials. P, 505 or CR.

524. **Methods and Materials in Bilingual Education** (3) I II Evaluation and study of methods and materials used in bilingual education programs. P, 504.

525. **Educating the Bilingual Learner** (3) I S Analysis of theories and practices affecting bilingual learners; historical, social, and cultural influences; relationship of theory to the characteristics and needs of the bilingual learner.

532. **Pre-Reading and Beginning Reading Development** (3) I II An examination of various aspects involved in pre-reading and beginning reading development, including psychological, sociological, physiological, linguistic and educational considerations.

534. **Reading Comprehension: Theories, Research and Methods** (3) I II Factors affecting cognitive development; methods of influencing growth in reading comprehension; examination and analysis of instructional materials; research related to comprehension and cognitive development. P, 505 or CR.

535. **Reading in the Secondary School Curriculum** (3) I II Organization of reading programs: skills and methodologies; evaluation of published materials; development of teacher-made materials. P, 505, 507 or CR.

537. **Classroom Diagnosis and Instruction** (3) I II Procedures for diagnosing and developing reading and writing skills for pupils of below-average achievement level. P, 505, 507, 534 or CR.

540. **Curriculum Development and Supervision in Reading** (3) I II Organizational patterns of reading curricula; approaches to the improvement of reading instruction; personnel relations. Designed for the reading supervisor and the school administrator. P, 505 and 507 or CR.

551. **Psycholinguistics and Reading** (3) I II Basics in psycholinguistics of reading and reading instruction, with emphasis on the comprehension of written language.

553. **Language Acquisition and Development** (3) I Study of the development of language in young children, and exploration of instructional techniques to maximize that development. P, 551 or CR.

554. **Applied Linguistics in Education** (3) I The application to curriculum, teaching and learning of concepts from linguistics, psycholinguistics and sociolinguistics. P, 551 or CR.

557. **Application of Miscue Analysis** (3) III Study of miscue analysis to explore the reading process, reading research, and readability, as well as to evaluate readers; applications to reading strategies and curriculum; focus on comprehension. P, 551 or CR.

578. **Field Experience** (3) I II Supervised experience in assessment and instruction of literacy-related practices. P, 504, 505, 507, 534 or CR.

595. **Colloquium**
   a. **Issues in Reading** (3) I II P, 504, 505 or CR.
   b. **Language, Learning and Reading Disabilities** (3) III (Identical with S.E.R. 595b, which is home.)
c. Issues in Educating Mexican American Children (3) [Rpt./9 units] 596. Seminar

a. Research in Reading (1 to 6) P, 504, 505, 507, 534 or CR.

b. Language Research Methodology in Education (3) II P, 553 or 554.

c. Research in Language and Literacy (1 to 6) [Rpt./9 units]

597. Workshop

a. Southern Arizona Writing Project (3 to 9) [Rpt./12 units] II S (Identical with Engl. 597a)

b. Miscue Analysis in Teacher Education (2 to 3) II 1988-89

c. Teaching of English (3) II S (Identical with Engl. 597c, which is home)

612. English Grammar for ESL (3) (Identical with Engl. 612)

613. Teaching of ESL (3) I (Identical with Engl. 613)

638. Reading Diagnostic Laboratory (3 to 6) [Rpt./6 units] II Supervised practice in reading assessment; identification of factors influencing reading achievement, evaluation, construction, and administration of assessment procedures; development of interview techniques. P, 507, 534, 535 or CR.

639. Reading Instructional Laboratory (3 to 6) [Rpt./6 units] II Supervised practice in teaching reading and writing; preparing, analyzing and critiquing special instructional programs for students. Open to majors only. P, 507, 534, 535 or CR.

653. Written Language Development (3) II S Exploration of the emerging writing and reading behavior of children ages 2-10 and the relationship between oral and written language development through current and original student research. P, 553, 554 or CR.

694. Practicum

a. Bilingual Education (3) [Rpt./2] P, 15 graduate units incl. 508 and 525.

795. Colloquium

a. Language and Culture (1 to 3) II [Rpt./15 units]

796. Seminar

a. Research and Evaluation (1 to 3) II [Rpt./15 units]

b. Bilingual Education (3) I

LATIN (See Classics)

LATIN AMERICAN STUDIES

Latin American Area Center

Director Michael C. Meyer
Assistant Director Raul P. Saba

Committee on Latin American Studies

Professors Michael C. Meyer (History), Director, Donald W. Carson (Journalism), Roger Fox (Agricultural Economics), Lanin A. Gyurko (Spanish and Portuguese), Boris S. Kozolchyk (Law), Edward J. Williams (Political Science)

Associate Professor Celestino Fernandez (Sociology)
Assistant Professor Raul P. Saba

The Latin American Area Center offers an interdisciplinary program leading to the Master of Arts degree with a major in Latin American studies. Programs are designed primarily for students planning government, business, teaching, or related careers. The Center assists its students in career development by providing counseling and information relating to internships and careers.

Applicants should indicate the intended area of concentration. A faculty member from the proposed area of concentration will evaluate the transcripts to determine whether there will be undergraduate deficiencies to be satisfied without graduate credit. Scores on the aptitude test of the Graduate Record Examination are strongly recommended.
The master's program consists of 35 graduate units, with an area of concentration and two related areas. Minimum unit requirements are fifteen (including one research seminar) for the concentration and eight and six for the respective related areas. Concentrations are available in anthropology; economics; geography and regional development; political science; history; Portuguese; and Spanish. Related areas may be cultural or professional and may be chosen from among the following areas: agricultural economics; anthropology; art; economics; English as a second language; educational foundations and administration; family and consumer resources, geography and regional development; political science; history; journalism; law; library science; nursing; pharmacy; Portuguese; sociology; and Spanish.

Neither of these supporting fields may duplicate the principal field of concentration. Both Portuguese and Spanish are required, one at a level of competence and the other at a level of proficiency. Competence may be established by completion of Port. 202b or Span. 301B with a grade of B or above, or by an equivalency examination. Proficiency may be established by completion of Port. 405b or Span. 330 with a grade of B or above, or by an equivalency examination. The student and the adviser will determine which language should be emphasized. All students are required to complete at least one semester of 596a.

Doctoral students in other departments may elect a minor in Latin American studies. Requirements include a minimum of fifteen units in courses related to the student's major and demonstrated competence, as defined above, in either Portuguese or Spanish.

LAW


Associate Professors Gary B. Born, Theresa A. Gabaldon, James R. Ratner, Jane B. Silverman

No graduate degree is offered by the College of Law. The College welcomes, however, the enrollment of properly qualified graduate students in selected courses relevant to their degree objectives. Graduate students so enrolled may earn graduate credit as their performance warrants. Prior to registration, such students must obtain the written approval of the instructor of the course in question and the Executive Committee of the College of Law.

For information concerning the professional degree Juris Doctor, see the College of Law Catalog.

LAW 205

495. Colloquium
   a. Latin American Studies (3) [Rpt./1] GC II P. Span. or Port. proficiency.

595. Colloquium
   d. Applied History (3) [Rpt./5] I (Identical with Hist. 595d, which is home)

596. Seminar
   a. Latin American Studies (3) [Rpt./1] I P. Span. or Port. proficiency.

LAW

600. Contracts (5)
601a-601b. Introduction to Legal Process and Civil Procedure (3-2)
602. Criminal Procedure (4)
603. Research and Writing (2)
604a-604b. Torts (2-3)
605. Property (5)
606. Constitutional Law I (3)
607. Appellate Practice and Moot Court (1)
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<th>Course Code</th>
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<td>Evidence (4)</td>
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<td>609</td>
<td>The Legal Profession (2)</td>
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<td>612</td>
<td>Family Law (3)</td>
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<td>Law and Medicine (3)</td>
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<td>Constitutional Law II (4)</td>
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<td>Corporations (3)</td>
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<td>Immigration Law (3)</td>
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<td>Administrative Law (3)</td>
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<td>Conflict of Laws (3)</td>
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<td>Labor Law (3)</td>
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<td>628</td>
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<td>Taxation of Multinational Transactions (3)</td>
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<td>Community Property (2)</td>
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<td>Estate and Gift Taxation and Basic Estate Planning (3)</td>
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<td>Torts II (3)</td>
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<td>Moot Court Board (2)</td>
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<td>Debtor-Creditor Law (3)</td>
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<td>658</td>
<td>Interviewing, Counseling and Negotiating (1-1)</td>
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<td>Lawyer Skills Outside the Courtroom (2)</td>
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667. Law and Economics (3) II
669. Preservation of Historic Environments (3) II 1987-88 (Identical with Plng. 669, which is home)
671. Business, Government and Society (3) I II (Identical with M.A. P. 671, which is home)
696. Seminar
c. Clinical Practice (2-3) I II P, 608, 609.
e. Business Planning (3) II P, 616, 647.
f. Advanced Civil Procedure (3) I
i. Current Business Regulation (3) II P, 616.
i. Labor and Employment Problems (3) II P, 624.
o. Mental Health Law (2) II 1987-88

LIBRARY SCIENCE

(Graduate Library School)

Professors Ellen Altman, Donald C. Dickinson, Robert K. Johnson (Emeritus), Margaret F. Maxwell, Lawrence Clark Powell (Emeritus), Elinor C. Saltus (Emerita), Arnulfo D. Trejo (Emeritus)
Associate Professors Charlie D. Hurt Ill, Director, Helen M. Gothberg, Helen Renthal (Emerita), Ronald A. Van De Voorde
Assistant Professors John M. Budd, Charles A. Seavey

The Graduate Library School offers programs leading to the Master of Library Science degree with a major in library science. The Master of Library Science degree qualifies graduates for positions in libraries and information centers. All students must pass a comprehensive final examination. The Graduate Library School is accredited by the American Library Association.

The goals of the Graduate Library School are (1) to establish an academic environment within which students develop proficiencies essential for present and future leadership in librarianship and information science, (2) to be a dynamic resource for providing the profession with personnel from diverse cultural and academic backgrounds, and (3) to maintain an active program to meet the continuing education needs of the library and information science community.

Degree

MASTER OF LIBRARY SCIENCE — For information concerning this degree, see Requirements for Masters' Degrees/Master of Library Science elsewhere in this catalog.

417. Media in Instruction (3) GC I II S (Identical with T.T.E. 417)
441. Children's Literature in Spanish (3) GC I (Identical with Span. 441)
443. Mexican-American Literature (3) GC II (Identical with Span. 443)
503. Library Collection Development (2) I II Principles of collection development; evaluation and review of materials; selection tools; acquisition of materials; problems in selection, including censorship.
504. Foundations of Library and Information Services (2) I II Elements of librarianship, historical backgrounds, types of libraries, the role of the library in American life, current issues.
505. Basic Reference (3) I II Survey of general reference sources; discussion of reference technique.
506. Research Methods (2) I II Need and opportunities for research in librarianship; types of research; research methodology; study of research design; elementary statistics.
507. Library Management (3) I II Introduction to management concepts, the organizational structure of libraries, systems analysis, financial administration and the utilization of library personnel.
509. Information Sources for Agricultural Scientists (1) I (Identical with P.L.S. 509)
208 DEPARTMENTS AND COURSES OF INSTRUCTION

510. **Introduction to Information Science** (3) Methods, theories, and technology of information science; elements of computer programming and systems design; implementation and management of computer systems in libraries and information centers.

511. **Information Storage and Retrieval** (3) Student involvement in on-line, interactive systems. P, 510.

512. **Automation in Libraries** (3) II Introduction to automated procedures currently in use in libraries, including systems analysis of actual technical services and planning for their automation. P, 510.


515. **Library Cooperation and Networks** (3) Study of the background and state of the art of library cooperative systems, networks, and bibliographic utilities.

516. **Coordination of Instructional Media Programs** (3) II (Identical with T.T.E. 516)

517. **Preparation of Instructional Materials** (3) II (Identical with T.T.E. 517)

520. **Technical Service Problems** (3) I Examination of problems in acquisitions, cataloging, serials, and other areas related to activities in academic, public, school, and special libraries; consideration of developing technology. P, 502.


522. **Automated Alternatives to the Library Catalog** (1) II Alternatives to the card catalog with consideration given to type of library function, size, and budget; comparisons of card, printed book, on-line, and micro-image catalogs. Field trips. P, 502, 505.

523. **Indexing and Abstracting** (3) II Theory and current practices for compiling manual and computer-produced indexes; vocabulary control and thesaurus construction; production and evaluation of indexes and abstracts.

526. **Introduction to Bibliography** (3) Introduction and critical examination of various styles of bibliographic description; practical application in construction of a systematic bibliography. P, 505.

530. **Public Librarianship** (3) I Administration of tax-supported libraries serving the general public; including problems of governmental relationships, community responsibilities, financial support, buildings, personnel, collections. P, 507.

540. **Academic Librarianship** (3) I Present trends in academic libraries, including financial administration, collection evaluation, personnel requirements and building needs. P, 507.

550. **Special Librarianship** (3) II Mission, organization and administration of the special library. P, 507 or equivalent experience.

560. **History of Books and Printing** (3) I Survey of the history of books and printing from early times to the present, including development of the alphabet, manuscript books, the invention and dissemination of printing and modern printing techniques.

561. **History of Children's Literature** (3) II Survey of literature for children in England and America from earliest times to the close of the 19th century, together with study of cultural and social values reflected in the literature. (Identical with Engl. 561)

562. **Library Public Relations and Communication** (3) I II Essentials for library public information activities, brochures, news releases and public service announcements for radio and television, communication problems at public service desks.

570. **Literature of Science and Technology** (3) I Creation, organization, and dissemination of scientific and technical literature; reference function and problems of bibliographic control. A science background is not required. P, 505.

571. **Information Sources in the Social Sciences and Humanities** (3) II Advanced bibliographic and reference sources in the humanities and social sciences, with emphasis on the structure of knowledge in the various disciplines and evaluation of user services. P, 505.

573. **Government Publications** (3) II Examination of the varieties of government publications available from municipal, county, state, national and international agencies, with emphasis on selection and use of publications of the U.S. government.

576. **Administration of Reference** (2) I Theory of information service, policy development, special services, and administration of reference services. Open to majors only. P, 505.

580. **Children's Literature for Librarians** (3) GC II Literature to promote literary appreciation and to meet the needs of children through preadolescence.

581. **School Library Administration and Organization** (3) II Services, finances, personnel, evaluation, quarters, organization and technical services in the school library. P, 502.
582. Audiovisual Materials in Libraries (2) Introduction to AV information resources for the library.
585. Literature for Adolescents (3) Literature to meet recreational and developmental needs of the junior and senior high school age, including some books for adults. Reviewing and book talks.
586. Oral Presentation of Children's Literature (2) Principles and techniques of storytelling and of reading aloud to children; stories for different age groups, presentation of picture stories; practice in reading and telling stories and in planning the story hour. P, 480.
600. Introduction to Graduate Study in Music (3) (Identical with Mus. 600)
607. Planning Library Services (3) The total planning cycle as a management approach to various library/information center services. Open to majors only. P, 506.
693. Internship
   a. Academic Library (2 to 4) Rpt./1 S P, 502, 503, 505, CR 507 or CR 540.
   b. Special Library (2 to 4) Rpt./1 S P, 502, 503, 505, CR 507 or CR 540.
   c. Public Library (2 to 4) S P, 502, 503, 505, CR 507 or CR 540.
   d. School Library (2 to 4) Rpt./1 P, 580 (elementary only) or 585 (secondary only), 502, 503, 505, CR 581.
   e. Community College Library (2 to 4) Rpt./1 S P, 502, 503, CR 507.
695. Colloquium
   a. Theory of Classification (1 to 3)
   g. Laboratory in Library Communications (1 to 3)
   f. Issues in Library and Information Science (1 to 3) Rpt./4 units

LINGUISTICS

Professors Jane Hill (Anthropology), Acting Head, Richard Demers, Robert Michael Hamish (Philosophy), Nils Hasselmo, Adrienne Lehrer, Susan Steele
Associate Professors Chisato Kitagawa (Oriental Studies), Richard T. Oehrle
Assistant Professors Diana Archangeli, Ann Farmer, Ofelia Zepeda (American Indian Studies)

The Department of Linguistics offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in linguistics. For the doctorate, specializations are available in the following areas: linguistics and philosophy, theoretical syntax, theoretical phonology, Chinese linguistics, Japanese linguistics, Native American linguistics, educational/pedagogical linguistics, socio-cultural linguistics, language acquisition and development, and language processing.

Applicants for admission must forward to the department scores on the aptitude test of the Graduate Record Examination, three letters of recommendation from previous instructors or academic advisers, a sample of work, and a departmental application form.

Degrees

All students, regardless of their intended specialization or degree objective, are expected to complete the following courses: 400, 414, 501, 514, 515, and 544.

MASTER OF ARTS — In addition to the courses listed above, students are expected to take the following: one of 422, 464, and 465, and one year of course work in a non-Indo-European language. No thesis is required.

DOCTOR OF PHILOSOPHY — In addition to the courses listed above, students will take two seminars and additional advanced course work. All students must take 502, 514, and 464. The language requirement varies with the specialization. A dissertation is required.

400. Foundations of Syntactic Theory (3) GC An introduction to fundamental issues in the theory of syntax, including phrase structure, the opacity conditions, government, control, binding, thematic relations, and theory of logical form. Intended to familiarize the student with the essentials of the Extended Standard Theory and related developments.
411a-411b. Modern Japanese Grammar (3-3) GC (Identical with Or.S. 411a-411b)
210 DEPARTMENTS AND COURSES OF INSTRUCTION

414. Foundations of Phonological Theory I (3) GC I Investigation of the principles that underlie current phonological theory, concentrating on the representation of sounds and the regular patterns of sound in natural language. Topics include the standard theory of generative phonology, distinctive feature theory, syllable theory, the core skeleton, rule formulation (linear and non-linear) and rule interactions.

420a-420b. Linguistic Structure of Modern Chinese (3-3) GC (Identical with Or.S. 420a-420b)

422. Linguistic Semantics and Lexicology (3) GC II 1988-89 Study of word and sentence meanings, relationship between the lexicon and the grammar, idioms, metaphor, etymology, and change of meaning. P. one course in linguistics. (Identical with Phil. 422)

423a-423b. Theory of Spanish Syntax (3-3) GC (Identical with Span. 423a-423b)

426. Introduction to Arabic Linguistics (3) GC II (Identical with Or.S. 426)

427. Applied Spanish Linguistics (3) GC I (Identical with Span. 427)

429. Pedagogical Linguistics: Applied Linguistics for Language Teachers (3) GC II (Identical with Or.S. 429)

430. Language Variation (3) GC II Study of geographical and social dialects, stylistic differences, and idiolectal variation and the implications of variation for writing grammars and for understanding language change. P. one course in linguistics.

445a-445b. Structure of a Non-Western Language (3-3) [Rpt./2] GC In-depth linguistic analysis of selected phonological, syntactic, and semantic problems in a non-Western language, concentrating on native languages of the Southwest area. P. 400, 414. (Identical with A.In.S. 445a-445b)

451. Acquisition of Speech and Language (3) GC II (Identical with Sp.H. 451)


465. Pragmatics (3) GC 1987-88 Study of language use, its relationship to language structure and context; topics such as speech acts, presupposition, implication, performatives, conversations. (Identical with Phil. 465)

473. Natural Language Processing (3) GC II Introduction to the processes underlying speech production and comprehension: speech sounds, words, parsing, semantics and pragmatics. (Identical with Phil. 473 and Psyc. 473)

476. Language in Culture (3) GC II (Identical with Anth. 476)

477. Discourse and Text (3) GC II 1987-88 (Identical with Anth. 477)

480. Historical Comparative Linguistics (3) GC I (Identical with Anth. 480)

495. Colloquium
a. Linguistics (1) [Rpt./3] GC I II

500. Linguistics for Nonmajors (3) I II Conceptual foundations, methodology, and current theoretical frameworks. Students will carry out actual linguistic analysis. For students majoring in fields other than linguistics.

501. Foundations of Syntactic Theory II (3) II Continuation of Ling. 400, with emphasis on recent literature.


514. Foundations of Phonological Theory II (3) II Investigation of the evidence and arguments for non-linear representations (autosegmental and metrical) and of the organization of the phonological component of grammar, including evidence for its interaction with morphological structures and rules.

515. Phonological Phonetics (3) II Analysis of the acoustic and articulatory properties of sounds and patterns of sounds that occur in human language. Emphasis on the significance of the properties of sounds for phonological theory, in particular, distinctive feature theory. Role of psycho-acoustic studies as a source of evidence for phonological theory.

540. Language Change and Reconstruction (3) II Introduction to the methods in, theory of, and problems in reconstruction of phonology, syntax, and semantics. Data will be drawn from a variety of the world's language families, but will concentrate on American Indian languages and languages with little or no written record.

544. Syntactic Analysis (3) I An examination of the syntactic diversity presented by natural human languages and an exploration of the issues that such diversity presents for syntactic analysis. Topics include AUX, word order, constituency, and subjects.

583. Sociolinguistics (3) I (Identical with Anth. 583)

600. Current Issues in Linguistic Research (3) [Rpt./1] Current research in linguistics, with emphasis on relationships among syntax, semantics, and phonology.
MANAGEMENT AND POLICY 211

696. Seminar
   a. Syntax and Semantics (3) [Rpt./2] I II
   b. Topics in Phonological Theory (3) [Rpt./2] I II
   c. Diachronic Linguistics (3) [Rpt./2] I II
   d. Current Issues in Syntactic Theory (3) II [Rpt./2]
   f. Linguistic Investigations and Applications (3) I II (Identical with Comm. 696f, which is home)

697. Workshop
   a. Linguistic Theory (1) I Open to majors only.

MANAGEMENT
(See Management and Policy)

MANAGEMENT AND POLICY

Professors James R. Lincoln, Head, Don L. Bowen, Terence Connolly, Edwin B. Flippo, Travis W. Hirschi (Sociology), Theodore H. Koff, James P. Logan, June M. Morrison (Emerita), Raymond A. Mulligan (Emeritus), Thomas R. Navin (Emeritus), Arthur L. Silvers, Shelby Stewman, George W. Summers, Harrison C. White (Sociology)

Associate Professors Michael K. Block, Robert W. Buckingham, Marvin Fortman, Michael R. Gottfredson, Margaret A. Neale, David A. Tansik, Robert E. Tindall, Ronald J. Vogel

Assistant Professors Lawton R. Burns, P. Christopher Earley, Jolene R. Galegher, Gregory B. Northcraft, Richard B. Polley, David L. Torres, W. Gary Wagner, Douglas Wholey

The department offers a program leading to the Master of Science degree in management and policy with concentrations in criminal justice administration, human resource management, organizational strategy, and policy and planning. The department also participates in programs leading to the Master of Business Administration, the Master of Public Administration, and the Doctor of Philosophy degree with a major in business administration. For information concerning these degrees see Requirements for Master's Degrees/Master of Business Administration and Master of Public Administration elsewhere in this catalog.

For admission, the applicant is expected to have completed undergraduate work in managerial accounting, economics, finance, organizational behavior, marketing, production, business law, business policy, statistics, and mathematics through calculus (Math. 119 and 123). A score in the seventieth percentile or better on the Graduate Management Admissions Test is required for admission consideration.

The program for the Master of Science degree in management and policy requires completion of thirty units, including a thesis. A minimum of sixteen units must be taken in courses open only to graduate students. Each graduate study program is individually planned in consultation with an adviser.

General Management and Policy

420. Advanced Business Law (3) GC I II GRD Negotiable instruments, partnerships, corporations, and property rights. P, CR 320 or admission to B.P.A. graduate programs. (Identical with Acct. 420)

426. Wills, Estates, and Trusts (3) GC I Wills, inheritances, estates, and trusts; the administration of estates, including the duties and liabilities of executors and trustees; basic estate and gift tax laws applicable to estate planning.

500. Management Case Analysis and Presentation (3) I II Written analysis of cases and other reports; development of skills in analysis, decision making, and written and oral presentation, with emphasis on the total situation of each case considered. Open only to students admitted to B.P.A. graduate programs.

535. International Management (3) I II S Analysis of management opportunities and challenges; evaluation and formulation of strategies of firms expanding internationally.

537. Finance for New Ventures (3) I (Identical with Fin. 537)

538. Marketing, Negotiation and Decision Tactics (3) II Development of bargaining and decision-making skills through simulated negotiations and role playing. Open only to students in the entrepreneurship program. P, Econ. 500a-500b, Fin. 511, Mktg. 500. (Identical with Mktg. 538)
539. Planning of New Ventures (3) II New venture development, financial projections, resource assessment, and long-range planning. Open only to students in the entrepreneurship program. P, Econ. 500a-500b, Fin. 511, Mktg. 500. (Identical with Fin. 539)

554. Research Methodology (3) I Behavioral research techniques; bias, validity, reliability, and applicable statistical techniques; critiques of research articles and reports. P, 552.

567. Design and Control of Production Systems (3) II (Identical with M.I.S. 567)

568. Environmental Scanning (3) I (Identical with Econ. 568)

571. Business Strategy and Policy Making (3) II Case method approach to problems and policies facing top management in making and effecting a strategic plan. P, 500, 502, Fin. 511, Mktg. 500. To be taken in the final semester of the M.B.A. program. Open only to students admitted to B.P.A. graduate programs. An M.B.A. integrative course.

696. Seminar 
n. Research Design: Statistical Methods (2 to 4) I II

**Criminal Justice Administration**

436. Crime and Public Policy (3) GC I II Role of government in the prevention and control of crime.

457. Law of the Elderly (2) GC II Examines the law as it affects the elderly in such areas as legislation, finances, housing, death, guardianship, access to services and ethics. Focuses upon the recognition and analysis of legal problems and identification of legal resources. (Identical with Gero. 457)

595. Colloquium 
f. Criminal Justice (3) [Rpt./12 units] I II

693. Internship 
b. Criminal Justice (1 to 6) I II

696. Seminar 
g. Criminal Justice Administration (1 to 3) I II

**Health Services Administration**

595. Colloquium 
c. Health Care (3) [Rpt./12 units] I II

650. Analysis of Health Systems (3) I Introduces the student to the scope and nature of public and private health systems in the U.S.; examines roles of government and private enterprise in the development and operation of health institutions. P, 601.

651. Health and Public Policy (3) II Examines public policy issues in health, including recent developments in health policy and planning at the national, state and local levels, and their impact on administrative behavior. P, 650. (Identical with Ping. 651)

653. Comparative Management in Health Administration (3) I Assists students in applying general management principles to particular types of health agencies. Models of organizational behavior are used to develop a paradigm for comparative analysis. P, 650.

655. Efficiency Analysis in Health Administration (3) II Professional-level treatment of economic and related principles as they apply to the health-care industry, and of the impacts of health policy and program alternatives; case study method used. P, Econ. 500a. (Identical with Ping. 655)

693. Internship 
d. Health Services Administration (1 to 6) I II

696. Seminar 
e. Health Services Administration (1 to 3) I II

**Human Services Administration**

595. Colloquium 
d. Aging and Society (3) [Rpt./12 units] I II

652. Management of Long Term Care Facilities and Programs (3) II Problems and principles of management of facilities and community based programs providing health and social services to the chronically impaired. P, 650.

662. Aging and Public Policy (3) I Policy framework for administration of programs, plans, priorities, and legislation related to the needs of the aging in modern society. (Identical with Ping. 662)
693. Internship
f. Long Term Care Administration (1 to 6) I II

Human Resource Management/Organizational Behavior

413. Administrative Leadership (3) GC I Elements of leadership, as applied to selected administrative situations.

430. Personnel Policies (3) GC II An integrative, case-oriented course focusing on problems and policies in the procurement, development, compensation, and motivation of personnel. P. 330 and 6 units in personnel management major.

432. Bargaining and Negotiation in Organizations (3) GC Examination of the state of the art of bargaining and negotiation and the development of bargaining skills in a wide variety of business and interpersonal settings. P. 305.

433. Topics in Performance Appraisal (3) GC Examination of theoretical and practical bases of various performance appraisal systems and techniques. P. 330.

444. Group-Process Methods in Management (3) GC II Application of behavioral science knowledge to group functioning in public agencies with emphasis on observation, analysis, feedback and intervention in small groups; the SYMLOG theory and method of group analysis, along with other perspectives from social psychology and sociology. P. 472. (Identical with Soc. 444)

502. Organization Theory and Behavioral Relations (3) I II The interactions, effects, and interrelationships of managers, employees, and organizational structures and systems. Open only to students admitted to a B.P.A. graduate program.

503. Human Resource Management (3) I Principles, methods, research relevant to management of an organization's human resources, with emphasis on employment psychology, training, development, compensation. P. 305 or 502.

504. Organization Development and Change (3) II Concepts and skills relevant to persons concerned with problem diagnosis and organizational development and change. P. 305 or 502.

505. Trends in Management Theory (3) I Review of management practices from the Industrial Revolution to modern high technology organizations. Focus on contemporary organizational issues and managerial responses to them. P. 305 or 502.

580a-580b. Theory of Management and Organization (3-3) 580a: Analysis of behavior in organizational systems; review of classical, behavioral, and contingency theories of management with a focus on internal systems phenomena. 580b: Organizations in their environments; analysis of organizations in the context of their environmental interfaces. P. 305 or 502. 580a is not prerequisite to 580b.

600. Behavioral Science Theory and Method in Management (3) [Rpt. /1] I Conceptual and theoretical frameworks for the analysis of management problems from a behavioral science perspective. Relevant material drawn from social psychology, sociology, anthropology, and political science.

696. Seminar
I. Organizational Behavior (3) [Rpt./6 units] I II P. 600.
m. Organizational Theory (3) [Rpt./6 units] I II P. 600.

Policy and Planning

485. Zoning Fundamentals (3) GC I Survey of the zoning process; nature, structure, and function of zoning, problems of zoning administration; new concepts of zoning content and administration. (Identical with Ping. 485)

506. Fundamentals of Physical Planning (3) I Basic considerations in site analysis and planning, and transportation and utility systems; subdivision planning and plat review. (Identical with Ping. 506)

507. Social Service Planning (3) I Survey of the variety of planning efforts designed specifically to increase social welfare through the delivery of services using historical, comparative, and evaluative perspectives. (Identical with Ping. 507)

575. Housing and Residential Areas (3) II Physical, social, and economic aspects of housing development and residential areas and their relationship to other land uses and functions. (Identical with Ping. 575)

602. Analytic Methods in Planning and Management (3) II Methods and models for program planning and policy analysis; forecasting, service demand, facility location in capital investment programming, task sequencing, program analysis and evaluation. P. 457 or 552. (Identical with Ping. 602)
609. **Policy Problems in Structure and Change** (3) II Problems presented by structure and change in modern urban society from the standpoint of social systems analysis; evaluation of strategy and effectiveness of public policy and planning. (Identical with Geog. 609, Ping. 609)

612a-612b. **Projects in Policy and Planning** (2-3) Lab. and field projects simulating various aspects of professional practice. Open to majors only. P, 12 units toward M.S. (Identical with Ping. 612a-612b)

693. **Internship**
   g. Policy and Planning (1 to 4) S Open to majors only. (Identical with Ping. 693g)

696. **Seminar**
   h. Land-Use Regulation (3) I II (Identical with Ping. 696h)
   i. Legal Inquiry in Policy and Planning (3) II (Identical with Ping. 696i)
   j. Environmental Planning (3) I II (Identical with Ping. 696j)
   k. Planning Administration (3) I II (Identical with Ping. 696k)

**Public Management**

411. **Public Administration and the Mexican-American** (3) GC I Hispanic-American cultural and historical impact on public administration in the southwestern U.S. from 1775 to the present; patterns of contemporary Spanish-speaking participation in state and local governmental administration of services. (Identical with M.A.S. 411)

514. **Cost-Benefit Analysis** (3) II (Identical with A.Ec. 514)

595. **Colloquium**
   a. Public Management (3) [Rpt./12 units] I II

601. **Public Management** (3) I Fundamentals of management structure and process in public sector: emphasis on professional practice. Open only to students admitted to a B.P.A. graduate program.

605. **Research and Evaluation in Public Administration** (3) I Research and evaluative methodologies which support public sector policies and administration, including the philosophical basis of these methods and a research design exercise. P, 552, 601.

610a-610b. **Fiscal and Budgetary Administration of Public Agencies** (3-3) 610a: Internal fiscal operation and the budgetary cycle of public and nonprofit agencies. P, 601, Acct. 572. 610b: Cost/benefit analysis for public agencies. 610a is not prerequisite to 610b. (Identical with Pol. 610a-610b)

621. **Administrative Patterns in the Federal System** (3) I Legal, political, and social framework of interjurisdictional and interagency relations; trends, emerging issues, and devices for securing coordination and responsibility.

671. **Business, Government and Society** (3) I II Relationships between the institutions of business and government; economic, social and political aspects. P, 305 or 502. (Identical with Law 671)

693. **Internship**
   c. Public Management (1 to 6) I II

696. **Seminar**
   a. Development Administration (1 to 3) I II
   b. Program Planning and Development (1 to 3) I II
   c. Performance Measurement and Accountability (1 to 3) I II

**MANAGEMENT INFORMATION SYSTEMS**

Professors Jay F. Nunamaker, Jr., Head, Seymour Goodman, Benn Konsynski III, James F. LaSalle, Averill M. Law, Roy E. Marsten

Associate Professor Nicholas Aquilano

Assistant Professors Joey George, Barat Kaku, Sudha Ram, Matthew Saltzman, Susan Sanchez, Olivia Sheng, Asso Vakaharia, Doug Vogel, Y. Richard Wang, E. Sue Weber

The department offers a program leading to the Master of Science degree with a major in management information systems. The department also participates in programs leading to the Master of Business Administration, Master of Public Administration, and Doctor of Philosophy (major in business administration) degrees.

Management information systems involves the use of computers in organizations and the integration of computer skills with the functional areas of management, including decision sci-
ence (operations management). Education in management information systems enables students to pursue careers involving the use, definition, analysis, design, implementation, and operation of computer information systems.

To be considered for admission, applicants must have earned a competitive, acceptable score on the Graduate Management Admissions Test and a competitive undergraduate cumulative grade-point average. Applicants must also have completed preparatory work in finite mathematics, statistics, economics, business law, accounting, finance, marketing, organizational behavior, production and business policy.

The program requires the completion of 30 graduate units, including a master's project (696h). Of the 30 hours required for the Master of Science degree with a major in management information systems, at least 16 units must be at the 500 and 600 level.

450. **Soviet Technology and Science** (3) GC I Introduction to the role of technology and science in the Soviet social, political, and economic environment. Selected assessments of Soviet technical and scientific achievements and problems. (Identical with Russ. 450)

461. **Accounting Information Systems** (3) GC I II (Identical with Acct. 461)

473a-473b. **Production and Operations Management** (3-3) GC Productive systems, including service type industries; activities entailed in selecting, designing, operating, controlling, and updating systems. 473a: General coverage, including planning, scheduling and control systems. 473b: Case analyses in a manufacturing environment. P. 373.

474. **Work Simplification** (3) GC I II Work simplification and motion economy; methods of increasing productivity of employees; flow process charts and flow diagrams; appraisal of fatigue. P. 305.

475. **Productivity Improvement** (3) GC II Productivity measurement; monitoring with statistical quality control techniques; improvement through use of small group processes. P. 373.

476. **Management of Service Operations** (3) GC I Application of operations management concepts to service organizations and interaction with other functional areas; case analyses of banks, airlines, health care, motels, food service, others. Field trip. P. 373.

477. **Materials and Logistics Management** (3) GC I Organization, management, and control of material flow processes; logistical strategies and relationships of procurement, handling, warehousing, transportation, and inventory control. P. 373, 473a.

478. **Project Management** (3) GC Definition of programs and projects, organizational forms, developing the work breakdown structure, scheduling techniques (PERT and CPM), control mechanisms such as milestones, cost reports and progress reports. Lectures and case analyses. P. 305, 373.

479. **Sociotechnical Systems** (3) GC I Theory and practice of installing high-commitment work systems to increase productivity and improve the quality of working life.

501. **Management Information Systems** (3) I II Introduction to computers and information systems. Use of personal computer productivity tools: word processors, spreadsheets, and database management systems. Current topics such as expert systems and office automation. Open only to students admitted to BPA graduate programs.

507a-507b. **Information Systems Architecture and Data Communications** (3-3) I II Overview of computer system organization, logic, microarchitecture, macroarchitecture, operating systems, and assembly languages; and hardware and system software concepts will be discussed as they relate to the systems analysis and design process and the development of application software. Provides a broad introduction to data communications with emphasis on the impact of communication technology on information systems. P. CR 531a or consult department before enrolling.

511. **Behavioral and Economic Aspects of Information Systems** (3) I Principles of organizational theory and strategy as they relate to M.I.S. The role of information in organizations, the information center concept and information system strategic planning; data validation and data completeness; comparison of centralized and decentralized systems; computer pricing policies and cost allocation; economies of scale; legal considerations and computer frauds; security considerations; problems of changing computer systems. Open only to students admitted to BPA graduate programs. P. 441 or 501. (Identical with Acct. 511)

521a-521b. **Advanced Systems Modeling and Simulation** (3-3) The nature of simulation, simulation software, including animation model validation, selecting input probability distributions, random variate generation, statistical analysis of output data. Simulation of manufacturing systems, manufacturing issues addressable by simulation, SIMAN simulation language, and statistical issues in manufacturing simulation. Open only to students admitted to BPA graduate programs. P. 501, M.A.P. 552, Math. 119. (Identical with C.Sc. 521a-521b)
531a-531b. File Organization and Data Base Management (3-3) Abstract data types, file organization and memory management; and an introduction to data base management systems. DBMS goals and objectives; organizational implications of data bases; design and implementation of network (CODASYL), hierarchic and relational data bases. Open only to students admitted to BPA graduate programs.

541a-541b. Computer-Aided Information Systems Analysis and Design (3-3) Analysis and logical design of M.I.S.; techniques for stating and analyzing information systems requirements; hardware/software selection and evaluation; system implementation and performance evaluation; strategic information systems and decision support systems. Open only to students admitted to BPA graduate programs. (Identical with C.Sc. 541a-541b)

551a-551b. Business Systems Programming Methods (3-3) Business systems programming environment; basic and advanced COBOL; file organization and access methods; external sort and multi-key files. Computer graphic display hardware and software components; graphic data structures; effective data display and general purpose graphics systems. Open only to students admitted to BPA graduate programs. P, 501.

552. Statistical Decision Making (3) I II Probability and statistical analysis; random variables, sampling distributions, hypothesis testing, Bayesian analysis, time series, statistical investigation. Open only to students admitted to BPA graduate program. P, M.I.S. 500, or Math. 119 and 123.

567. Design and Control of Production Systems (3) I II An introduction to the design of production systems and how decisions about them are influenced by the acquisition and use of accounting data. Aggregate planning and scheduling, inventory control, and forecasting. P, M.A.P. 552. Open only to students admitted to BPA graduate programs. (Identical with M.A.P. 567, Acct. 567)

570. Management and Evaluation of Information Systems (3) I II The methodologies of economics and management information systems applied to the problem of designing accounting and management information systems in the hierarchical structure of a profit-maximizing firm. An MBA integrative course. Open only to students admitted to BPA graduate programs. P, 501, Econ. 500a, Acct. 550 (Identical with Econ. 570 and Acct. 570)

572. Operations Management (3) I Intended for students without a background in production management. Survey of techniques useful in operating manufacturing and service production.


577. Nonlinear Mathematical Programming (3) I II S Introduction to the formulation, solution, and implementation of nonlinear and mathematical programming models; representative applications will be studied and solved on the computer. P, 422.

578. Systems Design for Management (3) I Decision support system concepts, applications and methodologies for developing and evaluating decision support systems; organizational and technical factors of office automation.


582a-582b. Multivariate Analysis in Management (3-3) 582a: Multiple, polynomial, stepwise regression including indicator variables, inference, remedial measures. 582b: Analysis of variance and covariance, principal components, discriminant analysis, canonical correlation. P, 275 or 552. 582a is not prerequisite to 582b.

585. Material Requirements Planning and Control (3) II Material management with emphasis on forecasting and inventory theory within a dependent demand environment.

696. Seminar
   b. Computers in Auditing (3) P, 541a or Acct. 461.
   d. Advances in Optimization Theory (3) P, 422 or S.I.E. 240 or Math 289.
   e. Recent Advances in Management Science (3) P, 422.
   g. Advanced Topics in Data Management (3) P, 531b.
   h. Master's Report Projects (3) S Open to majors only.

796. Seminar
   a. Research Methodology (3) [Rpt./6 units] Open to majors only.

797. Workshop
MARKETING

Professors Joseph W. Newman, Head, Dipankar Chakravarti, Gary M. Munsinger, Lyman E. Ostlund, Robert A. Westbrook, John H. Wieland (Emeritus)
Associate Professors Richard A. Scott, Melanie R. Wallendorf
Assistant Professors Bernard J. Jaworski, Deborah J. MacInnis, Jayashree Mahajan, S. Ram

The department offers a program leading to the Master of Science degree with a major in marketing. The department also participates in programs leading to the Master of Business Administration and the Doctor of Philosophy degrees with a major in business administration. For information concerning these degrees see Requirements for Master's Degrees/Master of Business Administration and the headnotes under Business Administration elsewhere in this catalog.

The Master of Science degree program prepares students for marketing careers which require strong empirical research skills. The program also is an efficient step toward the Ph.D. program with a concentration in marketing for students holding undergraduate degrees.

For admission, the applicant is expected to have completed undergraduate work in managerial accounting, economics, finance, marketing, organizational behavior, production, business policy, statistics, and mathematics through calculus. Some background requirements may be satisfied after admission. A superior score on the Graduate Management Admissions Test and evidence of strong academic performance at the undergraduate level are required for admission consideration.

Credit earned in fulfilling the background requirements named above will not count toward the 39 units of course work required for the M.S. degree. The 39 units include nine units for either a thesis or an internship, one of which is required.


454. Management of Sales Operations (3) GC I II The sales function and its relationship to the total marketing program; sales strategies and objectives; development and administration of sales organizations; control and evaluation of sales operations. P, 361.


458. Retailing Management (3) GC I II Management of the retail store, its environment, personnel, buying, merchandising, pricing, advertising, promotion, selling, expense control and customer service. P, 361; Acct. 200.

470. Marketing and Public Policy (3) GC I Trends in public opinion, legislation and practices of governmental regulatory bodies; implications for marketing decision making; role of marketing research in public policy development. P, 361.

500. Marketing Management (3) II Scope, environment and nature of marketing management; customer and market analysis for product, service, price, promotion and distribution decisions. Open only to students admitted to B.P.A. graduate programs.

530. Management of Marketing Communications (3) I Application of communications theory and research findings in advertising, sales promotion, publicity, personal selling; planning, conduct and administration of programs of information and persuasion. P, 500.

536. Innovation and Economic Growth (3) I Role of entrepreneurship and innovation in economic growth. Development of the new venture idea and assessment of market potential. Open only to students in the entrepreneurship program. P, Econ. 500a-500b, Fin. 511, Mktg. 500. (Identical with Econ. 536)

538. Marketing, Negotiation and Decision Tactics (3) II (Identical with M.A.P. 538)

550. Consumer and Organizational Buyer Behavior (3) I Nature of the purchase decision process for goods and services. Theories, concepts and research methods and findings are examined for use in management and public policy decision making. P, 500.

559. Product Strategy (3) II Formulating and implementing strategy for growth; analyzing and influencing market structure; developing, pricing, testing new entries; managing the portfolio. P, 500.
218 DEPARTMENTS AND COURSES OF INSTRUCTION

560. **International Marketing** (3) II Marketing planning and strategies for foreign environments; cultural, political, economic factors affecting the international marketer, multinational corporation and multinational market groups. P, 500.

566. **Environmental Scanning** (3) I (Identical with Econ. 568)

572. **Research and Marketing Management** (3) I Specification of management information needs, evaluation of research proposals and findings, methods of gathering and analyzing data, administrative aspects of research and decisions. P, 500, M.A.P. 552.

695. **Colloquium**
a. **Research in Marketing** (1) [Rpt./7] I II

696. **Seminar**
a. **Marketing Research Methodology** (3) I II P, 500, M.A.P. 552.
c. **Marketing Theory** (3) I II P, 500.

MATERIALS ENGINEERING

MATERIALS SCIENCE AND ENGINEERING

Professors Donald R. Uhlmann, Head, William G. Davenport, Louis J. Demer, J. Brent Hiskey, Kenneth L. Keating, Thomas M. Morris (Emeritus), Daniel J. Murphy (Emeritus), David R. Poirier, Subhash H. Risbud, Sigmund L. Smith (Emeritus), Richard A. Swalin, Michael C. Weinberg

Associate Professors David C. Lynch, Srini Raghavan

Assistant Professor Dunbar P. Birnie, Pierre A. Deymier, Mark D. Pritzker, Brian J.J. Zelinski

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in materials science and engineering.

The graduate programs in the department are designed to provide advanced study in the fields of materials properties, materials structures, and materials processing. Emphasis is placed on metals, alloys, electronic materials, ceramics, and composites. Courses and research are provided in extraction, thermodynamics, kinetics, transport, microstructural characterization, physical properties, processing and application.

Applicants with undergraduate backgrounds in related disciplines such as chemistry, mathematics, physics, or other engineering fields may be admitted to the Master of Science degree program. Ultimately, that program requires the completion of the same mathematics, chemistry (except analytical chemistry), and physics background (as well as certain materials science and engineering courses) that is required for the undergraduate curriculum in materials science and engineering. A limited number of deficiencies may be satisfied after admission to the Master of Science degree program and, in certain cases, graduate credit may be earned for such courses.

**Degrees**

**MASTER OF SCIENCE** — All students must complete nine units of 500-level course work including 510. In addition, all students must complete nine units of regularly scheduled course work and eight units of thesis. Each student who does not have previous credit for equivalent courses must complete M.S.E. 411, 412, 430a, 430b, and one of 401R, 420, or 450R. However, not more than six units from this required group may be applied toward meeting the requirements for the master's degree. All students must also demonstrate proficiency in the subject matter of M.S.E. 224 and 310.

**DOCTOR OF PHILOSOPHY** — A graduate study program will be designed to ensure that each student acquires a thorough understanding of advanced work in the major field as well as in an appropriate minor area. Proficiency in computer techniques or in some field of applied mathematics is also required. The dissertation, based on original research, is expected to represent a
distinct contribution to materials knowledge. It should establish the fact that the candidate is capable of independent, original, and creative thinking. It is not necessary that the research be entirely on a scientific aspect of materials, but may include economic and design consideration as well as scientific aspects of the problem.

401R. Mineral Processing (3) GC I Unit operations employed for the beneficiation of minerals.

401L. Mineral Processing Laboratory (1) GC I Laboratory experiments dealing with unit operations of mineral processing. P. 401R or CR.

409. Transport Phenomena (3) GC I Principles of momentum, energy and mass transport, as applied to materials processing. P. 240, Math. 254.


412. Physical Chemistry of Materials (3) GC I Physical and chemical topics of interest to material scientists including surface chemistry, electrochemistry and chemical kinetics. P. 310, Math. 223.

420R. Chemistry of Materials Science (4) GC II Fundamentals of chemical processes used in the extraction and separation of materials. Chemical thermodynamics and heterogeneous kinetics are applied to the recovery and preparation of selected metals and nonmetals. P. 224, 240, 409.

420L. Primary Processing Laboratory (1) GC II Lab. experiments involving application of thermodynamic and transport phenomena fundamentals to processes. P. 224, 310, 411 or CR.

421. Process Metallurgy of Iron and Steel (3) GC II Reduction, conversion, and refining of steel and ferrous alloys; thermodynamics, kinetics, optimization, process design economics. P. 420R.

422. Extractive Metallurgy of Nonferrous Metals (3) GC I Process and economic analysis of new and developing nonferrous metal extraction processes. Field trip. P. 420R.

423. Electrochemistry in Materials Science (3) GC I Principles and applications of electrochemistry in materials science with emphasis on charge-transfer reactions at electrode-solution interface; including electrodeposition, electroforming, electroless plating. P. 240.

430a-430b. Materials Science (3-3) GC Principles underlying the interrelationships among the structure, properties and behavior of materials and their engineering applications. P. 240 or CR; Phys. 103b; 104b; C.E. 217 or CR.

430L. Materials Laboratory (1) GC II Laboratory experiments on the physical and electrical properties of metals and semiconductors. P. 430b or CR.

432. Materials Characterization Methods (3) GC II Fundamentals of x-ray diffraction and fluorescence analysis techniques, and electron optical methods employing scanning electron and transmission electron microscopy. 2R, 3L. P. 331R or 430b or CR.

434. Electrical and Optical Properties of Semiconducting Materials (3) GC I Properties of semiconducting materials as related to crystal structure, interatomic bonding and defect structures. P. 331R, 430b, Phys. 230 or Chem. 480b. (Identical with E.C.E. 434 and Opti. 434)

435. Corrosion (3) GC II The science of corrosion reactions and their application to engineering problems. P. 331R; 412 or Chem. 480b or CR. (Identical with Ch.E. 435)

440. Thermodynamics of Condensed Phases (3) GC I Advanced treatment of the principles of thermodynamics with application to electronic and optical materials; emphasis on solutions, defect chemistry and modeling of multicomponent systems. P. 240.

442a-442b. Process Design (2-1) GC Practice in the application of engineering principles to the design of materials processes. 442a: 1R, 2L. 442b: 1R. P. 420, 331R or 430a.

450R. Materials Processing (3) GC I Applications of transport phenomena and materials science to solidification and semiconductor processing. Application of solids behavior to deformation processing. P. 410, 331R or 430a; C.E. 217.

450L. Materials Processing Laboratory (1) GC I Laboratory experiments in solidification and mechanical forming processes. P. CR 450R.

452. Nondestructive Evaluation of Materials (3) GC II Introduction to the nondestructive testing and evaluation of the various classes of engineering materials. Methods considered include leak detection, penetrant, electromagnetic, radiographic, ultrasonic, electrical, electronic, eddy current, acoustic emission, and thermal. 2R, 3L. P. 331R or 430b, or CR.

457. Integrated Circuit Technology Laboratory (3) GC I (Identical with E.C.E. 457)


489. Scanning Electron Microscopy (3) GC I Theoretical and practical aspects of electron-beam micro-
analysis. Lab emphasizes projects and independent research using scanning electron microscopy and
energy dispersive X-ray analysis. 2R, 3L. Field trips. Consult department before enrolling.

510. Thermodynamic Characterization of Materials (3) II 1988-89 Advanced treatment of ther-
modynamics in the processing of materials through characterization of surfaces, interfaces, plasmas,
complex equilibria, silicate chemistry, and super-critical fluids. P. 440.

513. Characterization of Multicomponent Systems (3) III 1987-88 Analysis and representation of multi-
component chemical systems using both quantitative and visual techniques. Examples taken from all
fields of materials science. P. 440.

525. Kinetics of Solid-State and Electrochemical Reactions (3) I Kinetics of nucleation and growth,
phase transformations, electrodeposition, electrodissolution, electrocatalysis, photoelectrochemistry.
P. 340, 412.

532. Solid-Fluid Reactions (3) I (Identical with Ch.E. 532)

533. Imperfections in Solids (3) I Nature and behavior of imperfections in metals, ceramic, and semicon-
ductor crystals and polycrystalline aggregates, and their effects on various properties. P. 430a.

534. Electronic, Magnetic and Optical Materials (3) II Advanced topics in defects, processing and
properties of electronic, magnetic and optical materials. P. 434. (Identical with E.C.E. 534)

535. Advanced Microstructural Characterization (3) I Theory and applications of modern techniques for
characterizing chemical and microstructural features of solids; transmission and scanning electron
microscopy, microprobe, and Auger analysis. 2R, 3L. P. 430a, 432. Consult department before enroll-
ing.

550. Statistical Thermodynamics in Materials Science (3) I Introduction to classical and quantum statis-
tical thermodynamics as applied to materials science. Electronic properties of metals and semicon-
ductors; phase transformations. P. 510 or other classical thermodynamics course.

551. Atomistic Computational Techniques in Materials Science (3) II Monte Carlo and molecular dy-
namics techniques; application to calculation of materials properties (structural, thermodynamic, trans-
port properties). P. 550 or other statistical mechanics or statistical thermodynamics course.

560. Materials Science of Polymers (4) II Microstructure, crystallization, rhealogy, relaxation and mechan-

characterization. Specimen preparation; instrumental techniques; interpretation of micrographs and
diffraction patterns. 2R, 3L. Open only to graduate students in engineering and science. Consult
department before enrolling.

595. Colloquium
a. Materials Colloquium (1) [Rpt./5] II

MATHEMATICS

(See also Applied Mathematics)

Professors Alan C. Newell, Head, Gregory R. Baker, Clark T. Benson, John Brillhart, M. S.
Cheema, James R. Clay, Jim M. Cushing, J. L. Denny, William G. Faris, Paul C. Fife,
Hermann Flaschka, W. M. Greenlee, Helmut Groemer, Larry C. Grove, George L.
Lamb (Optical Sciences), David O. Lomen, John S. Lomont, David Lovelock, Henry B.
Mann (Emeritus), Warren May, David McLaughlin, Donald E. Myers, Charles M.
Newman, Richard S. Pierce, Edwin J. Purcell (Emeritus), Moshe Shaked, Arthur
Steinbrenner (Emeritus), Elias Toubassi, Deonisie Trifan (Emeritus)

Associate Professors William E. Conway, Carl L. DeVito, David Gay, Oma Hamara, Christopher
Jones, Theodore W. Laetsch, Daniel Madden, John N. Palmer, Tudor Ratiu, Frederick
W. Stevenson, Richard B. Thompson, William Y. Vélez, Bruce Wood, A. Larry Wright,
Lai-Sang Young

Assistant Professors Moysey Brio, Nicholas M. Ercolani, Paul Fan, Luc Haine, William G.
McCallum, Robert Valentini, Maciej P. Wojtkowski, Yong-Quan Yin

The department offers programs leading to the Master of Arts, Master of Science, and
Doctor of Philosophy degrees with a major in mathematics. Concentrations are available in pure,
applied, computer mathematics or in probability and statistics. As there are no sharp boundaries
between these concentrations, students are encouraged to pursue a broad range of mathematical topics. Programs are planned in consultation with the departmental faculty. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in mathematics. For information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

To be admitted, applicants must have completed an undergraduate major in mathematics with at least fifteen units of upper-division or higher level work including one semester each of advanced analysis at the level of Math. 425 and modern algebra at the level of 415. Applicants are asked to submit scores on the Graduate Record Examination.

Students in master's degree programs are required to pass the Computer Programming examination of the Department of Mathematics as a part of the graduate program.

Degrees

MASTER OF ARTS — This program is for students who wish to combine mathematics with some other discipline. The program must include two year-long courses at the 400 level or one year-long course at the 500 level in mathematics and between nine and twelve units of approved work outside the department. No thesis is required.

MASTER OF SCIENCE — This program is for students who wish to earn all of their graduate credits in mathematics. Thirty graduate units in mathematics are needed: at least 18 units must be at the 500 level, some in required basic courses covered on the oral exam. A thesis is not required, but up to six units may be earned if the student elects to submit one.

DOCTOR OF PHILOSOPHY — Prior to taking the preliminary examination, the student must complete all major and minor course work. The major course work consists of at least 36 graduate mathematics units. Of these, no more than 12 can be at the 400 level, and several will be in basic courses covered on the preliminary exam. Commonly the minor, consisting of at least 12 units of approved courses, is within the department in a concentration different from the major. A minor consisting of approved courses outside the department is also encouraged. There is a language requirement which can be satisfied in any two of the following: French, German, Russian, or computer programming. The principal component of the program is the completion of a dissertation involving original creative research. Ph.D. candidates with other majors who wish to minor in mathematics are required to take four graduate level courses in mathematics and a written examination which covers the content of those courses.

The faculty of the Department of Mathematics carries on research (and research seminars) in a variety of purely mathematical and interdisciplinary fields. In algebra and number theory, research includes finite groups, rings, associative algebras, algebraic number theory, arithmetic, algebraic geometry, and primality testing. Research in analysis is being carried out on unbounded operators, quantum fields, relativity, and nonlinear problems of ecology, chemistry, and fluid dynamics. In geometry, there is work on convex sets, incidence geometry, and fibre bundles; in probability and statistics, projects involve geostatistics, reliability theory, and non-parametric inference. A detailed summary of faculty research appears yearly and is available on request.

402. **Mathematical Logic** (3) GC II 1987-88 Sentential calculus, predicate calculus; consistency, independence, completeness, and the decision problem. Designed to be of interest to majors in math. or phil. P, 124 or 125a or Phil. 325. (Identical with C.Sc. 402)

403. **Foundations of Mathematics** (3) GC II 1988-89 Topics in set theory such as functions, relations, direct products, transfinite induction and recursion, cardinal and ordinal arithmetic; related topics such as axiomatic systems, the development of the real number system, recursive functions. P, 215. (Identical with Phil. 403)

404. **History of Mathematics** (3) GC I The development of mathematics from ancient times through the 17th century, with emphasis on problem solving. The study of selected topics from each field is extended to the 20th century. Not applicable to M.A., M.S., or Ph. D. degrees for math majors. P, 125b.

405. **Mathematics in the Secondary School** (3) GC II Not applicable to M.A., M.S., or Ph.D. degrees for math majors. (Identical with T.T.E. 405)

410.** Matrix Analysis** (3) GC I II General introductory course in the theory of matrices. Advanced-degree credit not available to math majors. P, 123 or 125b.
222 DEPARTMENTS AND COURSES OF INSTRUCTION

413.* Linear Algebra (3) GC II Vector spaces, linear transformations and matrices, eigenvalues, bilinear forms, orthogonal and unitary transformations. Not applicable to M.A., M.S., or Ph.D. degrees for math majors. P. 215.

415. Introduction to Abstract Algebra (3) GC I Introduction to groups, rings, and fields. P. 215.

416. Applications of Algebra (3) GC II Various applications of abstract algebra, e.g. to coding theory, combinatorial designs, crystallography, etc. P. 415.

420. Calculus of Variations (3) GC I 1987-88 Euler equations and basic necessary conditions for extrema, sufficiency conditions, introduction to optimal control, direct methods. P. 223, and 254 or 255.

421. Fourier Series and Orthogonal Functions (3) GC I Linear spaces, orthogonal functions, Fourier series, Legendre polynomials and Bessel functions. P. 223 and 254 or 255.

422a-422b.* Advanced Analysis for Engineers (3-3) GC Laplace transforms, Fourier series, partial differential equations, vector analysis, integral theorems, matrices, complex variables. Not applicable to M.A., M.S., or Ph.D. degrees for math majors. Credit allowed for 422a or 322, but not for both. P. 223 and 254 or 255. 422a is not prerequisite to 422b. Both 422a and 422b are offered each semester.

423. Intermediate Analysis (3) GC I and II Elementary manipulations with sets and functions, properties of real numbers, topology of the real line, continuity, differentiation, sequences and series of real valued functions of a real variable, with emphasis on proving theorems. Not applicable to graduate programs in math. P. 223.

424.** Elements of Complex Variables (3) GC I and II Complex numbers and functions, conformal mapping, calculus of residues. P. 223.

**Credit will be allowed for only one of 424 or 422b. 422a-422b will not be considered a two-semester course at the 400 level in the Master of Arts degree program.

425. Advanced Calculus I (3) GC I Continuity and Riemann integration in one or two dimensions, improper integrals, uniform convergence, differentiation in n-space, inverse function theorem. P. 423.

426. Advanced Calculus II (3) GC II Curves, surfaces, change of variables in multiple integrals; extremal properties; theorems of Green, Gauss, and Stokes; exact differentials. P. 425.

430. Second Course in Geometry (3) GC II 1988-89 Topics to be selected from projective geometry, algebraic geometry, metric geometry or combinatorial topology. P. 215.

434. Introduction to Topology (3) GC II Properties of metric and topological spaces and their maps; topics selected from geometric and algebraic topology, including the fundamental group. P. 423.

436. Metric Differential Geometry (3) GC II Differential geometry of surfaces; nonintrinsic geometry: fundamental forms, Gaussian and mean curvatures; intrinsic geometry: Theorem Egremium, geodesics, Gauss-Bonnet theorem. P. 223, and 254 or 255.

443. Theory of Graphs and Networks (3) GC II Undirected and directed graphs, connectivity, circuits, trees, partitions, planarity, coloring problems, matrix methods, applications in diverse disciplines. P. 215 or 223 or 243. (Identical with C.Sc. 443)


447. Combinatorial Mathematics (3) GC II 1988-89 Enumeration and construction of arrangements or designs, theorems on existence and nonexistence of designs, applications to design of experiments and error correcting codes. P. 215 or 243.


455.* Elementary Partial Differential Equations (3) GC II Theory of characteristics for first order partial differential equations; second order elliptic, parabolic, and hyperbolic equations. P. 223, and 254 or 255.


*Credit allowed for only one from each of the following groups: 117e or 117f; 117i or 118; 119, 145 or 243; 123, 124 or 125a; 160 or 263; 254 or 255; 455 or 456; 410 or 413.

461. Elements of Statistics (3) GC I and II Probability spaces, random variables, standard distributions, point and interval estimation, parametric and nonparametric hypothesis testing. Math majors will not receive grad. credit. P. 123 or 125b. (Identical with Stat. 461)


473. **Theory of Computation** (3) GC I II (Identical with C.Sc. 473)

475a-475b. **Mathematical Principles of Numerical Analysis** (3-3) GC 475a: Analysis of errors in numerical computations, solution of linear algebraic systems of equations, matrix inversion, eigenvalues, roots of nonlinear equations, interpolation and approximation. P, 215; 223; 254 or 255; and a knowledge of a scientific computer programming language. 475b: Numerical integration, solution of systems of ordinary differential equations, initial value and boundary value problems. (Identical with C.Sc. 475a-475b)

478. **Computational Methods of Algebra** (3). GC II Applications of machine computation to various aspects of algebra, such as matrix algorithms, character tables and conjugacy classes for finite groups, coset enumeration, integral matrices, crystallographic groups. P, 410 or 413 and a knowledge of a scientific computer programming language. (Identical with C.Sc. 478)

479. **Game Theory and Mathematical Programming** (3) GC II 1987-88 Linear inequalities, games of strategy, minimax theorem, optimal strategies, duality theorems, simplex method. P, 410 or 413 or 415. (Identical with C.Sc. 479)

484. **Operational Mathematics** (3) GC I Basic concepts of systems analysis, Fourier and Laplace transforms, difference equations, stability criteria. P, 421 and 424, or 422b.

515a-515b. **Modern Algebra** (3-3) Structure of groups, rings, modules, algebras; Galois theory. P, 415.

516a-516b. **Algebraic Number Theory** (3-3) 1987-88 Dedekind domains, complete fields, class groups and class numbers, Dirichlet unit theorem, algebraic function fields. P, 515b.

517a-517b. **Group Theory** (3-3) 1988-89 Selections from such topics as finite groups, noncommutative groups, abelian groups, characters and representations. P, 515b.

518. **Topics in Algebra** (3) [Rpt.] I II Advanced topics in groups, rings, fields, algebras; content varies.

519. **Topics in Number Theory and Combinatorics** (3) [Rpt.] I II Advanced topics in algebraic number theory, analytic number theory, class fields, combinatorics; content varies.


529. **Topics in Modern Analysis** (3) [Rpt.] I II Advanced topics in measure and integration, complex analysis in one and several complex variables, probability, functional analysis, operator theory; content varies.

534a-534b. **Topology** (3-3) 1988-89 Point set topology, homotopy, homology. Applications, such as manifolds, duality, fixed point theorems, solutions to differential equations. P, 415 and 434.

536a-536b. **Calculus of Tensors and Exterior Differential Forms** (3-3) 1988-89 Affine tensors, tensor analysis on differentiable manifolds, calculus of exterior differential forms; calculus of variations, Riemannian geometry, applications to field theories. P, 423.


538. **Topics in Geometry and Topology** (3) [Rpt.] I II Advanced topics in point set and algebraic topology, algebraic geometry, differential geometry; content varies.

539. **Algebraic Coding Theory** (3) II 1987-88 Construction and properties of error correcting codes; encoding and decoding procedures and information rate for various codes. P, 415. (Identical with E.C.E. 539)

555a-555b. **Partial Differential Equations** (3-3) 1987-88 Theory and examples of linear equations; characteristics, well-posed problems, regularity, variational properties, asymptotics. Topics in nonlinear equations, such as shock waves, diffusion waves, and estimates in Sobolev spaces. P, 522a, 522b, or 585a.
256a-556b. Dynamical Systems and Chaos (3-3) 1987-88 Qualitative theory of dynamical systems, phase space analysis, bifurcation, period doubling, universal scaling, onset of chaos. Applications drawn from atmospheric physics, biology, ecology, fluid mechanics and optics. P, 422a-422b or 454.


567a-567b. Statistical Inference (3-3) 1987-88 A decision theoretic approach to estimation and hypothesis testing, sequential methods, large sample methods. P, 423, and 464 or 564a. (Identical with Stat. 567a-567b)


579. Topics in Applied Mathematics (3) [Rpt.] Advanced topics in asymptotics, numerical analysis, approximation theory, mathematical theory of mechanics, dynamical systems, differential equations and inequalities, mathematical theory of statistics; content varies.


585a-585b. Principles and Methods of Applied Mathematics (3-3) Boundary value problems; Green's functions, distributions, Fourier transforms, the classical partial differential equations (Laplace, heat, wave) of mathematical physics. Linear operators, spectral theory, integral equations, Fredholm theory. P, 424 or 422b or CR 525a.

586. Case Studies in Applied Mathematics (1 to 3) [Rpt./6 units] In-depth treatment of several contemporary problems or problem areas from a variety of fields, but all involving mathematical modeling and analysis; content varies.


588. Topics in Mathematical Physics (3) [Rpt.] Advanced topics in field theories, mathematical theory of quantum mechanics, mathematical theory of statistical mechanics; content varies.

589. Nonlinear Wave Motion (3) II 1988-89 Nonlinear partial differential equations describing wave phenomena in water, gases, plasmas, lasers; shocks, modulated wave trains, parametric resonance, solitons and exactly solvable equations. P, 422b or 456 or 455.

596. Seminar a. Topics in Mathematics (3) [Rpt./1] S

636. Information Theory and Coding (3) II 1988-89 (Identical with E.C.E. 636)

MECHANICAL ENGINEERING
(See Aerospace and Mechanical Engineering)

MEDICAL TECHNOLOGY
(See Health-Related Professions)

MEDICINE

Interdepartmental

495. Colloquium a. Introduction to the Neurosciences I (2) GC P, Consult department before enrolling. (Identical with Anat. 495a and Psio. 495a)
b. Introduction to the Neurosciences II (2) GC P, 495a or consult department before enrolling. (Identical with Neur. 495b, Psio. 495b and Psyi. 495b)
Many interdepartmental seminars are numbered at both the 500 and the 800 levels. See 896 below for a complete listing.

**801. Preparation for Clinical Medicine (1-12)**
No grade is given until the full 12 units are completed.

**802. Human Behavior and Development (6)**

**830. Supplementary Registration (1-9)**

**896. Seminar**

- a. Introduction to Forensic Pathology (1-3)
- b. Physical and Biological Basis of Nuclear Medicine (2)
- c. Introduction to Computers in Medicine (2)
- d. Pathogenesis and Approach to Immunological Diseases (2)
- f.* Clinical Epidemiology (2)
- j. Medical Jurisprudence (2)
- h. Human Sexuality (2)
- n. Research Methods for Clinical and Epidemiological Studies (2)
- s. Fluid and Electrolyte Balance and Renal Immunology (2)
- t. Pathophysiology of Respiratory Diseases (2)

*Available as both 596 and 896.

**Anatomy**

See Anatomy elsewhere in this catalog.

**Anesthesiology**

Professors Burnell R. Brown, Jr., **Head**, I. Glenn Sipes
Associate Professors Randall C. Cork, A. Jay Gandolfi, Stuart R. Hameroff, Charles W. Otto
Assistant Professors Joseph A. Gallo, Jr., Lawrence B. Weiss

**800. Research (1-6)** [Rpt./1]

**810. Clerkship**

- a. Anesthesiology (1-18)

**815. Subspecialty**

- p. Critical Care Medicine (1-18) (Identical with I.Med. 815p)

**891. Preceptorship**

- a. Anesthesiology and Subspecialties (1-18)
- c. General Anesthesiology (4-6)

**Biochemistry**

See Biochemistry elsewhere in this catalog.

**Family and Community Medicine**

Professors Anthony F. Vuturo, **Head**, Herbert K. Abrams, John T. Boyer, George D. Comerci, Eric P. Gall, Melvin H. Goodwin, Gail G. Harrison, Thomas E. Moon, Andrew W. Nichols, James R. Shaw, William A. Stini, Hugh C. Thompson
Associate Professors Peter J. Attarian, Daniel O. Levinson, Ronald E. Pust, Arthur B. Sanders
Assistant Professors Dorian H. Cordes, Mark Dambro, Harolyn Gilles, Evan W. Kligman, Craig L. McClure, J. Kristin Olson-Garewal, Barry D. Weiss

**500. Research (2-16)** [Rpt./2]. P. basic science courses.

**588. Clinical Anthropology (3)** I II (Identical with Nurs. 588)

**596. Seminar**

- g. Occupational Disease (1) II Open to medical or industrial hygiene students only. Consult department before enrolling.
- h. Prevention and Control of Disease (1) I Consult department before enrolling.
n. Community and International Nutrition (1-3) II (Identical with N.F.S. 596n)
   Note: Some seminars are numbered at both the 500 and the 800 levels. See 896 below for a
   complete listing.

800. Research (2-16) [Rpt./2].

803. Clinical Clerkship (6-9)

811. Subinternship
   a. Family Medicine (3-6) I II S

815. Subspecialty
   b. The Dying Patient (1-6) [Rpt./1]
   d. Community Health Problems (6-12)
   g. Community-based Care of the Older Patient (3-12) [Rpt./12 units] Field trips. Consult department
      before enrolling.

891. Preceptorship
   a. Primary Care (6-12)
   b. Family Medicine (3-12) P, 4th year medical student. Consult department before enrolling.
   c. Epidemiology at CDC (3) I II P, open to majors in medicine, public health, and nursing. Consult
      department before enrolling.
   d. Rural Care (4-12)
   f. Clinical Preceptorship in International Health (6-12)

896. Seminar
   a. International Health (3) S Open to health majors only.
   b.* Epidemiologic Methods (3) I II
   c. Approaches to Managing Behavior Problems of Children and Adolescents (2)
   d. Wholistic Health (2) II Open to majors only. Consult department before enrolling.
   f. The Doctor-Patient Relationship (2)
   k.* Nutrition in Disease (1-2) [Rpt./1] P, Bioc. 801, Psio. 601/801.
   l.* Alternative Strategies for Coping with Illness: A Cross-Culture View (2) II
   m.* Practice of Community-Oriented Medicine in Rural Areas (2) II
   n.* Community and International Nutrition (1-3) II
   q.* Occupational and Environmental Health (3) S Consult department before enrolling.
   r.* Basic Principles of Epidemiology (3) [Rpt./1]
   t.* Tropical Disease Problems (2)
   u.* Current Issues in Health Services (2)

   *Available as both 596 and 896.

Internal Medicine

Professors Rubin Bressler, Head, David S. Alberts, F. Paul Alepa, Robert Barbee, John T. Boyer,
Benjamin Burrows, William F. Denny, Brian G.M. Durie, David L. Earnest, Gordon A.
Ewy, Eric P. Gall, Evan Hersh, David G. Johnson, Murray A. Katz, Louis J. Kettel,
Ronald Knudson, Michael Lebowitz, Frank I. Marcus, Frank Meyskens, Eugene
Morkin, Charles A. Nugent, David A. Ogden, William Roeske, Sydney E. Salmon, Jay
W. Smith, Lawrence Stern

Associate Professors Thomas Boyden, Sammy C. Campbell, Kenneth A. Conrad, Paul Fenster,
John N. Galgiani, Steven Goldman, Bernard R. Greenberg, Ronald Hansen, Murray
Korc, Stanley M. Lee, Norman Levine, Thomas Miller, Eskild A. Petersen, Jacob L.
Pinnas, Richard E. Sampliner

Assistant Professors Frederick Ahmann, Neil Ampel, John W. Bloom, Marlene Bluestein,
Samuel Bulman, Anthony Camilli, Keith Comess, William Dalton, Irene Edwards,
Timothy C. Fagan, Harinder Garewal, Richard Gay, Michael Habib, Shoei-Kuen
Huang, Karl Kern, Laryenth Lancaster, Joy Logan, Charles Otto, John Palmer, Stuart
E. Quan, Paul Rutala, Arthur B. Sanders, David Schneiderman, John Stivelman,
Gayle A. Traver, David B. VanWyck, David Yocum

596. Seminar
   a. Pathophysiology and Immunology of the Clinical Manifestations of Coccidioidomycosis (2) II

800. Research (3-30) [Rpt./30 units]

803. Clinical Clerkship (12)

810. Clerkship
   b. Ambulatory Diagnosis and Therapeutics (6)
c. Geriatrics and General Medicine Extended Care (4) [Rpt./1] P, 803.
d. Ambulatory Geriatrics (3-12) P, 803.

811. Subinternship
a. Internal Medicine (6-12)
c. Coronary Care Unit (4)
i. Medical Intensive Care Unit (4)
m. General Medicine (4)

815. Subspecialty
a. Clinical Cardiology Elective (4-8)
b. Clinical Dermatology (3)
c. Endocrinology (4-12)
d. Clinical Gastroenterology (4-8)
e. Hematology-Oncology (6)
g. Infectious Diseases (4-12)
h. Pulmonary Diseases (4)
i. Pulmonary Laboratory and Consultation Service (3-6)
j. Nephrology, Renal Diseases (3-6)
l. Clinical Allergy (1-6) (Identical with Ped. 815i)
m. Medical Subspecialties (3-6) [Rpt.]
n. Physical Medicine and Rehabilitation (4-6) [Rpt./1] CDT P, 3rd or 4th year medical school.
p. Critical Care Medicine (3-6) (Identical with Anes. 815p)
q. Cardiology Consultation (4)
r. Neurological and Neuromuscular Disorders (3-6) P, 803. (Identical with Neur. 815r)
s. Rheumatology (4-6) P, 803.
t. Nephrology (4)

891. Preceptorship
a. General Medicine and/or Subspecialties (3-12) [Rpt./2]
b. Ambulatory Internal Medicine: Clinical Problems (6)

896. Seminar
a. Pathophysiology and Immunology of the Clinical Manifestations of Coccidioidomycosis (2) II

Microbiology and Immunology

See Microbiology and Immunology elsewhere in this catalog.

Neurology

Professors Alan B. Rubens, Head, Peggy Ferry (Pediatrics), William A. Sibley
Associate Professor Colin R. Bamford
Assistant Professors William Feinberg, Enrique L. Labadie, Kalarickal Oommen, Steven Rapcsak

800. Research (1-12) [Rpt./1] (See College of Medicine Electives Manual)
803. Clinical Clerkship (3-6)

810. Clerkship
a. Neurology (3-6)

815. Subspecialty
n. Spinal Cord Injury (3) (Identical with Surg. 815n which is home)

891. Preceptorship
a. Neurology (1-18) [Rpt./2]

Obstetrics — Gynecology

Professors C. D. Christian, Head, Jack Pearson, Lewis Shenker
Associate Professors Diane S. Fordney, William C. Scott, Louis Weinstein
Assistant Professors Herbert E. Pollock, Kathryn Reed

800. Research (1-18) [Rpt./1]
803. Clinical Clerkship (6-9)
810. Clerkship
a. Preparation for Practice (1-18)

815. Subspecialty
a. Clinical Infertility (4-6)

891. Preceptorship
a. Obstetrics and Gynecology (1-18)
b. Gynecology-Endocrinology (6)

Ophthalmology

Professor Barton L. Hodes, Head
Assistant Professors Richard W. Allinson, William D. Mathers, Sam E. Sato, Kenneth B. Simons

800. Research (6-18) (See College of Medicine Electives Manual)

810. Clerkship

815. Subspecialty
a. Ophthalmology (3-6)

891. Preceptorship

Pathology

Associate Professors James M. Byers, III, Anna R. Graham, Thomas M. Grogan, Mary Jane Hicks, Douglas H. McKelvie
Assistant Professors Ronald Schifman, Catherine M. Spier, Karen K. Steinbronnn

489. Introduction to Forensic Science: Pathology, Anthropology, Toxicology and Law (2) GC I II
Opportunity for the criminal investigator and attorney with a background in forensic pathology to better understand the results of trauma, toxic substances and environmental catastrophes. Taught off campus only.

801. General and Systemic Pathology (10) I II

810. Clerkship
a. Anatomic Pathology (1-18)
b. Clinical Pathology (1-18)
c. Special Topics (1-18) [Rpt.]. P, 801.

891. Preceptorship
a. Pathology (1-18) [Rpt./2]

Pediatrics

Associate Professors Sergio A. Bustamante, Ronald C. Hansen, Gail G. Harrison, John J. Hutter, Stanley M. Lee, Michael J. Schumacher, Elsa Sell, John N. Udall, Jr.

800. Research (1-18) (See College of Medicine Electives Manual)

803. Clinical Clerkship (6-9)

810. Clerkship
a. Externship in Inpatient Pediatrics (6) P, 803
c. Pediatric Care in a Cross-Cultural Setting (6)
d. Inpatient Pediatrics (6)
811. Subinternship
   a. Ambulatory Pediatrics (1-18)
   b. Behavioral and Developmental Pediatrics (1-18)

815. Subspecialty
   a. Advanced Neonatology (6)
   b. Pediatric Infectious Diseases (6)
   d. Cardiac Ultrasound Echo and Doppler (4-6)
   e. Pediatric Cardiology (6)
   f. Pediatric Neurology (6)
   g. Pediatric Hematology/Oncology (6)
   h. Poison Center (4-6) P, 803
   k. Pediatric Clinical Pharmacology (1-12) [Rpt./1]
   l. Clinical Allergy (1-6) (Identical with I.Med. 8151, which is home)
   p. Pediatric Endocrinology (1-18)

891. Preceptorship
   a. Pediatrics (1-18)
   b. Preparation for Practice (1-18)

Pharmacology

See Pharmacology elsewhere in this catalog. Toxicology courses are listed under Pharmacology and Toxicology.

Physiology

See Physiology elsewhere in this catalog.

Psychiatry

Professors Alan I. Levenson, Head, Allan Beigel, Larry E. Beutler, Henry W. Brosin, John C. Racy, Alayne Yates
Associate Professors Diane S. Fordney (Obstetrics and Gynecology), Henry I. Yamamura (Pharmacology)
Assistant Professors Peter J. Attarian (Family and Community Medicine), Shirley N. Fahey, Milton Frank

495. Colloquium
   b. Introduction to Neurosciences II (2) GC (Identical with Med. 495b, which is home)

800. Research (1-12) (See College of Medicine Electives Manual)

803. Clinical Clerkship (6-9) [Rpt./1]

810. Clerkship
   a. Clinical and Community Psychiatry (1-18)
   b. Child Psychiatry (1-18)

815. Subspecialty

891. Preceptorship

Radiation Oncology

Professors J. Robert Cassady, Head, Silvio Aristizabal, Thomas C. Cetas, Eugene W. Gerner
Associate Professors George T. Bowden, Jeffrey Trent, Robert B. Roemer
Assistant Professors Anne E. Cress, Kullervo Hynynen, Wendell Lutz, David Shimm, Del V. Steinbronn, Jeffrey Williamson
230 DEPARTMENTS AND COURSES OF INSTRUCTION

501. Radiation Biology (3) II Basic principles of radiation effects in mammalian cell and tissue systems, with emphasis on biochemical aspects, such as DNA damage and DNA repair, and cellular responses, such as cell kinetics defects and radiation repair and recovery; radiation and chemical (especially radiomimetic drugs) carcinogenesis. P, introductory biology and chemistry.

551. Environmental Carcinogenesis (3) II 1988-89 See 851 for description. (Identical with Micr. 551)

555. Cancer Biology (3) II 1988-89 (Identical with Micr. 555)

596. Seminar
h. Control of Proliferation in Animal Cells (1-2) I P, consult department before enrolling. (Identical with Micr. 596h)

815. Subspecialty
a. Introduction to Radiation Oncology (1-6)

851. Environmental Carcinogenesis (3) II 1988-89 Phenomenological and mechanistic aspects of cancer etiology as induced by physical and chemical agents in our environment, with special emphasis on possible molecular and cellular mechanisms involved in cancer etiology. P, consult department before enrolling. (Identical with Micr. 851)

896. Seminar
h. Control of Proliferation in Animal Cells (1-2) I (Identical with Micr. 896h)

Radiology

Professors M. Paul Capp, Head, Harrison H. Barrett (Optical Sciences), Theodore Bowen (Physics), Kai Haber, Bruce J. Hillman, Theron W. Ovitt, Dennis D. Patton (Optical Sciences), Michael J. Pitt (Surgery), Arthur J. Present (Emeritus), Joachim F. Seeger, William L. Wolfe, Jr. (Optical Sciences), James M. Woolfenden

Associate Professors John C. Bjelland, William J. Dallas, Robert E. Henry, Tim B. Hunter, Gerald D. Pond, Bryan Westerman

Assistant Professors Raymond Carmody, Peter Yang

800. Research (1-6) [Rpt./1]

815. Subspecialty
a. Diagnostic Radiology (6)
b. Nuclear Medicine (1-6)

891. Preceptorship

Surgery


Associate Professors Kenneth V. Iserson, James M. Malone, Edward C. Percy, Arthur B. Sanders, Thomas H. Stanisic, John B. Sullivan

Assistant Professors James B. Benjamin, Michael K. Brawer, Gary L. Dunnington, J. David Gibeault, Robert P. Iacono, Timothy B. Icenogle, Stanely P. L. Leong, Mark M. Levinson, Jerry D. Mohr

800. Research (1-12) P, 803. (See College of Medicine Electives Manual)

803. Clinical Clerkship (6-9)

807. Specialty Clerkship (3) P, basic science courses.

810. Clerkship
a. General Surgery (6)

811. Subinternship
a. Emergency Medicine (4-6) P, 815t.

815. Subspecialty
a. Urinary Stone Disease (6)
b. Cardiothoracic Surgery (6)
c. Neurosurgery (6)
d. Surgical and Medical Problems in Fluid and Electrolyte Balance (1-3) [Rpt./1]
e. Urology (6)
f. Orthopedics (3)
g. Cardiovascular Physiology and Research (1-12)
h. Lymphvascular System in Health and Disease (6-12)
i. Otorhinolaryngology (3)
j. Sports Medicine (Section of Orthopedic Surgery) (1-6) [Rpt./1]
k. Orthopedic Bioengineering (3-6) P, Nine weeks of surgery clerkship, 803 and or 807.
l. Trauma (3-6)
m. Spinal Cord Injury (3) Open to majors only. P, senior standing. (Identical with Neur. 815n)

891. Preceptorship
a. Surgery and Subspecialties (1-18) [Rpt./3]

896. Seminar
a. Medical Ignorance (2) [Rpt./1] II

MEDIEVAL STUDIES

Committee on Medieval Studies (Graduate)

Professors Sigmund Eisner (English), Chairperson, John Boe (Music)
Associate Professors Jonathan Beck (French and Italian), Alan E. Bernstein (History), Richard C. Jensen (Classics), Stephen H. West (Oriental Studies)

The Graduate Committee on Medieval Studies does not offer any major at this time. Programs constituting appropriate minors are available for doctoral students with majors in other disciplines. Students interested in the medieval studies minor must secure the approval of the committee in advance.

The program of study for the Doctor of Philosophy minor in medieval studies requires: a minimum of fifteen hours in graduate course work (note that no course may serve a student for both the major and minor); a reading knowledge of either classical or medieval Latin; knowledge of an old form of one language (for language majors, this requirement is in addition to the major field); a course in medieval history or culture such as art (for non-art majors), music (for non-music majors), or philosophy (for non-philosophy majors).

Related Courses

Refer to the appropriate department for course descriptions and unit values. Courses which are applicable to the program are Art 412a-412b, 413a, 512, 596c; Clas. 401; Engl. 426, 427, 527a-527b, 596a; Ger. 400a, 511a-511b, 520a-520b, 696a; Hist. 405a-405b, 406, 407, 408; Mus. 500q, 530; Fren. 402, 422, 520a-520b, 696a, 696c; Ital. 422, 435a-435b, 696a; Port. 422, 696a; Span. 400a, 422, 540, 541, 620, 696a, 696b; Russ. 583, 685.

METALLURGICAL ENGINEERING
(See Materials Science and Engineering)

METEOROLOGY
(See Atmospheric Sciences)

MICROBIOLOGY
(See Microbiology and Immunology)
MICROBIOLOGY AND IMMUNOLOGY

Professors John Spizizen, *Head*, Harris Bernstein, Charles P. Gerba (Nutrition and Food Science), Junetsu Ito, Wayburn S. Jeter (Pharmacology and Toxicology), Rein Kilkson (Physics), Peter P. Ludovici (*Emeritus*), William Meinke, George B. Olson, Kenneth Ryan (Pathology), Irving Yell (*Emeritus*)

Associate Professors Robert J. Janssen, Norval A. Sinclair, Associate Head, James T. Sinski, J. Glenn Songer (Veterinary Science), Murray Korc (Internal Medicine)

Assistant Professors Richard Friedman, Ruthann Kibler

The graduate program in microbiology and immunology has three major areas of emphasis: (1) molecular, genetic and physiological microbiology, (2) environmental, pathogenic and industrial microbiology, and (3) immunology. The research systems used include viruses, viroids, bacteria, bacterial plasmids, fungi, protozoan, parasites, cell and tissue culture, and animal models standardly used in immunological studies.

Master of Science and Doctor of Philosophy degrees with a major in microbiology are offered by a program whose faculty include members from a variety of different departments. The Microbiology Specialist degree is also offered.

Applicants are required to submit scores on the verbal, quantitative and analytical sections of the Graduate Record Examination. Scores in an advanced section are recommended. At least two letters of recommendation are required for both the M.S. and Ph.D. programs.

403R. Biology of Animal Parasites (3) GC I (Identical with V.Sc. 403R)
410a-410b. Advanced Cell Biology (3-3) GC (Identical with M.C.B. 410a-410b)
417. General Microbiology (2) GC II Instrumentation and technology in microbial physiology. P. 317.
419R. General Immunology (3) GC I Basic concepts of the immune system. Presentation of the roles of antigen, immunoglobulins, complement, lymphokines and types of immune cells play in humoral and cell-mediated immunity. P, 317, Chem. 241b, 243b. (Identical with V.Sc. 419R)
419L. General Immunology Laboratory (2) GC I Laboratory techniques in immunology. P, 419R or CR. (Identical with V.Sc. 419L)
420L. Pathogenic Bacteriology Laboratory (2) GC II Isolation and identification of pathogenic bacteria; techniques in pathogenic bacteriology. P, 420R or CR. (Identical with V.Sc. 420L)
423R. General Pathology (3) GC II (Identical with V.Sc. 423R)
423L. General Pathology Laboratory (1) GC II (Identical with V.Sc. 423L)
427R. General Mycology (3) GC I General mycology, with emphasis on the microfungi. P, 110.
427L. General Mycology Laboratory (2) GC I General mycology lab., with emphasis on the microfungi. P, 427R or CR.
428R. Advanced Microbial Genetics (3) GC II (Identical with M.C.B. 428R)
428L. Advanced Microbial Genetics Laboratory (2) GC I (Identical with M.C.B. 428L)
430. Introduction to Biophysics (2) GC I (Identical with Phys. 430)
435. Soil Microbiology (3) GC I (Identical with S.W. 435)
450. Medical Mycology (4) GC II The isolation and identification of fungi of medical importance. 2R, 6L. P, 110. (Identical with V.Sc. 450)
451. Diagnosis and Control of Plant Diseases (3) GC I (Identical with Pl.P. 451)
470. Food Microbiology and Sanitation (3) GC II (Identical with N.F.S. 470)
471. Food Microbiology and Sanitation Laboratory (2) GC II 1988-89 (Identical with N.F.S. 471)
473. Recombinant DNA Techniques (3) GC II (Identical with M.C.B. 473)
501. Medical Microbiology (6) I The biological characteristics of microorganisms of importance in human health and disease; the reaction of the host to infectious agents and the mechanisms of host defense; diagnosis and management of infectious disease. Lectures, discussions, and lab. experiments. P, Chem. 241b, Bioc. 501.


530. Biophysical Theory (2) (Identical with Phys. 530)


551. Environmental Carcinogenesis (3) II 1987-88 (Identical with R.Onc. 551)

555. Cancer Biology (3) II 1988-89 Fundamental biological aspects of neoplastic growth at the organ, cellular, and molecular levels; emphasis on the etiology, behavior, and therapy of neoplasms. (Identical with Anat. 555, I.Med. 555, and R.Onc. 555)


570. Molecular Genetics (3) I 1987-88 Molecular genetics and biology of the bacterial viruses; molecular mechanisms of gene regulation, DNA replication, DNA repair, mutation and genetic recombination; current research in bacterial genetics (lysogeny, transduction, conjugation, use of transposons and gene fusions in genetic analysis and transformation); introduction to gene cloning and its uses in analysis of gene structure and regulation. (Identical with Gene. 570)


577. Advanced Microbial Physiology (2) I 1987-88 Studies of metabolic pathways of selected microorganisms with an emphasis on industrial applications. P, 517.


582. Immunotoxicology (2) (Identical with Tox. 582)

596. Seminar
   a. Current Problems in Molecular Biophysics (1) I II (Identical with Phys. 596a, which is home)
   b. Control of Proliferation in Animal Cells (1 to 2) I (Identical with R.Onc. 596h, which is home)

630. Immunology of Infectious Disease (4) II 1988-89 Methods for investigating changes in humoral and CMI during the disease process. Laboratory and library work for the preparation of a grant using NIH or NSF format. 12L. P, 419, 560 or 561, Bioc. 460. Consult department before enrolling. (Identical with V.Sc. 630)

672. Food Safety (2) I 1987-88 (Identical with N.F.S. 672)


695. Colloquium
   a. Readings in Microbiology (1) [Rpt.] I II
   b. Immunopathology (1) I II
   c. Molecular Genetics of Microorganisms (1) I II
   d. Molecular and Cellular Immunology (1) I II
   f. Tumor Virology (1) I II
   g. Host-Parasite Interactions (1) I II

696. Seminar
   a. Research Seminar (1) [Rpt.] I II

801. Medical Microbiology (6)

851. Environmental Carcinogenesis (3) II 1988-89 (Identical with R.Onc. 851)

891. Preceptorship
   a. Microbiology and Immunology (3-12) [Rpt./12 units]

896. Seminar
   h. Control of Proliferation in Animal Cells (1-2) I (Identical with R.Onc. 896h, which is home.)
MINERAL ECONOMICS
(See Mining and Geological Engineering)

MINING AND GEOLOGICAL ENGINEERING

Professors Ian W. Farmer, DeVerle P. Harris, Y. C. Kim, Richard Newcomb, William C. Peters (Emeritus), Michael Rieber
Associate Professors Charles E. Glass, Head, Jaak J. K. Daemen, Ben K. Sternberg
Assistant Professors Satya Harpalani, Pinnaduwa Kulatilake

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in mining engineering, geological engineering, and mineral economics. Advanced work in mining engineering is directed toward research and professional development in several fields including mine planning, geomechanics, operations research, robotics, mine health and safety, and the development of new extractive techniques. Advanced work in geological engineering is directed toward the fields of geophysical engineering, ground stabilization, earthquake engineering, urban planning, remote sensing, and conservation. Mineral economics is a field of applied economics encompassing the interface of minerals engineering and earth science with the business of mineral production and the setting of public policy.

Admission to graduate work normally requires the completion of an undergraduate major in these fields whereas mineral economics students frequently hold bachelor's degrees in the mineral engineering fields, earth sciences, or in economics. Students with undergraduate majors in other engineering fields or in the physical sciences, however, are encouraged to apply because training in such fields provides an excellent background for approaching some areas of graduate study in this department. The department requires that scores on the Graduate Record Examination be submitted by all applicants for mining engineering and geological engineering.

Students working toward the Master of Science degree in either mining engineering or geological engineering will be required to complete a thesis and must pass a final examination covering both the thesis and course work. At least fifteen units of course work must be completed in the major field. A thesis is not required for the master's degree in mineral economics but is recommended as a desirable element of graduate education and as excellent preparation for studies leading to the Doctor of Philosophy degree. Programs leading to the Doctor of Philosophy degree require completion of at least six units of graduate-level course work in computer science, computer programming, or mathematics. Any questions regarding the qualification of a particular course in satisfying this requirement should be submitted to the department's graduate committee for clarification. Foreign-language competency for doctoral candidates in the Department of Mining and Geological Engineering is not required. Due to the increasingly international nature of engineering and the mineral fields, however, the department recommends that doctoral candidates give serious consideration to developing communication skills in a foreign language.

There are specific course requirements for both the master's and the doctor's degrees in all three majors. These requirements along with other policies and procedures are contained in "Guide to Graduate Study," which is available on request from the Department of Mining and Geological Engineering.

Geological Engineering


407. Photogeology (3) GC II Use of aerial photographs in geologic mapping. 1R, 6L. P, Geos. 221. (Identical with Geos. 407) Glass

415. Rock Excavation (3) GC I (Identical with Mn.E. 415)

420. Geophysical Exploration: Potential Field Methods (4) GC I (Identical with Geos. 420)

422. Geophysical Engineering (4) GC I Principles of gravity, magnetic, electrical, electromagnetic, and reflection and refraction seismic methods; acquisition and interpretation of data to define geologic structures for engineering projects and to evaluate resources. 3R, 3L. P, Phys. 103a-103b or 110 and 116; Math. 223. Sternberg


425. Geotechnical Investigations (3) GC II Investigation and analysis of geologic factors in the design and construction of engineering projects. 1R, 6L. Farmer

427. Geomechanics (4) GC I (Identical with Mn.E. 427)

460. Health Hazards in the Mine Environment (2) GC II 1987-88 (Identical with Mn.E. 460)

461. Accident Prevention in the Mine Environment (2) GC II 1988-89 (Identical with Mn.E. 461)

470. Computer Methods in Geological Engineering (3) GC I Use of computers to solve problems in geological engineering, including computer contouring, map filtering and enhancement, and multivariate analysis of geologic data. P, introductory courses in computer programming, math, and earth science. Sternberg

507. Applied Multispectral Imagery (3) GC II Application to mineral exploration, engineering geology, groundwater location, and pollution monitoring. P, 407. (Identical with Geos. 507) Glass

522. Well Logging Interpretation (3) GC II Basic well logging theory. Fundamentals of quantitative formation evaluation. Detailed investigation of aspects of well logging applicable to student's research interests. P, consult department before enrolling. (Identical with Geos. 522)

527. Fundamentals of Geomechanics (4) GC II (Identical with Mn.E. 527)

550. Earthquake Engineering (3) GC I 1987-88 Applied course in earthquake causes and effects, integrating the fields of seismology, engineering, and seismic geology. P, Math. 254. Glass

560. Electrical Exploration Methods (3) GC I Electrical properties of minerals and rocks, resistivity and resistivity exploration, induced polarization and complex resistivity, magnetotelluric methods, and electromagnetic prospecting methods. P, 420 or 422. Consult department before enrolling. (Identical with Geos. 560) Sternberg

649. Probabilistic Methods in Geotechnical Engineering (3) GC II 1987-88 (Identical with C.E. 649)

660a-660b. Estimation of Mineral Resources by Quantitative Methods (3-3) 1987-88 (Identical with Mn.Ec. 660a-660b)

696. Seminar a. Research Seminar (1-3) [Rpt.] I II

Mineral Economics

418. Mine Investment Analysis (3) GC II (Identical with Mn.E. 418)


550. Economics of the Metal Industries (3) GC II Reserves, resources, and major deposits, production technologies, market structure, industrial organization, consumption trends, foreign trade, and geopolitics of selected industries. P, A.Ec. 504.


584. Economics of Coal, Nuclear, and Alternative Energy Sources (3) GC I Reserves and resources, economics of production, utilization and conversion, externalities, market structure, policy issues for alternative energy sources such as oil shale, tar sands, coal gasification, and solar. P, A.Ec. 504.

586. Economics of Petroleum and Natural Gas (3) GC I Reserves and resources of petroleum and natural gas, production technology, market structure, industrial organization, pricing, competitive behavior, consumption trends, and policy issues. P, A.Ec. 504.
Concepts of, measures of, and models for economic development, foreign investment in mineral resources development, problems and conflicts of investor and host countries; case studies. P, Econ. 361.

600. Readings in Mineral Economics (3) II Selected readings in the economics of mineral resource exploration and exploitation, environmental protection, national mineral policy, world mineral development, and international trade. P, Econ. 361.

650a-650b. Advanced Principles of Mineral Economics (3-3) Risk analysis; optimum production, depletion and exhaustion; productivity and technical change; imperfect competition in mineral markets; resource distribution, trade and mineral policy. P, Econ. 501a or A.Ec. 504.


Mining Engineering

401. Analysis of Mine Operations (3) GC I Use of operations research principles and techniques to analyze various problems in mine operations. P, 402. Harpalani

402. Probability and Statistical Concepts in Geologic Media (4) GC II (Identical with G.En. 402)

415. Rock Excavation (3) GC I Methods of excavation of rock in surface and underground mines and construction, ranging from the empiricism of conventional blasting practice to the application of the fundamental mechanics of rock fracture. Field trips. 2R, 3L. P, C.E. 217. (Identical with G.En. 415)

418. Mine Investment Analysis (3) GC II Economic factors, including taxation, mineral depletion allowance, and finance in the mining industry; includes fundamentals of engineering economics, capital budgeting, and risk analysis. P, 430. (Identical with Mn.Ec. 418)

435. Mine Design (3) GC II Computer-aided design of a modern mine; feasibility study, pit limit design, mining sequence development and short-term mine planning. 2R, 3L. P or CR, 430, 440. Kim

427. Geomechanics (4) GC I Mechanical behavior of rock and rock masses; response to load changes: deformations, failure, discontinuity slip; in situ stress state; rock testing; geomechanical classifications; engineering applications: slopes, pillars, tunnels, dam foundations; reinforcement design. 3R, 3L. P, C.E. 217, Geos. 221. (Identical with G.En. 427) Daemen

430. Mine Examination and Valuation (3) GC I Principles and procedures in mineral property valuation, geostatistical ore reserve estimation, engineering, economy, investment analysis; use of a microcomputer. P, 402, 220. Kim


500. **Economics of Mineral Resource Development and Production** (4) I (Identical with Mn.Ec. 500)

501. **Analysis of Mining Decisions** (3) I Use of geostatistics, system simulation languages and computers to analyze various mining decisions related to reserve estimation and mine planning. P, 402, 430, 401. *Kim*

527. **Fundamentals of Geomechanics** (4) II Mechanical behavior of geological materials: stress and strain analysis; friction; elasticity, strength and failure; discontinuity slip. Laboratory testing and applications to selected mining or geological problems. 3R, 3L, P, 427 or C.E. 340, Geos. 221. (Identical with G.En. 527) *Daemen*

622. **Advanced Kriging Techniques** (3) II Theory and application of advanced kriging techniques to mining and earth science related problems; universals, lognormal, indicator, co and probability kriging. P, 402, 430, 501 or Math. 579. *Kim*

627. **Fracture and Flowage of Rock** (3) I 1988-89 Rock failure: effects of size, stress-gradients, fluid pressure, temperature; ductile, brittle and time-dependent (dynamic, static, creep) behavior; fracture mechanics. 2R, 3L, P, 527. *Daemen*


696. **Seminar**
   a. **Research Seminar** (1-3) [Rpt.] I II

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**MOLECULAR AND CELLULAR BIOLOGY**

Professors H. Vasken Aposhian, Wayne R. Ferris, Mac E. Hadley, Richard B. Hallick (Biochemistry), John Hildebrand (Arizona Research Laboratory), Konrad Keck, Henry Koffler, Neil H. Mendelson, Frank L. Meyskens (Internal Medicine), David W. Mount, James W. O'Leary (Environmental Research Laboratory), Peter E. Pickens, Diane H. Russell (Pharmacology), Nobuyoshi Shimizu

Associate Professors Thomas J. Lindell, Acting Head, Hans J. Bohnert (Biochemistry), Don P. Bourque (Biochemistry), Wah Chiu (Biochemistry), William J. Grimes (Biochemistry), Jennifer D. Hall, Martinez J. Hewlett, John W. Little (Biochemistry), Kaoru Matsuda

Assistant Professors Danny L. Brower, Gail Burd, James F. Deatherage (Biochemistry), Carol L. Dieckmann (Biochemistry), Martha Hawes, Karen Oishi, Elizabeth Vierling (Biochemistry)

The University Department of Molecular and Cellular Biology is a research-oriented department in which students may receive advanced training in all aspects of research which employ cellular, molecular, biochemical, and genetic approaches. The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in molecular and cellular biology.

Applicants for admission should be prepared in chemistry, physics, and mathematics and must submit scores on the aptitude test of the Graduate Record Examination. Applicants must communicate directly with the department regarding other admission requirements. The deadline for completion of all application files for admission to the programs beginning with the fall semester is April 1 (March 15 for applicants desiring financial assistance).

Students are expected to specialize in areas of interest to the faculty. These include viral oncology, regulation of gene expression, neurobiology of simple systems, cellular ultrastructure and function, structure and function of nucleic acids, developmental biology of higher plants, plant molecular biology, molecular genetics, invertebrate developmental biology, environmental plant physiology, and gene transfer systems for mammalian cells. A listing of the faculty of the department and their research interests can be obtained from the department on request. A thesis is required for the master's degree.

404. **Contemporary Biology and Human Affairs** (3) GC II Advances in biomedical research will be reviewed and their ethical, social and legal implications discussed. P, one course in bioc. or biology; botany not acceptable.

410a-410b. **Advanced Cell Biology** (3-3) GC Regulation at the cellular and molecular levels; gene expression; nature, function, and integration of organelles and ultrastructural components of the cell. P, 181, Chem. 241b or 480a. (Identical with Micr. 410a-410b)
412. Radioisotopes in Biology (3) GC I Advanced techniques in the application of radioactive tracers to problems of molecular biology; kinetics of labeling, fractionation procedures; detection systems and processing of data. P, Chem. 103b, 104b, Phys. 102a-102b.

413. Advanced Cell Biology Laboratory (2) GC I Modern lab. techniques for genetic and molecular analyses of mammalian cells in culture. 6L; P, CR 415.

415. Somatic Cell Genetics (2) GC I Modern concepts of eucaryotic cell genetics and molecular mechanisms of cell growth control. P, Chem. 241a-241b, 243a-243b. (Identical with Gene. 415)


428R. Advanced Microbial Genetics (3) GC II Modern concepts of microbial genetics: basic genetic theory, the molecular architecture, biosynthesis and genetic regulation of bacterial cell structure, control of growth and cell division. P, 181, Micr. 328, Ecol. 320 or 321. (Identical with Ecol. 428R, Gene. 428R, and Micr. 428R)

428L. Advanced Microbial Genetics Laboratory (2) GC I Individual research projects within the framework of microbial genetics, with emphasis on the genetic system of Bacillus subtilis. (Identical with Ecol. 428L and Micr. 428L)


457. Experiments in Developmental Biology (4) GC II Experimental analysis of the principles of development. 2R, 6L; P, 456, Chem. 241b. (Identical with Anat. 457)

460. Plant Physiology (4) GC I Introduction to water relations, photosynthesis, respiration, growth and development of higher plants. 3R, 3L; P, Chem. 241a, 243a. (Identical with Ecol. 460)

461. Introduction to Neurobiology (3) GC I Physiology and anatomy of invertebrate and vertebrate nervous systems. P, 8 units of biology.


463a-463b. Human Physiology Laboratory (1-1) GC (Identical with Ecol. 463a-463b)

464a-464b. Human Physiology (3-3) GC (Identical with Ecol. 464a-464b)

465. Neuroethology (2) GC II Selected topics in current neuroethological research on vertebrate and invertebrate nervous systems. P, 461, or consult department before enrolling.

467R. Endocrinology (3) GC II (Identical with Anat. 467R)

467L. Endocrinology Laboratory (1) GC II (Identical with Anat. 467L)

469. Developmental Neurobiology (2) GC II Development of the nervous systems of invertebrates and vertebrates from embryonic stages to the adult. P, 8 units of biology.

473. Recombinant DNA Techniques (3) GC II Relevant techniques for the isolation, purification and cloning of genes in E. Coli hosts. Cloned DNA will be characterized by restriction mapping and hybridization techniques. 1R, 6L; Consult department before enrolling. P, 410a, Bioc. 462a. (Identical with Bioc. 473, Gene. 473, and Micr. 473)

514. Supramolecular Structure (2) II 1988-89 Application of diffraction techniques in the study of structure and function of biological macromolecules.

550. Topics in Pigment Cell Biology (2) I (Identical with Anat. 550)


558. Advanced Subjects in Endocrinology (2) [Rpt.] I (Identical with Anat. 558)


563. Plant-Water Relations (3) II Analytic approach to the study of water movement into and through plants; development of internal water deficits and their significance to physiological processes. P, 460. (Identical with Ws.M. 563)


568. Nucleic Acids (3) II (Identical with Bioc. 568)

570. Molecular Biology of the Cell Membrane (3) I 1988-89 (Identical with Bioc. 570)

595. Colloquium
a. Topics in Molecular Biology (1) [Rpt./1] II Open to majors only.
b. Topics in Electron Microscopy (2) [Rpt./2] II 1987-88 P, Math. 125b, Phys. 102b or 103b. (Identical with Bioc. 595b)
MOLECULAR AND MEDICAL MICROBIOLOGY
(See Microbiology and Immunology)

MOLECULAR BIOLOGY
(See Molecular and Cellular Biology)

MUSIC


Associate Professors Koste A. Belcheff, Gary D. Cook, Elizabeth Thompson Ervin, Thomas Ervin, John R. Fitch, Jeffrey Haskell, Grayson Hirst, Keith M. Johnson, Carrol McLaughlin, Rodney M. Mercado, Thomas Patterson, Jeffrey Showell, Daniel Sullivan, Charles West

Assistant Professors Angela Cofer, William Dietz, Paula Fan, Timothy Kolosick

The school offers a program leading to the Master of Music degree with majors in composition, music education, musicology, music theory, and performance. The school also offers a program leading to the Doctor of Musical Arts degree with majors in composition, conducting, music education, and performance. With the doctoral performance major, concentrations are available in bassoon, cello, clarinet, flute, guitar, horn, harp, oboe, organ, percussion, piano, saxophone, string bass, trombone, trumpet, viola, violin, and voice. The school also offers a program leading to the Doctor of Philosophy degree with a major in music theory. All candidates for admission to the Ph.D. program with a major in music theory will show evidence of satisfactory competencies in their fields of concentration. There are two minors, one in music with a minimum of nine units and one in a field outside of music, also with a minimum of nine units. German and French are the required languages for this degree. In the event a candidate works in a field of specialization that warrants it, another language, such as Greek, Latin, or Italian, can be substituted for French with the permission of the School of Music Graduate Committee. If the research specialization lies within a computer-assisted field, expertise in that technology can be substituted for French. For further information concerning these degrees see Requirements for Master's Degrees/Master of Music and Requirements for Doctor's Degrees/Doctor of Musical Arts and Doctor of Philosophy elsewhere in this catalog.

Applicants are required to audition by personal interview or by submitting a tape recording. Beginning graduate students must take placement tests in music theory and in music history/literature. Doctoral students are not admitted to a particular curriculum until they have passed a qualifying examination administered each semester by the School of Music. Admission is limited to applicants who exhibit superior musical aptitude and training and who show continued growth in their chosen fields of music.

Music Theory, Composition, and Technology

422. **Jazz Arranging** (2) GC II Class instruction and practice in writing arrangements for small jazz combos, rock groups, stage bands, and pop-vocal combinations; detailed study of jazz instrumental practices and problems. Open to majors only or consult department before enrolling. P, 200r, 201j, 220b.

423. **Band Arranging** (2) GC II 1987-88 CDT Detailed study of band instrumentation; major works transcribed for concert band. P, 421.
240 DEPARTMENTS AND COURSES OF INSTRUCTION

441a-441b. Introduction to Electronic Music (3-3) GC [Rpt./1] Survey of the historical, theoretical and technical aspects of electronic music as applied to the composition of music in the contemporary idiom, including actual lab. applications.

521. Introduction to Graduate Music Theory (3) II Introduction to graduate analysis with emphasis on the survey of analytical systems as applied to a number of stylistic periods. Both cognitive and aural procedures will be investigated. Open to majors only.

620a-620b. History of Speculative Theory (3-3) 1987-88 Survey of speculative theory in music, classical Greeks to present.

621a-621b. Analysis of Music of the 18th and 19th Centuries (3-3) Intensive analysis of works written in the larger forms. 621a: 18th century. 621b: 19th century. Open to majors only. 621a is not prerequisite to 621b.

622. Theory Pedagogy (3) I 1988-89 Study of the philosophies, procedures, techniques, and materials used in teaching theory at the college level.


696. Seminar c. Music Theory (1 to 6) [Rpt./9 units] I II

Music History and Literature

430a-430b. Art Song Repertory (2-2) GC 1988-89 Class performance of representative selections from the standard repertory of German, Italian, French, Russian and English language art songs; problems of accompaniment, interpretation, style and ensemble. Registration restricted to singers and pianists. Open to majors only.

431a-431b. History of the Opera (3-3) GC 1987-88 Detailed study of the course of opera from its inception by the Florentine Camerata through Berg, Menotti, Stravinsky, Ginastera, Penderecki, Britten and others. Open to majors only.

432. Music in World Cultures (3) GC II CDT Overview of nonwestern musics in selected world cultures.

433a-433b. Piano Literature (3-3) GC Historical and stylistic study of keyboard literature, instruments and performance practices. 433a: Baroque through the early Romantic periods. 433b: Mid-Romantic through the Contemporary periods. P. 285-P. 433a is not prerequisite to 433b.

434. History and Literature of Guitar (3) GC II 1987-88 In-depth study of the evolution of the guitar, lute, and vihuela, including repertoire, style periods, and composers. Open to majors only.

520. Aesthetics of Music (3) I Exploration of the problems of musical meanings, including a panoramic examination of what philosophers, philosophic musicians and artists, and others of critical intelligence have contributed to comprehensive theory.

530. Music in the Renaissance (3) II 1987-88 Vocal and instrumental genres from Dufay through Palestrina. Open to majors only.

531. Music in the Baroque (3) I 1987-88 CDT The age of the basso-continuo; instrumental and vocal genres from Monteverdi through J. S. Bach. Open to majors only.

532. Music in the Classical Period (3) I 1988-89 CDT The Viennese classical tradition from its origins to Beethoven. Open to majors only.

533. Music of the Twentieth Century (3) II 1988-89 CDT Contemporary idiom in music; study of genres, styles, and techniques from post-Romanticism to the present. Open to majors only.


537. Survey of Early Music (3) I S Intensive survey of music history from Gregorian chant to the late Baroque. Open to majors only.

600. Introduction to Graduate Study in Music (3) II Bibliographical materials; research resources, techniques, and problems directed toward grad. study in music. Required of all doctoral candidates in music. (Identical with u.s.snu)

630. The Music of Bach (3) II 1988-89

631. The Music of Mozart (3) II 1987-88

635. Choral Literature and Techniques (3) [Rpt./5] I II A research-oriented study of choral literature from all stylistic periods and genre from the Renaissance to the present, together with appropriate conducting techniques. 2R, 3L. Open to majors only. P. graduate standing in choral conducting or choral music education. No more than 12 units of this course may be applied to a graduate degree program.
653. **The Music Cultures of Asia and Oceania** (3) I 1988-89 Study of the musical styles and practices of Oceania and selected cultures in Asia, with emphasis on materials, instruments and ideas appropriate for classroom use.

696. **Seminar**
   b. Musicology (1 to 6) [Rpt./9 units] I II

**Music Education**

450. **Teaching Music in the Elementary School** (3) GC I CDT Role of the music specialist in the elementary school; materials, activities, and observation of demonstration teaching as they relate to a comprehensive music curriculum and qualitative musical experiences for children in grades K-6.

451. **Production and Techniques for Special Ensembles and Musicals** (3) GC I CDT Objectives, materials and activities for swing choirs, musicals and small ensembles in the secondary schools. Lecture and laboratory experience.

550. **Advanced Studies in General Music Teaching** (3) I S Development of musical concepts through creative experiences; survey of research into music learning in children; alternative systems: Dalcroze, Orff, Kodaly, MCCP. P, 361 or 451.

570. **Advanced Conducting** (3) [Rpt.] II Styles of choral, band, and orchestral literature, as they pertain to the problems of the conductor; references to the styles of all periods, with emphasis on the contemporary and modern.

645a-645b. **Techniques for the Vocal and Instrumental Coach** (3-3) Techniques needed by accompanists to coach singers and chamber music ensembles. P, CR 685p or 785p.

650. **Foundations and Principles of Music Education** (3) I History and philosophy of music education in the public schools, with emphasis on the basic concepts needed for effective teaching in the field of music, curriculum development and evaluation of the music program.

651. **Curriculum Development in Music** (3) II 1988-89 Principles and techniques of curriculum construction applied to the field of music.

652. **Management Techniques in Music** (3) II 1987-88 The management of music at all levels of education, industry, and performance.

672. **Teaching Music in Higher Education** (3) II Contemporary practices in planning, organizing, and evaluating learning experiences in music for college and university students. Open to music majors only.

696. **Seminar**
   a. **Music Education** (1 to 6) [Rpt./9 units] I II

**Music Performance**

410a-410b. **Pedagogy** (2-2) GC Study of methods and repertory suitable for studio teaching. Open to music majors in their major performance area only.

**Ensembles**

All courses listed below are offered both first and second semesters and may be repeated. Prerequisite for all ensembles is an audition or permission of the School of Music.

500. **Large Conducted Ensembles** (1)
   a. Summer Band
   b. Marching Band
   c. Concert Band
   d. Symphonic Band
   e. Wind Ensemble
   h. Summer Chorus
   i. Symphonic Choir
   j. University Singers
   k. University-Community Chorus
   l. Chamber Choir
   m. Choraliers
   o. Symphony Orchestra
   p. Chamber Orchestra
   q. Collegium Musicum
   r. Jazz Ensemble
501. *Coached Ensembles* (1) Offering chamber music experience; designed to develop musical indepen-
dence.
   a. Accompanying
   b. Brass Ensemble
   c. Percussion Ensemble
d. Guitar Ensemble
e. Jazz Combo
f. Saxophone Ensemble
g. String Ensemble
h. Woodwind Ensemble

502. *Small Conducted Ensembles* (1)
a. Brass Choir
b. Contemporary Ensemble
c. Clarinet Choir
d. Musical Theatre
e. Pep Band
f. Flute Choir
g. Recital Choir

605. *Opera Theatre* (1 to 4) Training in all aspects of operatic production, including major singing roles,
minor roles, opera chorus, opera scenes and chamber operas; technical training in set construction,
makeup, costumes and lighting. 605 may also include operatic staging techniques. P for 405, 2 units of 205; P for 605, 4 units of 405 or permission of the School of Music.

*Composition Studies: Individual and Group Instruction*

640. *Advanced Composition* (2 to 6) I II [Rpt.] Individual projects in composition. Open to theory and
composition majors only.

*Performance Studies: Individual and Group Instruction*

All of the courses listed below are offered both first and second semester.

**PIANO**

580-P (1 to 2); 685-P, 785-P (1 to 4)

**PIANO ACCOMPANYING**

685-W (1 to 4)

**VOICE**

580-V (1 to 2); 685-V, 785-V (1 to 4)

**VOCAL COACHING**

685-J (1)

**ORGAN**

580-O (1 to 2); 685-O, 785-O (1 to 4)

**CONDUCTING**

685-Q, 785-Q (1 to 4)

**STRING INSTRUMENTS**

Violin
580-K (1 to 2); 685-K, 785-K (1 to 4)

Cello
580-M (1 to 2); 685-M, 785-M (1 to 4)

Viola
580-L (1 to 2); 685-L, 785-L (1 to 4)

String Bass
580-N (1 to 2); 685-N, 785-N (1 to 4)

Harp
580-H (1 to 2); 685-H, 785-H (1 to 4)

Guitar
580-G (1 to 2); 685-G (1 to 4); 785-G (1 to 4)
Clarinet
580-C (1 to 2); 685-C, 785-C (1 to 4)

Flute
580-F (1 to 2); 685-F, 785-F (1 to 4)

Oboe
580-A (1 to 2); 685-A, 785-A (1 to 4)

Trombone
580-R (1 to 2); 685-R, 785-R (1 to 4)

Horn
580-D (1 to 2); 685-D, 785-D (1 to 4)

Bassoon
580-B (1 to 2); 685-B, 785-B (1 to 4)

Saxophone
580-S (1 to 2); 685-S, 785-S (1 to 4)

Trumpet
580-T (1 to 2); 685-T, 785-T (1 to 4)

Baritone
580-E (1 to 2); 685-E (1 to 4)

Tuba
580-Y (1 to 2); 685-Y (1 to 4)

Percussion
580-Z (1 to 2), 685-Z, 785-Z (1 to 4)

MUSIC EDUCATION
(See Music)

MUSICOLOGY
(See Music)

NATURAL RESOURCE RECREATION
(See Renewable Natural Resources)

NUCLEAR AND ENERGY ENGINEERING

Professors Robert L. Seale, Head, Barry D. Ganapol, David L. Hetrick, Richard L. Morse, Roy G. Post, Morton E. Wacks

Associate Professors W. Morris Farr, Rocco A. Fazzolare, William Filippone, George W. Nelson

Assistant Professor Leland M. Montierth

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in nuclear engineering. These programs prepare the student for advanced study and research in various applications of nuclear energy including the analysis and design of fission and fusion reactors, the dynamics of nuclear systems, the interaction of radiation with matter, nuclear safety, energy systems analysis and management, nuclear fuel cycle evaluation, and the many specialized uses of isotopes. Master's degree students may select one of the following interdisciplinary options: biomedical engineering or energy systems engineering. For details concerning these options see Engineering elsewhere in this catalog.

The applicant should have completed the equivalent of the undergraduate major in nuclear engineering, but liberal substitutions are allowed for those with undergraduate majors in mathematics, physics, chemistry, or other engineering disciplines.

For the Master of Science degree a thesis is required of all students except those working in the energy systems engineering option.

410. Energy System Design (3) GC II Modern techniques in synthesis and analysis are reviewed and applied to contemporary energy problems; economic evaluation, system modeling, optimization, and decision analysis. P, 348, A.M.E. 340a or Ch.E. 306.

415. Environmental Analysis of Energy Conversion (3) GC I Engineering analysis, assessment, and resolution of energy-environment interaction, with consideration of power plant siting, emissions, thermal effects, and waste management.
416. **Radiation Health Physics and Safety** (3) GC I Study of health physics practices and safety responsibilities; analysis of radiation environments and applications of basic shielding methods to provide understanding of accepted working practices.

417. **Nuclear Energy and Power** (3) GC I Fundamentals of nuclear energy and radiation; engineering applications; the basic concepts of nuclear reactors and power systems. Designed for nonmajors.

420. **Nuclear Engineering Laboratory** (3) GC I II Experimental techniques for determining various parameters in nuclear systems; experiments using the critical and subcritical reactors. P. 343.


435. **Radiation Effects** (3) GC II Radiation effects on solids and radiation chemistry of gases and liquids, with emphasis on effects encountered in nuclear reactor, detector, and dosimeter systems. P, 343, CR M.S.E. 331R.

437. **Introduction to Radioactive Waste Management** (3) GC II Influence of public policy and waste physical form on the design criteria for waste management systems.

441. **Contemporary Nuclear Power Systems** (3) GC I Analysis of present nuclear power plants, with emphasis on design decisions as they affect performance of individual systems; comparison of different contemporary systems. P, 348 or 417.

445. **Direct Energy Conversion** (3) GC II Engineering requirements for achieving direct conversion of energy to electrical power; the engineering of thermoelectric and thermionic convertors, fuel cells, magnetohydrodynamic, and photoelectric systems. P, Math. 254; A.M.E. 340a; or Phys. 121. (Identical with A.M.E. 445 and E.C.E. 445)

450. **Introductory Nuclear Physics** (3) GC II (Identical with Phys. 450)

453. **Air Conditioning Engineering** (3) GC I (Identical with A.M.E. 453)

454. **Dynamics of Nuclear Systems** (3) GC I Nuclear reactor kinetics, integral transform methods, internal feedback effects, stability; reactor instrumentation and control. P, 343.

456. **Engineering System Simulation** (3) GC II Dynamic modeling and simulation of engineering systems, including energy conversion systems, nuclear and chemical reactors, and control systems, using digital continuous-system simulation languages. P, A.M.E. 340a or Ch.E. 306a; Math. 254.

463. **Energy from Biomass** (3) GC II (Identical with A.En. 463)

465. **Current Problems in Energy and Power** (1 to 4) [Rpt./6 units] GC II A multidisciplinary course with guest lecturers who are practicing professionals from the energy and power industry; a number of week-long, self-contained minicourses, with topics varying from year to year. (Identical with Ch.E. 465, and E.C.E. 465)

466. **Power Plant Electrical Design** (3) GC II (Identical with E.C.E. 466)

467. **Solar Energy Engineering** (3) GC I Energy analyses of solar collectors; selective surfaces; solar cells; energy storage; systems for solar heating and cooling; mechanical and electrical power; perspective. P, A.M.E. 340 or Ch.E. 306. (Identical with A.M.E. 467 and E.C.E. 467)

469. **Energy Engineering Laboratory** (3) GC II Basic measurements of energy quality, quantity, flow, and conversion. Includes active and passive solar as well as other alternative energy sources. 2R, 3L. P, 467 or CR. (Identical with A.M.E. 469)

477. **Environmental Impact of Energy-Related Systems** (3) GC II (Identical with C.E. 477)

500. **Radiochemistry and Radiation Detection** (3) I Radiation detection and measurement, health physics, isotope applications, activation analysis, and instrumentation. 2R, 3L. P, Chem. 480b or Phys. 330. (Identical with Chem. 530)


541. **Power Plant Engineering** (3) II The application of fluid dynamic heat transfer and mechanical interaction principles to the engineering design of a power plant. P. 441, 540.

554. **Nonlinear Reactor Dynamics** (3) II Nonlinear dynamics of nuclear reactors; shut-down mechanisms, inertial effects, nonlinear stability criteria, time-dependent neutron transport, neutron waves, and applications to pulsed reactors, start-up transients, reactor stability, and reactor safety. P, 454.

567. **Advanced Solar Engineering** (3) II Research and development studies related to solar applications: engineering design, analysis, and economics. Course includes invited lectures, literature research, and an original paper. P, A.M.E. 340a, 442. (Identical with A.M.E. 567, Ch.E. 567, and E.C.E. 567)
569. Energy Use: Analysis and Management (3) I Analysis of energy utilization; methods to evaluate and improve efficiency of energy. (Identical with Ch.E. 569 and E.C.E. 569)


583a-583b. Plasma Physics and Thermonuclear Theory (3-3) 583a: II Fundamentals of the theory of fully ionized plasmas, including wave phenomena and stability of plasma fluids; introduction to plasma kinetic theory. 583b: I Deposition of energy in thermonuclear plasmas; relaxation times and transport coefficients from Fokker-Planck theory; advanced subjects. P, 483b. (Identical with Phys. 583a-583b)

596. Seminar s. Advanced Nuclear Power Activities (1) I II


630. Fuel Cycles for Nuclear Reactors (3) II 1988-89 The design and analysis of fuel cycles for nuclear reactors; the processes and requirements for fuel element design and the limitations of fuel element performance to reactor design; economic factors in fuel cycles. P, 540.

642. Reactor Theory II (3) II Fundamental theory of heterogeneous reactors, integral transport, blackness theory, perturbation theory, and applications; temperature coefficient, changes in reactivity due to fission product accumulation, fuel consumption, and conversion. P, 540.

645. Nuclear Safety (3) II Possible incidents involving nuclear materials in critical reactors, chemical processing systems, fuel shipment operations or subcritical arrays, including assessments of the magnitudes and consequences of nuclear incidents; determination of criteria for evaluating nuclear system safety, including plant siting and operational procedures. P, 540.


681a-681b. Analytical Methods of Transport Theory (3-3) 1987-88 Application of the Boltzmann equation to neutron and photon transport problems; exact solutions, the method of singular eigenfunctions, spherical harmonic expansions, the moments methods, integral transport theory, invariant embedding, variational techniques, applications to slowing-down problems. P, 642, Math. 422a-422b.

685. Inertial Confinement Controlled Fusion (3) I Advanced topics in inertial confinement fusion, including energy absorption and transport phenomena, stability of spherical implosion systems, laser and charged particle drivers and reactor designs. P, 483b, 470b. (Identical with E.C.E. 685)

687. Magnetic Confinement Controlled Fusion (3) II Theory and design of magnetic fusion systems; instabilities; transport and reactor design considerations associated with linear magnetic fusion systems; Tokamaks and mirror machines. P, 483b; Phys. 415b, 470b. (Identical with E.C.E. 687)

NURSING

Professors L. Claire Parsons, Dean, Agnes M. Aamodt, Jan R. Atwood, Eleanor E. Bauwens, Pearl P. Coulter (Emerita), Ada Sue Hinshaw, Margarita A. Kay, Beverly A. McCord, Arlene M. Putt (Emerita), Gladys E. Sorensen


Assistant Professors Mary Alexander, Terry Badger, Jacqueline Blank, Carrie Jo Braden, Jane Byleckie, J. Keenan Casteel, Leanna Crosby, Wanda Frank, Jennie Joe, Elaine B. Jones, Angela Leal, Kathleen May, Pamela Reed, Joyce Verrani, Anne Woodtli

The College of Nursing offers programs leading to the Master of Science, Nursing Specialist, and Doctor of Philosophy degrees with a major in nursing. Applicants for all degree programs are required to submit (1) evidence of completion of an undergraduate program in nursing substantially equivalent to the Bachelor of Science degree program at the University of Arizona, (2) a current license to practice as a registered nurse in
one of the fifty states, (3) references attesting to professional competence, (4) evidence of satisfactory completion of a course in elementary statistics, (5) scores on the aptitude test of the Graduate Record Examination, (6) a statement indicating academic and professional goals as well as research interests, and (7) evidence of skills in physical assessment. Computer literacy required.

An automobile is essential since the clinical facilities are located throughout the Tucson area.

Degrees

MASTER OF SCIENCE — Concentrations are available in child, community health, gerontological, maternal-newborn, medical-surgical, and psychiatric-mental health nursing. Upon completion of the Master of Science program, the student will have met the following objectives: competence in a selected area of clinical nursing, competence in a functional area of nursing, knowledge in a related discipline; ability to use principles of theory construction and research processes; critique theories and conduct research, design, analyze and critique alternative solutions for health care issues and analyze and apply advanced technologies.

The program includes a minimum of 36 units of which no fewer than 24 units (including the thesis) must be in nursing. The remaining units may be selected from one or two related disciplines or may be distributed as six to nine units from the related discipline plus additional units in nursing. Students with a concentration in gerontological, maternal-newborn, or medical-surgical nursing must include one or more graduate courses in human physiology.

The time required for completion of degree requirements is at least two regular semesters plus one summer. Most students enroll for an additional semester. The sequence of nursing courses begins with the fall semester but a new student may begin non-nursing courses during the preceding summer if desired. Study on a part-time basis is possible. Concurrent with the nursing practicum offered each spring, students select role preparation in either administration or teaching.

NURSING SPECIALIST — For information concerning this degree program see Requirements for Specialist Degrees/Nursing Specialist elsewhere in this catalog.

DOCTOR OF PHILOSOPHY — Applicants must present evidence of the completion of a bachelor’s degree or both bachelor’s and master’s degrees substantially equivalent to those nursing programs at the University of Arizona. Admission is based upon the evaluation of the following criteria: undergraduate cumulative grade-point average of at least 3.00 or "B," graduate grade-point average of 3.50, Graduate Record Examination scores of 1,100 on the quantitative and verbal portions of the aptitude test. In addition, applicants must submit references attesting to their potential as graduate students. A personal interview is encouraged. The major purpose of the program is the preparation of the clinical nurse researcher.

482. Legal Implications in Nursing (3) GC I II Overview of the nurse’s relationship with law, as a practicing nurse, and as an individual; exploration of roles from student to expanded practice, in the community, in the legislative process. Advanced degree credit available for non-Ph.D. majors only.

483. Perspectives of Cancer Care for Health Professionals (3) GC S Current methods of care for individuals with cancer and for their families. 6R, 9L. Not accepted in doctoral program of study in nursing. P, enrollment in baccalaureate or graduate programs in nursing, pharmacy, or health-related professions. (Identical with H.R.P. 483 and Ph.Pr. 483)

484. The Health Professions and the Social Sciences (3) GC I Implications of concepts and theories from anthropology, psychology and sociology for health care. Advanced degree credit available for non-Ph.D. majors only.

487. Poverty and Health (3) GC II Study of the relationship between poverty and health. Concepts and theories from anthropology, psychology and sociology will be used to analyze problems associated with poverty. Advanced degree credit available for non-Ph.D. majors only. P, six units of soc. sci. (Identical with Anth. 487 and F.C.M. 487)

488. School Nurse Practice (3) GC S Analysis and application of nursing in school systems. Communication skills, teaching-learning principles for family, physical, psychological assessment. P, R.N. (Offered alternate summers.)
495. Colloquium  
a. Bilingual Health Communication (3) GC II (Identical with Anth. 495a, which is home.)

588. Clinical Anthropology (3) I II Application of principles from anthropological theory to the actual practice of patient care, with emphasis on culture content of groups living in the greater Southwest. P, nine units of behavioral sci. (Identical with Anth. 588 and F.C.M. 588)

589. Health of the Older Adult (3) I Current research of the aging process including physical and mental alterations; emphasis on physiological changes. Consult college before enrolling. (Identical with Gero. 589)

600a-600b-600c. Nursing Theory and Practice (3-3-3) I II S Maintenance, therapeutic and preventive nursing care of persons in various settings. Student elects practice in one area of nursing: (1) child; (2) community health; (3) gerontology; (4) maternal-newborn; (5) medical-surgical; (6) psychiatric-mental health. Laboratory is required.

602. Evaluation Process in Nursing (3) II Development and use of models and tools for assessing nursing processes, programs and performances. Approaches to and psychological reactants of evaluation are explored.

620. Clinical Teaching in Collegiate Schools of Nursing (6) I Curriculum planning and implementation; principles of teaching and learning, formulation of objectives, the selection and organization of learning experiences in the clinical area. Directed practice teaching is included in the area of clinical interest. P, 600a or 600c, CR 600b.

624. The Administrative Process (6) II Theoretical and practical applications of administration as a decision-making process in formulating a course of action essential to solving patient care and personnel issues in nursing. P, 600a or 600c, CR 600b.

625a-625b. Physiologic/Pathophysiologic Concepts: Nursing (3-3) I II S 625a: Stressor activated and host defense responses. Includes fever, nutritional deficits, pain, sleep disorders. 625b: Health response disorders such as hypoxia, perfusion deficits, fluid imbalance, immune response disorders and neurologic insults. Physiology of reproduction, menopause, infertility. 625a is not prerequisite to 625b. (625a and 625b are offered alternate summers.)

630. Methods in Nursing Research (3) I Critical examination of selected problems and methods in the nursing research process. P, 600a or CR.

631. Clinical Phenomena: Theories and Research (3) I Theory and research surrounding common clinical phenomena (e.g., pain, stress), with emphasis on description of clinical phenomena and identification of strengths and weaknesses in available knowledge and research. Laboratory is required. P or CR, 630, 600a or 600b or 600c.

705. Testing Nursing Theory (3) I Examination of selected theories currently utilized in nursing; testing of theories in practice; provision for an exercise in theory construction. Laboratory is required. P, 600a-600b-600c, 602, 630, six units of advanced human physiology, six units of an advanced social science.

710. Clinical Nursing Research (3) II Investigation of selected strategies appropriate to researching problems in clinical nursing. P, 600a-600b-600c, 602, 630, 705.

771. Methods in Clinical Nursing Research (3) I Application of research methods from the physical and social sciences to clinical nursing; experimental and nonexperimental designs; collection, analysis and interpretation of data; computer use. P, 630, 705, 710.

775. Study of Social Influences (3) S 1988 In-depth examination of social forces affecting the health care system.

779. Quantitative Nursing Research (3) II Provides knowledge necessary to deal with clinical nursing research numerical data sets. Emphasis on confirmatory and exploratory data. Analysis issues. Residual analysis is stressed. P, 771, graduate statistics course.

781a-781b. Instrument Construction (3-3) S Deductive and inductive processes for constructing/testing instruments to measure nursing care interventions/patient outcomes. 781a: Instrumentation for behavior and objective phenomena. 781b: Instrumentation for subjective phenomena. Includes instrument strategies; experience developing a pilot measure. 2R, 3L. Open to majors and minors only. P, 705, 710, graduate level statistics. 781a is not prerequisite to 781b. (781a and 781b offered alternate summers.)

782a-782b-782c. Field Work in Nursing Research (3-3-3) S I II Individualized course of study incorporating research and clinical knowledge in a selected area of nursing practice in the laboratory and field setting. P, 600a-600b-600c, 602, 630, 705, 710.
NUTRITION
(See Nutrition and Food Science, Nutritional Sciences)

NUTRITION AND FOOD SCIENCE


Associate Professors Ronald E. Allen, Don P. Bourque, K. Y. Lei, Ralph L. Price, Edward T. Sheehan, Alice B. Stanfield (Emerita), Ann M. Tinsley

Assistant Professors Patsy M. Brannon, Roger A. Sunde

The Department of Nutrition and Food Science is concerned with advanced training in the areas of dietetics, food science and nutritional sciences and offers programs leading to the Master of Science degree with majors in these areas. Graduate study prepares students for careers in government and universities, industry, and as dietitians. The department also cooperates with the Committee on Nutritional Sciences and with the Departments of Biochemistry and Microbiology and Immunology through courses and research direction for students working toward the Doctor of Philosophy degrees with majors in nutritional sciences, in biochemistry, or in microbiology. Cooperative arrangements are maintained with the Arizona Health Sciences Center and other health care and educational facilities to provide work applicable to particular degree programs.

Applicants for the food science major should have a fundamental background in the physical and biological sciences, including one year each of general biology, organic chemistry with lab, and physics, as well as one semester each of microbiology and calculus. Applicants for the nutritional sciences major should have a strong background in nutrition, chemistry and biology including physiology. Specific requirements must include one year of mathematics (calculus recommended) and one year each of general biology, physics and organic chemistry with laboratory. Admission to the dietetics program is contingent upon completion of a bachelor’s degree with a strong concentration in human nutrition and dietetics.

A thesis based on experimental work is required for the food science and nutritional sciences majors for the Master of Science degree. Students in the dietetics major must do a thesis unless otherwise approved by the department graduate committee prior to the start of a program. The thesis option requires 30 units (a maximum of six units may be from the department’s A.D.A.-approved internship), including a thesis based on experimental work. The non-thesis option requires 40 units (a maximum of 12 units may be from the department’s A.D.A.-approved internship). Graduate units from other A.D.A.-approved internships may be used to the limit of transfer-unit requirements. In lieu of internship credit, units may be applied from the following functional areas: clinical nutrition, food service management, community nutrition, and consumer service in foods.


408. Human Nutrition (3) GC I Concepts of the physiology and biochemistry of nutrients and nutrient homeostasis in humans. P, 406a-406b or Biol. 460, Ecol. 159a-159b, CR 464a. Lei

410. General Human Nutrition (3) GC II Advanced principles of nutrition: digestion, absorption and utilization of nutrients. Open to non-majors only. P, Chem. 112 or Micr. 103 or consult department before enrolling. Weber

411. Consumer Fraud in Nutrition (3) GC S Consumer issues in fraud and its effects on nutritional status, general health, and family economic means. Methods of combating nutrition misinformation. P, 101 or 201, Econ. 201a or 201b. (Identical with C.S. 411, H.E.E. 411) Tinsley

430. Principles of Nutrition (3) GC I I (Identical with An.S. 430)

438. Problems in the Biochemistry of Aging (2) GC I 1987-88 Current topics in the biochemistry of mammalian aging; examination of the metabolic, hormonal, immunologic and neural aspects of aging in lower mammals and humans. P, 406a-406b or Chem. 460 or 462b. (Identical with Gero. 438) McCaughey
441. **Therapeutic Nutrition (4) GC II** Therapeutic principles of nutrient acquisition and utilization, including modification of the diet, for selected disease and/or deficiency states; factors of importance in client/patient care, rehabilitation and education. P, 408.

447. **Perspectives in Geriatrics Laboratory (1) GC II** (Identical with Ph.Pr. 447)

448. **Perspectives in Geriatrics (2) GC II** (Identical with Ph.Pr. 448)

455. **Food Product Development (3) GC II 1988-89** Flavor, color, texture, temperature and appearance, as related to acceptability of food products; analysis of change during storage, preservation and preparation, as related to food composition and quality. 1R, 6L. P, 251, 360. Tinsley.

458. **Food Service Organization and Management (3) GC II** Organization and management of food service systems; responsibilities of management for leadership, sanitation, maintenance, and care of food service plant and its equipment. P, 258.

459. **Sensory Evaluation of Food (3) GC II 1987-88** Fundamentals of taste, odor, color, and rheology perception as related to food; design and methodology of small-panel and consumer-panel testing. 2R, 3L.

460. **General Biochemistry (5) GC I** (Identical with Bioc. 460)

463. **Food Analysis (3) GC II 1988-89** Lab. procedures for chemical and physiochemical analysis of food products. 1R, 6L. P, 360, 406a. (Identical with An.S. 463)

465. **Food Engineering (3) GC II 1988-89** (Identical with A.En. 465)

466. **Postharvest Physiology (3) GC I 1987-88** (Identical with Pl.S. 466)

468. **Food Processing (3) GC I** Refrigeration, freezing, dehydration, heating, fermentation and pickling, irradiation and addition of chemicals, as they apply to food preservation and processing, retention of nutritive value, flavor, appearance and safety. P, Chem. 241b, Micr. 110. Price

470. **Food Microbiology and Sanitation (3) GC II** Microbiology in processing and handling of foods; relation of microorganisms, insects, and rodents to design and function of processing and handling equipment. P, Micr. 120 or 217. (Identical with Micr. 470) Gerba

471. **Food Microbiology and Sanitation Laboratory (2) GC II 1988-89** Lab. procedures for assessment of sanitary quality of foods. P, 470 or CR. (Identical with Mìcr, 471) Gerba

548. **Nutrition in Sport and Exercise (3) II S (Identical with Ex.S.S. 548)

560. **Advanced Food Chemistry (3) I 1987-88** Chemical and physical structure and functions of food constituents, additives, and food properties. P, 360, CR 406a. Berry

568. **Nucleic Acids (3) II** (Identical with Bioc. 568)

580. **Composition and Structure of Meat (2) I 1988-89** (Identical with An.S. 480)

596. **Seminar**

Bioenergetics (2) I Energy utilization and nutrient interactions in higher animals. Efficiency of energy use in body processes. P, 408. (Identical with An.S. 601) Reid

Metabolic Integration (3) II Food intake, transport, protein and amino acid utilization in higher animals. P. 408. Sunde

Nutritional Biochemistry Techniques (3) II Biochemical methods for evaluating metabolic functions of nutrients. 1R, 6L. P, 408, Chem. 324 or 325, and 323 or 326. (Identical with An.S. 609) Reid

Chemistry and Metabolism of Lipids (3) I 1987-88 Chemistry and structure of lipids and their digestion, absorption, transport and utilization; current research in lipid metabolism and the role of lipids in certain disease states. P, 406a-406b. (Identical with An.S. 615) Marchello

Vitamins (2) I 1988-89 The chemistry and metabolism of vitamins. P, 408. Weber


Steroid and Lipoprotein Chemistry and Metabolism (2) II 1987-88 Chemistry and metabolism of mammalian sterols and lipoproteins; biosynthesis and metabolism of sterols and lipoproteins in health and disease; the role of diet in treating abnormalities of sterol and lipoprotein metabolism; sterols and disease. P, 406a-406b, 408. McNamara

Developmental Nutrition (3) II 1988-89 Role of nutrients in development and growth; changes in maternal and child nutritional requirements due to development and growth; current research in developmental nutrition. P, 408. Brannon

Field Methods in Human Nutrition (3-3) Case-oriented approach to nutritional assessment, diagnosis, prescription, plan and prognosis; application of dietary, clinical and biochemical methods. 2R, 3L. Open to majors in N.F.S. and other health sciences areas only. Kight

663. **Chemistry of Food Carbohydrates** (2) II 1988-89 Chemical and physical properties of carbohydrates important to their presence in food. P. Bioc. 462a, 460 or N.F.S. 406a-406b Berry

665. **Chemistry of Food Proteins** (3) II 1987-88 The chemical and physical properties of proteins important to their use as food; analysis and purification of proteins; biochemical properties of proteins in muscle, milk, eggs, cereals, and other foods. P. Bioc. 462a preferred, Bioc. 460 or N.F.S. 406a-406b acceptable. (Identical with Bioc. 665) Goll

672. **Food Safety** (2) I 1987-88 Significance and control of foodborne hazards associated with pathogenic microorganisms, microbial toxins, industrial chemicals, and other environmental contaminates. P. 471, Chem. 241b. (Identical with Micr. 672) Gerba

893. **Internship**

   a. Dietetic Internship, ADA Accredited (1 to 6) [Rpt./2] I II Field trips. Consult dept. before enrolling. Open to majors only. P. Course work equivalent to American Dietetic Association Plan IV.

696. **Seminar**

   b. Nutrition (1) [Rpt./6 units] I II (Identical with Nu.Sc. 696b)

   c. Food Science (1) [Rpt./6 units] I II

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**NUTRITIONAL SCIENCES**

Committee on Nutritional Sciences (Graduate)

Professors Donald J. McNamara (Nutrition and Food Science), Chairperson, David S. Alberts (Internal Medicine), James W. Berry (Nutrition and Food Science), William H. Brown (Animal Sciences), Herbert E. Carter (Emeritus, Biochemistry), Milos Chvapil (Surgery), David L. Earnest (Internal Medicine), Charles Gerba (Microbiology-Immunology), Darrel E. Goll (Nutrition and Food Science; Biochemistry), Gail G. Harrison (Family and Community Medicine; Pediatrics: Nutrition and Food Science), Mark Haussler (Biochemistry), J. Tal Huber (Animal Sciences), Wayburn S. Jeter (Microbiology and Immunology), Mary Ann Kight (Nutrition and Food Science), Olakar Koldovský (Pediatrics), Timothy Lohman (Exercise and Sport Science), John A. Marchello (Animal Sciences; Nutrition and Food Science), W. F. McCaughey (Nutrition and Food Science), Frank D. Rollins (Animal Sciences; Nutrition and Food Science), Richard W. Rice (Animal Sciences), Frank L. Meyskens (Internal Medicine), Bobby L. Reid (Animal Sciences; Nutrition and Food Science), Richard W. Rice (Animal Sciences); Frank D. Rollins (Animal Sciences; Nutrition and Food Science), William A. Stini (Anthropology), Brent Theurer (Animal Sciences), Marc E. Tischler (Biochemistry), Hugo V. Villar (Surgery), Charles W. Weber (Nutrition and Food Science; Animal Sciences), Frank M. Whiting (Animal Sciences)

Associate Professors Ronald E. Allen (Animal Sciences; Nutrition and Food Science), James Blanchard (Pharmaceutical Sciences), Sergio Bustamante (Pediatrics), Murray Korc (Internal Medicine), K. Y. Lei (Nutrition and Food Science), Ralph L. Price (Nutrition and Food Science), Ronald E. Pust (Family and Community Medicine), Edward T. Sheehan (Nutrition and Food Science), Spencer Swingle (Animal Sciences), Ann M. Tinsley (Nutrition and Food Science), John Udall (Pediatrics)

Assistant Professors Alan D. Bedrick (Pediatrics), Patsy M. Brannon (Nutrition and Food Science), W. A. Schurg (Animal Sciences), Roger A. Sunde (Nutrition and Food Science)

The interdepartmental Committee on Nutritional Sciences offers graduate work leading to the Doctor of Philosophy degree with a major in nutritional sciences. Options in nutritional biochemistry, human nutrition (clinical or community), or animal nutrition may be selected within this major. The Committee on Nutritional Sciences represents a group of faculty members located in various departments of the University, who participate in graduate training in all areas of nutrition. Only faculty who are members of this larger group, called the Graduate Group in Nutritional Sciences, may serve as major advisers for students majoring in nutritional sciences.
Research direction is available in all areas of nutrition, including nutritional biochemistry, human nutrition, clinical and community nutrition, and animal nutrition.

Undergraduate preparation must include one year of college-level mathematics (calculus recommended) and one year each of general biology, physics, and organic chemistry with laboratory. A semester of quantitative analysis is required for students selecting the options in nutritional biochemistry or animal nutrition. GRE scores for quantitative and verbal tests are requested for admission.

Degree

DOCTOR OF PHILOSOPHY — The student's course of study will be developed by the student and the dissertation director and approved by the student's graduate advisory committee and the Committee on Nutritional Sciences. Students must meet the minimum requirements established for the master's degree in their options, plus additional requirements specified by the student's graduate advisory committee, before obtaining the Ph.D. A maximum of ten units of individual studies (599, 699, 900) and seminar (596, 696) credits will be counted toward requirements for the degree.

A minor may be chosen from a variety of areas including biochemistry, animal physiology, physiology, molecular and cellular biology, ecology and evolutionary biology, food science, anthropology, pharmacology, and chemistry.

Programs for both degrees will emphasize courses from the following listing.

Related Courses


696. Seminar
b. Nutrition (1) I II (Identical with N.F.S. 696b, which is home)

OCCUPATIONAL SAFETY AND HEALTH
(See Health-Related Professions)

OPERATIONS MANAGEMENT
(See Management and Policy)

OPTICAL SCIENCES

Committee on Optical Sciences (Graduate)

Sargent Ill, Dror Sarid, Bernhard O. Seraphin, Roland V. Shack, Richard L. Shoemaker, Philip N. Slater (Remote Sensing), Orestes N. Stavroudis, George I.A. Stegeman, A. Francis Turner (Emeritus), William H. Wing (Physics), William L. Wolfe, Jr. (Radiology), James C. Wyant, Donald R. Uhlmann (Materials Science)

Associate Professor Eustace L. Dereniak, Stephan W. Koch (Physics), George N. Lawrence, Robert R. Schowengerdt (Electrical and Computer Engineering /Arid Lands)

Assistant Professors Ursula J. Gibson, William M. Hetherington III (Chemistry), Chris L. Koliospoulos, Nasser Peyghambarian, Robin N. Strickland (Electrical and Computer Engineering)

The Committee on Optical Sciences offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in optical sciences. Areas in which research is currently being conducted include electro-optics, image formation, image processing, laser physics, materials, medical optics, non-linear optics, optical bistability, optical design, optical fabrication and testing, optical properties of materials, pattern recognition, quantum optics, remote sensing, spectroscopy, surface physics, and thin-film technology. Interdisciplinary programs in progress involve the departments of Astronomy, Chemistry, Civil Engineering and Engineering Mechanics, Electrical and Computer Engineering, Physics, and Radiology, as well as the Microelectronics Laboratory, Arizona Research Laboratory, the Optical Circuitry Cooperative and the Optical Data Storage Center.

Applicants should hold a bachelor's degree in engineering, mathematics, or physics. In addition to the application materials submitted to the Graduate College, applicants must submit to the Assistant Director, Academic Affairs, Optical Sciences Center, University of Arizona, Tucson, Arizona 85721, the following materials: one complete set of transcripts, scores on the aptitude and advanced (engineering, mathematics, or physics) tests of the Graduate Record Examination, and at least two letters of recommendation. Normally, students are only admitted to begin their studies in optical sciences during fall semester. The deadline for submission of all application materials is March 1; however, because of the large number of applications received each year, early submission is encouraged to enhance the chances of admission.

Degrees

MASTER OF SCIENCE — There is no core curriculum for the Master of Science degree, and students are allowed considerable freedom in planning their study programs. Students may elect either of two options:

Thesis option — A minimum of 32 units of graduate credit in optics or optics-related courses, including 8 units of 910 (thesis) and at least 2 units of optics laboratory courses, and a final oral examination based primarily on the thesis.

Non-thesis option — A minimum of 35 units of graduate credit in optics or optics-related courses, including at least 2 units of optics laboratory courses; demonstrated competence in written communication (either by writing an acceptable Master's Report or successfully completing an appropriate course in technical writing); a final oral examination, based primarily on the subject matter of the courses taken.

In addition, the Master of Science degree may be awarded to prospective candidates for the Doctor of Philosophy degree upon successful completion of the preliminary examination.

DOCTOR OF PHILOSOPHY — A core curriculum, including courses 501, 502, 503, 504, 505, 506, 507, 508, and 509 has been developed to help doctoral students prepare for the preliminary examination. These courses are not required, but students are expected to know the material presented in them. There is no foreign language requirement for the Doctor of Philosophy major in optical sciences. Students must include at least two units of optical laboratory courses or provide evidence of equivalent laboratory experience. At the discretion of the committee, doctoral students with majors in optical sciences, as well as those majoring in other disciplines, may elect a minor in optical sciences. Such students must complete, for the minor, twelve units of course work with a grade of "B" or better in optical sciences or obtain approval for the equivalent in transferred course work. No more than six of these units may be crosslisted with the student's major department (if other than optical sciences).
434. Electrical and Optical Properties of Semiconducting Materials (3) GC I (Identical with E.C.E. 434 or M.S.E. 434)

440a-440b. Atomic and Molecular Spectroscopy for Experimentalists (3-3) GC (Identical with Phys. 440a-440b)

501. Electromagnetic Foundations of Optics (3) I Gauß' law; Coulomb's law; dipole moment; polarizability; Faraday's law; Maxwell's equations; the wave equations; plane waves; spherical waves; Fresnel's formulas; dipole radiation; magneto-optic effects; electro-optic effects. P, Phys. 116, Math. 422b.

502. Introduction to Fourier Optics (3) I Harmonic analysis; linear systems; impulse response; convolution; Fourier transform; transfer function; diffraction; image formation; holography; optical data processing. P, Math. 223.

503. First-Order Optical Design (3) I Rays and wavefronts; Fermat's principle; Snell's law; dispersion; systems of plane mirrors; Gaussian imagery; paraxial imagery; paraxial design methods; Delano diagram; introduction to aberrations.

503L. First-Order Optical Design Laboratory (1) I Lab. in support of 503. P, CR 503.

504. Introduction to Quantum Optics (3) II Quantum background; interaction of radiation with matter; dipole moments; line broadening; quantization of radiation fields; spontaneous emission; stimulated emission; lasers. P, 501, Phys. 230. (Identical with Phys. 504)

505. Interference and Interferometry (3) II Wave equations; energy flow; polarization; interference; coherence; interferometers; optical testing; heterodyne interferometry; holography; speckle interferometry. P, 501, 502.

505L. Interference and Interferometry Laboratory (1) II Lab. in support of 505. P, CR 505.

506. Principles of Optical Systems Design (3) II Sources of aberrations; aberration control; aberrations in simple systems; vision; color; mechanical design principles. P, 503, 503L.

507. Introduction to Solid-State Optics (3) I Solid-state background; lattice vibrations; energy bands; energy gaps; optical properties of metals, insulators and semiconductors; measurement techniques; modulators; light-emitting diodes. P, 504.

508. Probability and Statistics in Optics (3) II Probability; random variables; stochastic processes; autocorrelation; Wiener spectrum; noise; applications in photography; atmospheric turbulence; analysis of random data. P, 502.

509. Radiometry, Sources, Materials and Detectors (3) II Radiometry; sources; materials and components for optical systems; imaging and non-imaging detectors. P, 502, 503, 503L.

513. Optical Testing (3) I 1987-88 Metrology of components; aspheric surface testing; assembly and alignment of systems; system evaluation. P, 505.


514. Aberration Theory (3) II 1988-89 Aberration theory; geometrical image formation; diffraction; pupil, spread, and transfer functions; random wavefront perturbations; system effects; image evaluation; image processing. P, 503.

517. Lens Design (4) I Fundamentals of optical system layout and design; exact and paraxial ray tracing; aberration theory; chromatic and monochromatic aberrations. 2R, 6L. P, 506.

524. Optical Data Processing (3) II 1987-88 Inverse filtering; matched filtering; frequency-domain synthesis; the Vander Lugt filter; shadow-casting correlators; OTF synthesis; coded-aperture imaging. P, 505.

527. Holography (3) II 1988-89 Historical background; the Gabor hologram; the hologram as a zone plate; Fresnel, image, Fourier-transform, and reflection holograms; practical holography; limitations. P, 505.


531. Image Processing Laboratory (3) I (Identical with E.C.E. 531)

532. Pattern Recognition and Computer Vision (3) II (Identical with E.C.E. 532)

533. Image Processing: Devices, Systems and Applications (3) II 1987-88 Image formation; resolution; noise; linear processing; display; discrete images; sampling; coding; maximum efficiency codes; nonlinear computer processing; coherent processing. P, 502 or background in theory of linear systems. (Identical with E.C.E. 533)


541. **Introduction to Lasers** (3) I Laser theory; properties of lasers; stimulated emission; dispersion theory; gain saturation and rate equation; optical resonators; survey of laser types and mechanisms. P, Phys. 103b.

.541L. **Introduction to Lasers Laboratory** (1) I Lab. in support of 541. P, CR 541.

543. **Laser Physics** (3) I Density matrix formulation of interaction of radiation with matter; semiclassical laser theory; single and multimode scalar fields; moving atoms; ring and Zeeman lasers; pressure effects. P, 504. (Identical with Phys. 543)

544. **Advanced Electrodynamics** (3) I 1987-88 Normal modes of matter; macroscopic electrodynamics; optical activity; crystal optics; electro-optics; magneto optics; bulk acousto-optics; scattering. P, 501.

545. **Nonlinear Optics** (3) II 1987-88 Scattering of light; parametric amplification; Brillouin, Raman, Rayleigh scattering; stimulated and spontaneous interactions; frequency multiplication; intense field effects; materials damage theory. P, 501.

550. **Fundamentals of Remote Sensing** (3) I Physics and methodology of remote sensing; radiometry; data collection systems; photointerpretation; photogrammetry; image enhancement and classification; applications in the earth sciences.

551. **Radiometry** (3) I 1987-88 Units and nomenclature; Planck's law; black bodies; gray bodies; spectral emitters; Kirchoff's law; flux concepts; axial and off-axis irradiance; radiative transfer; normalization; coherent illumination; radiometric instruments. P, 501.

552. **Infrared Techniques** (3) I 1988-89 The radiant environment; atmospheric properties; optical materials and systems; detector description and use; data processing; displays, systems design and analysis. P, 558.

560. **Physics of the Solid State** (3) II (Identical with Phys. 560)

563. **Photoelectronic Imaging Devices** (3) II 1987-88 Intensifiers; camera tubes; electronography; storage tubes; specifications; evaluation; applications. P, Phys. 116.

565. **Radiation Detector Laboratory** (2) I 1987-88 Operational amplifiers, noise, signal processing, photovoltaic and photoconductive detectors, photomultipliers, thermal detectors. 6L. P, 509, CR 566.

566. **Optical Detectors** (3) II 1988-89 Photoconductors; semiconductors; signal and noise mechanisms; figures of merit; limitations on the sensitivity of detectors; photoemitters; detectors of ionizing radiation. P, 507.

567. **Photographic Recording Processes** (3) II 1987-88 Theory and practice of obtaining a photographic record of an optical image.

568. **Solid-State Imaging Devices** (2) I 1988-89 Charge transfer devices; monolithic and hybrid focal planes, figures of merit; time-delay integration; fat zero; transfer efficiency; double-correlated sampling; buried-channel and surface-channel devices. P, 507.

570. **Advanced Optics Laboratory** (2) II Hands-on experience in current optics research areas. Emphasis is device-oriented. Guided waves; acousto-optics; optical bistability; diode lasers; nonlinear optics; optical phase conjugation. 1R, 3L. P, Phys. 121.


577. **Optics of Thin Films** (3) II Dielectric interference films; semiconductor and metallic films; planar wave guide films; design methods for multilayer interference filter coatings; thin film components for integrated optical circuits. P, 505.

595. **Colloquium**
a. Current Subjects in Optical Sciences (1) I II

596. **Seminar**

597. **Workshop**
a. Optical Shop Practices (3) I II 1R, 6L. P, 513, 513L.


643. **Quantum Optics** (3) II 1988-89 Quantum theory of electromagnetic radiation; spontaneous emission; Dicke superradiance; optical coherence and noise; quantum theory of the laser; superconductivity and Josephson radiation. P, 543. (Identical with Phys. 643)

656a-656b. **Atmospheric Optics and Radiation** (3-3) 1988-89 (Identical with Atmo. 656a-656b)
680. Microcomputer Interfacing in the Optics Laboratory (3) I Design and construction of interfaces between microcomputer systems and a variety of devices in the optics laboratory, including switches, motors, optical sensors, displays and terminals. Hardware and assembly language software drivers.
1R, 6L. P. C.Sc. 122 or E.C.E. 171.

696. Seminar
a. Advanced Optical Design (1-3) II P, 517.

ORIENTAL STUDIES


Associate Professors Michael E. Bonine, Constance Cronin (Anthropology), Richard M. Eaton, Leslie A. Flemming, Charles H. Hedtke, Chisato Kitagawa, Ronald C. Miao, Michael Schaller (History), Daniel Swetschinski, William J. Wilson, Norman Yoffee (Anthropology)

Assistant Professors Marie Chan, John Y. Hou

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in Oriental studies. Instruction is available in the languages, cultures, and civilizations of the Middle East and North Africa, India and Pakistan, China, Japan, the Judaic world, and the Ancient Near East. Concentrations are available in language and literature, history, thought, and society (either ancient or modern) of these areas. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in Oriental studies. For information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

Applicants must forward to the head of the department scores on the aptitude test of the Graduate Record Examination and two letters of recommendation from previous instructors or academic advisers. Students without previous disciplinary or language training related to Asia may be required to make up deficiencies without graduate credit.

Degrees

MASTER OF ARTS — Requirements include thirty units of course work with a thesis or, when a departmental paper is submitted in lieu of thesis, no fewer than 32 units. Two degree plans are available in consultation with an adviser: (1) a nonspecialist terminal program, multi-area if desired, and (2) a specialist program requiring a minimum of two years of an appropriate language. This program normally requires three or more semesters and often serves as preparation for the Doctor of Philosophy degree program.

DOCTOR OF PHILOSOPHY — This program requires completion of the Master of Arts degree (specialist program) or equivalent training plus those additional courses in the major and minor areas selected by the student's guidance committee.

General Oriental Studies

421a-421b. East Asian Buddhism (3-3) GC Buddhism in China, Korea and Japan with emphasis on the relationship between East Asian Buddhist thought and practice and the various historical contexts in which they emerged. P, 330a or consult department before enrolling. (Identical with Reli. 421a-421b)

429. Pedagogical Linguistics: Applied Linguistics for Language Teachers (3) GC II Survey of applied linguistics, with emphasis on phonology, morphology, syntax, contrastive/error analysis, and implications for language teaching of current linguistic theories. (Identical with Ling 429, R.Lg. 429 and T.T.E. 429)

432. Islamic Mysticism (3) GC II 1988-89 Origin and development of Sufism and its impact on the Muslim and non-Muslim worlds. (Identical with Reli. 432)

451. The United States and East Asia: 1840 to the Present (3) GC II 1988-89 (Identical with Hist. 451)
256 DEPARTMENTS AND COURSES OF INSTRUCTION

463. Marxism in East Asia (3) GC I Evolution of Marxist thought in China and Japan. (Identical with Hist. 463)

464. International Relations of East Asia (3) GC II (Identical with Pol. 464)

468a-468b. Asia and the West (3-3) GC 1987-88 Processes of interaction between Europeans and the peoples and cultures of the Middle East, South Asia, and East Asia, from the Portuguese explorations to the present. (Identical with Hist. 468a-468b)

488a. The Prehistory of East Asia (3) GC I (Identical with Anth. 488a)

489. Women in East Asia (3) GC I Women in traditional China and Japan; analysis of changes occurring in the modern period. (Identical with Hist. 489 and W.S. 489)

496. Proseminar
   a. Special Topics in Asian Studies (3) [Rpt./4] GC
   j. The Prehistory of East Asia (3) GC I (Identical with Anth. 496j, which is home.)

503b. Introduction to Comparative Literature and Literary Theory (3) II (Identical with Cp.Lt. 503b)

China

400a-400b. Intermediate Modern Chinese (5-5) GC CDT Grammar, reading, and conversation in the modern (Mandarin) language. P, 100b.


418. Classical Confucianism (3) GC I Formative, classical period in the history of the Confucian tradition, up to 200 A.D.; emphasis on the thought of Confucius, Mencius, and Hsun Tsu. P, 330a or consult department before enrolling. (Identical with Reli. 418)

419. Neo-Confucianism (3) GC II Major figures and themes in the Revival Confucianism from the 11th century through recent times; emphasis on the thought of Chu Hsi and Wang Yang-ming. P, 330b or consult department before enrolling. (Identical with Reli. 419)

420a-420b. Linguistic Structure of Modern Chinese (3-3) GC Linguistic study of the phonological, morphological, and syntactic systems of modern Chinese, with particular attention to linguistic analysis. (Identical with Ling. 420a-420b)

440. Chinese Calligraphy (2) [Rpt.] GC I 1987-88 Theory, practice, and aesthetics of Chinese brush writing, with emphasis on individual training and development.

443. Chinese Aesthetics (2) GC II Survey of traditional Chinese aesthetic concepts in language, literature, painting, calligraphy, and design.

460. Modern Chinese Foreign Relations (3) GC II (Identical with Pol. 460)

475a-475b-475c-475d-475e. Periods in Chinese History (3-3-3-3-3) GC In-depth treatment of major pre-modern eras. 475a: Ancient and classical, to 200 B.C. 475b: Early Empire, 200 B.C.-200 A.D. 475c: Medieval, 200-750 A.D. 475d: New Empire, 750-1350 A.D. 475e: Late Empire, 1350-1800 A.D. May be taken in any order and CR. (Identical with Hist. 475a-475b-475c-475d-475e)

476. Modern Chinese History (3) GC Historical survey of the period since 1911 which examines the revolutionary developments shaping contemporary China. (Identical with Hist. 476)

482. Social History of China (3) GC Formation of ancient Chinese society; organization of families and clans; social stratification, mobility, conflict, and control in traditional China; and transformation from traditional to modern society. (Identical with Hist. 482)

488b. The Archaeology of Pre-Han China (3) GC II (Identical with Anth. 488b)

495. Colloquium
   a. Revolution in Chinese History (3) GC II (Identical with Hist. 495a)
   d. Modern Chinese Frontier Areas (3) GC I 1987-88 (Identical with Hist. 495d)

496. Seminar
   g. The Archaeology of Pre-Han China (3) GC II (Identical with Anth. 496g, which is home)


510a-510b. Chinese Historical Linguistics (3-3) II 1988-89 Historical survey of the development of the Chinese language, with particular attention to linguistic changes in phonology, morphology, and syntax. P, 400b and a course in general linguistics.
520. **Resources and Methods in Sinology** (3) II 1987-88 Introduction to and exercises in the use of standard Sinological reference and research resources. P, 500b.

550. **Studies in Modern Chinese** (3) [Rpt./1] S Grammar, conversation, and readings in modern Chinese texts, with emphasis on oral and written comprehension and expression. P, 410b.


553. **Readings in Classical Chinese Prose** (3) [Rpt./2] I 1987-88 Readings in selected texts from literary, philosophical, and historical traditions; includes selections from the Five Classics and the great prose masters of the Han-Quing. Variable content. P, 500b.


570. **Chinese Historical Texts** (3) [Rpt./2] II 1988-89 Readings in traditional historical texts of various types. P, 500b.

595. **Colloquium**
   a. **India-Pakistan**

   431. **Indian Religion and Thought** (3) GC II 1987-88 Traditional religious and philosophical thought of India. (Identical with Reli. 431)

   444a-444b. **Literature of India** (3-3) GC 444a: Ancient and classical literature; philosophical, epic, dramatic, and poetic literature until 1200 A.D. 444b: Modern literature; lyric poetry, short stories and novels by contemporary writers. In Engl. 444a is not prerequisite to 444b.

   445. **Hindu Mysticism** (3) GC II 1988-89 Introduction to the major concepts and practices of Hindu mysticism, including yoga techniques, rites, symbols, and myths. (Identical with Reli. 445)

   471. **Introduction to Indic Civilization** (3) GC I Social and political institutions, arts and philosophy of traditional society from prehistoric times to c. 1000 A.D., with emphasis on Hindu religion and its interrelations with the social order. (Identical with Anth. 471 and Hist. 471)

   472. **History of Medieval India** (3) GC I 1987-88 Survey of Indian history from the 7th century to 1750. (Identical with Hist. 472)

   473. **History of Modern India and Pakistan: 1750-Present** (3) GC II 1987-88 Survey of political, social and economic developments in South Asia from the mid-18th century to the present. (Identical with Hist. 473)

   485. **Social Organization of India and Pakistan** (3) GC I Survey of family, kin, and caste in the peasant societies of India and Pakistan. (Identical with Anth. 485)

   486. **Political Systems of India and Pakistan** (3) GC II Survey of post-independence political developments in Pakistan and India. (Identical with Pol. 486)

   495. **Colloquium**
   c. **South Asia** (3) [Rpt./4] GC

595. **Colloquium**
   c. **South Asia** (3) [Rpt.] I II
Japan

Prior to registering in any Japanese language course other than 102a, the student must demonstrate the minimum knowledge of Japanese recommended by the instructor.

402a-402b. Intermediate Japanese (5-5) GC CDT Grammar, reading, and conversation in the modern language.

411a-411b. Modern Japanese Grammar (3-3) GC Introduction to Japanese linguistics: morphology, syntax, semantics, and pragmatics. (Identical with Ling. 411a-411b)

412a-412b. Advanced Japanese (5-5) [Rpt.] GC CDT Reading from modern scholarship, fiction, and essays, with attention to grammatical analysis.


437. Japanese Religion (3) GC I Japanese Buddhism, Shinto, new religions, with emphasis on the period since 1600. Reading is in English; basic knowledge of Japanese history required. (Identical with Reli. 437)


474a-474b-474c. History of Japan (3-3-3) GC Social, cultural and political history of Japan. 474a: From earliest times to 1500. 474b: 1500-1800. 474c: 1800-present. (Identical with Hist. 474a-474b-474c)

495. Colloquium b. Japan (3) [Rpt./2] GC I II

502. Literary Japanese (3) Introduction to the varieties of writing styles used from the 8th century to modern times, including Sino-Japanese, documentary, epistolary and purely literary styles.

595. Colloquium b. Japan (3) [Rpt.] I II

596. Seminar r. Japanese History (3) [Rpt.] I II

Judaic Studies

401. Ancient Mesopotamia (3) GC I 1988-89 (Identical with Anth. 401)

403a-403b. Intermediate Modern Hebrew (5-5) GC CDT Intermediate grammar, reading, conversation, and extensive presentation of the syntax and vocabulary of modern Hebrew, leading to a firm foundation in the language. P. 403b.


427. Religion and Mythology of Mesopotamia (3) GC II 1987-88 (Identical with Anth. 427)

428. Anthropology of Law (3) GC II 1988-89 (Identical with Anth. 428)

430. Prophecy in Ancient Israel (3) GC II Nature and origins of Biblical prophecy and its ancient Near-Eastern analogues, including intensive study of several major Biblical prophets. (Identical with Reli. 430)

435. Jewish Mysticism (3) GC II 1987-88 Outline of the thinking of Philo, Saadia, Gebril, Halevi, and Maimonides. (Identical with Reli. 435)

453. Advanced Hebrew (3) [Rpt.] GC Advanced topics in Biblical, Rabbinic, and/or modern Hebrew language and literature. P. 403b or 409b.

454. Spanish Inquisition (3) GC I 1988-89 (Identical with Hist. 454)

455. Introduction to Rabbinic Literature (3) GC II Reading in translation and interpretation of Hellenistic, Jewish, Rabbinic, and related literatures including legal, ethical, moral, and social interpretation of Scripture and oral traditions (Identical with Reli. 455)
495. Colloquium
   g. Judaic Studies (3) [Rpt./4] GC Consult department before enrolling.

595. Colloquium
   g. Judaic Studies (3) [Rpt./4] Consult department before enrolling.

Middle East

404a-404b. Intermediate Arabic (5-5) GC CDT Intermediate conversation and readings in modern standard
Arabic. P, 104b.

405a-405b. Intermediate Persian (4-4) GC CDT Conversation in the dialect of contemporary Iran; extensive
readings in classical and modern literature. P, 105b.

414a-414b. Advanced Arabic (3-3) GC Continuation of 404b, with emphasis on oral and written comprehen-
sion and expression. P, 404b. 414a is not prerequisite to 414b.

415a-415b. Advanced Persian (4-4) GC CDT Readings in Persian, with the objective of preparing the student
415a is not prerequisite to 415b.

424a-424b. Conversational Levantine Arabic (3-3) GC 1987-88 Extensive oral drill, with emphasis on the
acquisition of facility in normal conversation and comprehension. P, 104a.

425a-425b. Conversational Gulf Arabic (3-3) GC 1988-89 Extensive oral drill, with emphasis on the acquisi-
tion of facility in normal conversation and comprehension. P, 104a.

426. Introduction to Arabic Linguistics (3) GC II History and structure of the Arabic language in its
various forms. P, 104b, Ling. 101. (Identical with Ling. 426)

434. Islamic Thought (3) GC II Traditional ideological systems of Islamic countries and their evolutionary
transformations. (Identical with Reli. 434)

439a-439b. Egyptian Arabic (3-3) GC Introduction to the Cairene dialect. Phonology, common greetings,
basic vocabulary and grammar.

441. Arab-Israeli Conflict (3) GC I II S (Identical with Pol. 441)

442. Transformation of Agrarian Societies in the Middle East (3) GC II Dynamics, processes, and
implications of rural change in the Middle East; focus on changes in peasant communities, nomadic
pastoralists, rural-urban relations, and planned change. (Identical with A.Ec. 442, Pol. 442, Soc. 442)

448. Arabic Literature in English (3) GC 1987-88 Historical survey of Arabic literature of the Middle East
and Mediterranean world, with readings in English translations.

449. Persian Literature in English (3) GC II 1988-89 Historical survey of Persian literary traditions, with
readings in English translations.

457. Prehistoric Mesopotamia (3) GC I 1987-88 (Identical with Anth. 457)

458. Government and Politics of the Middle East (3) GC II Government and politics of the Middle East,
combining study of Islamic institutions with a view to their applicability in the contemporary Middle
East. (Identical with Pol. 458)

459. Topics in Economic Geography of the Middle East (3) GC II (Identical with Geog. 459)

467. Population and Development in the Middle East (3) GC I Review of theories and research in
population, resources and socioeconomic development, with emphasis on determinants and conse-
quence of population growth and migration in contemporary Middle East. (Identical with A.Ec. 467, Pol.
467)

469. Geography of the Middle East (3) GC I Physical environments and cultural areas of Southwest Asia,
with emphasis on man-environment interrelationships, settlement systems and impact of Islam. (Iden-
tical with Geog. 469)

477a-477b. History of the Middle East (3-3) GC History of civilization in the Middle East from the rise of
Islam to the 18th century. 477a: Period of Arab dominance. 477b: Period of Turkish dominance. 477a is
not prerequisite to 477b. (Identical with Hist. 477a-477b)

478. Modern History of the Middle East (3) GC I Near and Middle Eastern history since the late 18th
century, with special emphasis on Egypt and areas to the east. (Identical with Hist. 478)
479.  The Ottoman Empire to 1800 (3) GC II 1988-89 Great age of the Ottoman state, its origins and
decline. (Identical with Hist. 479)

480a-480b. History of Iran and Central Asia (3-3) GC 480a: History of Iran from 226 A.D. to 1722. 480b:
18th, 19th and 20th century Iran. (Identical with Hist. 480a-480b)

481a-481b. Archaeology of Syria-Palestine in the Bronze and Iron Ages (3-3) GC Survey of the Bronze
and Iron Age cultures of Syria-Palestine, ca. 3500-500 B.C., with emphasis on the use of archaeologi-
cal materials in historical reconstruction. (Identical with Anth. 481a-481b)

484a-484b. Akkadian Linguistics (3-3) GC 1988-89 (Identical with Anth. 484a-484b)

495.  Colloquium
   h. Middle East (3) [Rpt./4] GC Consult department before enrolling.
   n. Modern Arabic Prose (3) [Rpt./1] GC P, 2 years of Arabic.
   o. Classical Arabic Prose (3) [Rpt.] GC P, 2 years of Arabic.
   z. Readings in Classical Arabic Poetry (3) GC S P, 3 years of Arabic for non-native speakers of
   Arabic.

584a-584b. Readings in Akkadian (3-3) 1987-88 (Identical with Anth. 584a-584b)

595.  Colloquium
   d. Middle East (3) [Rpt.] I II

596.  Seminar
   m. Middle East: Topics in History and Civilization (3) [Rpt.] I II
   p. Middle Eastern Urbanism (3) [Rpt.] I II
   q. Near Eastern Archaeology (3) [Rpt.] I II (Identical with Anth. 596q)
   t. Tribe and State in the Middle East (3) I

PALEONTOLOGY
(See Geosciences)

PERFORMANCE
(See Music)

PERSIAN
(See Oriental Studies)

PERSONNEL MANAGEMENT
(See Management and Policy)

PHARMACEUTICAL SCIENCES

Professors Arnold R. Martin, Head, Willis R. Brewer (Emeritus), Jack R. Cole, Michael B.
Mayersohn, William A. Remers, Samuel H. Yalkowsky, Joseph A. Zapotocky
(Emeritus)

Associate Professors James Blanchard, Karl H. Schram
Assistant Professors Michael D. Karol, Nair Rodriguez-Hornedo

The Department of Pharmaceutical Sciences includes the academic disciplines of phar-
maceutical chemistry, biopharmaceutics/pharmacokinetics, pharmaceutics, and pharmacog-
nosy. It offers programs leading to the Master of Science and Doctor of Philosophy degrees with
a major in pharmaceutical sciences. Concentrations within the major include pharmaceutical
chemistry, biopharmaceutics/pharmacokinetics, pharmaceutics and pharmacognosy.
A bachelor's degree in pharmacy, chemistry, or biological science is prerequisite to admission to the graduate program. Admission to the doctoral programs usually requires, in addition, appropriate preparation in mathematics.

Teaching is part of the graduate learning process, and one or more years of teaching is generally required of graduate students. A thesis based upon laboratory research is required for the master's degree. Acceptable minor fields for doctoral students include biology, chemistry, mathematics, microbiology, nutrition, pharmacology, physiology, zoology, or pharmacy concentrations different from the principal concentration selected by the student.

Specialized facilities of the College of Pharmacy available for graduate studies include a clinical pharmacokinetics laboratory, a mass spectrometry laboratory, large-scale natural product extraction equipment, computer graphics facilities, animal facilities, and well-equipped laboratories for chemical synthesis, structure elucidation, and pharmaceutics research.


424. Antibiotics (2) GC I (Identical with Ph.Pr. 424)

427. Antineoplastic Drugs (2) GC II Discovery and development of natural and synthetic antineoplastic drugs; preclinical screening and toxicity evaluation; phase I, II, and III clinical studies in humans. P, 437b or CR.

430e-430b. Medical Radiopharmaceuticals (3-3) GC Medical applications, safe handling, measurement and preparation of radiopharmaceuticals. 2R, 3L. P, Math. 123, 263, Phys. 102b. 180b. Chem. 103b, 104b.

437e-437b. Medicinal Chemistry and Pharmacognosy (4-4) GC Relationships between the chemical structure and physiological activity, incompatibilities and stability of the organic and inorganic compounds obtained from natural and synthetic sources; essentials of pharmacognosy, including biologicals. P, 302b, Chem. 241b, 243b.

438. Pharmaceutical Analysis (2) GC II Modern methods and instrumentation used for qualitative and quantitative determination of drugs and metabolites. P, Chem. 323.

475a-475b-475c. Pharmacotherapeutics (2-3-6) GC (Identical with Ph.Pr. 475a-475b-475c)

512. Quantitative Structure-Activity Relationships (3) 1987-88 Approaches to the quantification of pharmacological actions of drugs on the basis of chemical structure.

575. Advanced Pharmacotherapeutics (6) II (Identical with Ph.Pr. 575)

596. Seminar a. Pharmaceutical Sciences (1) [Rpt./5] I II b. Pharmaceutical Chemistry Research (1) [Rpt./5] I II c. Pharmacuetics Research (1-2) [Rpt./5] I II Open to majors only.

601. Advanced Physical Pharmacy (3) II 1988-89 Applications of physical chemistry to pharmacy. P, physical pharmacy or physical chemistry course.


630a-630b. Advanced Organic Medicinals (3-3) 1988-89 Rational drug design, receptor site theories, mechanism of drug action, and metabolic pathways of medicinal agents; chemical and enzymatic synthesis of important pharmaceuiticals. P, 437b, Pcol. 471b.


875. Advanced Pharmacotherapeutics (Pharmacy) (8) (Identical with Ph.Pr. 875)
PHARMACOLOGY

(Department, College of Medicine)

Professors Thomas F. Burks, Head, David S. Alberts (Internal Medicine), H. Vasken Aposhian (Molecular and Cellular Biology), Klaus Brendel, Rubin Bressler (Internal Medicine), Burrnell R. Brown (Anesthesiology), Ryan J. Huxtable, David G. Johnson (Internal Medicine), Eugene Morkin (Internal Medicine), Charles W. Putnam (Surgery), William R. Roeske (Internal Medicine), Diane H. Russell, I. Glenn Sipes (Pharmacology and Toxicology), Henry I. Yamamura

Associate Professors Dean E. Carter (Pharmacology and Toxicology), Kenneth A. Conrad (Internal Medicine), Thomas P. Davis, A. Jay Gandolfi (Anesthesiology), David L. Kreulen, Thomas J. Lindell, John D. Palmer

Assistant Professors William Banner (Pediatrics), Timothy C. Fagan (Internal Medicine), Laurel A. Fisher, Frank Porreca

The Department of Pharmacology in the College of Medicine cooperates with the Department of Pharmacology and Toxicology in the College of Pharmacy, through the Committee on Pharmacology and Toxicology, in offering programs leading to the Master of Science degree with a major in pharmacology and the Doctor of Philosophy degree with a major in pharmacology and toxicology. See the entry for the Committee on Pharmacology and Toxicology for details on admission and degree requirements.

Pharmacology is a broad discipline involving the investigation of the actions of chemicals upon living material at all levels of organization. It occupies an important interface between the basic medical sciences and the clinical sciences, drawing strongly upon the former for its contribution to the latter. Pharmacologic knowledge is applied to the understanding of the basic mechanisms of drug action, the diagnosis, prevention, cure, or relief of the symptoms of disease and the promotion of optimal health. The emphasis on basic pharmacologic principles enables the student to develop techniques of problem-solving to keep abreast of advances in pharmacology and its applications to other sciences.

501. The Pharmacological Basis of Therapeutics (6) II Actions of chemical agents upon living material at all levels of organization, with emphasis on mechanisms of action of prototype drugs; foundation for a rational approach to human therapeutics and toxicology. P, Psio. 601, Bioc. 501. (Identical with Tox. 501)

520. Clinical Pharmacology (2) I Effects of drugs on natural history of disease; drug-drug interactions; drug testing designs; drug abuse; drug literature evaluation; aspects of clinical toxicology. P, 501.

550. Drug Disposition and Metabolism (2) I Principles of absorption, distribution and excretion of drugs, with emphasis on mechanisms of drug metabolism and pharmacokinetics. P, 462a-462b or 501; Bioc. 501, Tox. 602a. (Identical with Tox. 550)


561a-561b. Introduction to Pharmacological and Toxicological Literature (1-1) Designed to broaden the background of students in pharmacology and toxicology, and to improve scientific communication skills. P, 501. (Identical with Pcol. 561a-561b)

576. Environmental Toxicology (3) I (Identical with Tox. 576)

582. Immunotoxicology (2) I (Identical with Tox. 582)

586a-586b. Introduction to Pharmacology and Toxicology Research (1-1) Introduction to basic research techniques in pharmacology and toxicology through supervised laboratory rotations; student-initiated and faculty-structured lab. exercises in modern pharmacological and toxicological techniques. P, CR 501, Bioc. 565, Psio. 601.

596. Seminar
a. Advanced Graduate Research (1-3) [Rpt./3] II P, 561b. (Identical with Pcol. 596a)
Analytical Instrumentation and Techniques (4) I (Identical with Tox. 601)

602a-602b. Biotoxicology (3-1) (Identical with Tox. 602a-602b)

653. Neuropharmacology (3-4) II (Identical with Pcol. 653)

695. Colloquium 
   a. Cellular/Molecular Pharmacology (1-3) [Rpt./4 units] II P, Bioc. 462a-462b; 568a-568b and/or Phcl. 551.

800. Research (1-6)

801. The Pharmacological Basis of Therapeutics (6)

815. Subspecialty 

891. Preceptorship  
   a. Pharmacology (3-12) [Rpt./12 units]

PHARMACOLOGY AND TOXICOLOGY

(Professor, Department of Pharmacology)

Professors I. Glenn Sipes, Head, Lincoln Chin, J. Wesley Clayton, Paul F. Consroe, Wayburn S. Jeter, Albert L. Picchioni, Findlay E. Russell, Theodore Tong (Pharmacy Practice)

Associate Professors G. Timothy Bowden (Radiation/Oncology), Dean E. Carter, A. Jay Gandolfi (Anesthesiology), Hugh E. Laird, II, David L. Nelson

Assistant Professors James R. Haipert, John Sullivan (Emergency Medicine and Pharmacology)

Pharmacology is the science concerned with all aspects of the action of drugs on living systems. Its primary aim is the development and evaluation of drugs for the treatment of human disease. The broad scope of interests of pharmacology ranges from the study of intermolecular reactions of chemical constituents of cells with drugs to the effects of chemicals in our environment on entire populations.

Toxicology is the science concerned with the harmful effects of chemicals (including drugs) on living systems. The toxicology program manages the University of Arizona Toxicology Laboratories. The program prepares students for careers in hospital laboratories, police crime laboratories, medical examiners' offices, industrial hygiene laboratories, and toxicology laboratories in industry, government, and universities.

Pharmacology

The Department of Pharmacology and Toxicology in the College of Pharmacy cooperates with the Department of Pharmacology in the College of Medicine, through the Committee on Pharmacology and Toxicology, in offering programs leading to the Master of Science degree with a major in pharmacology and the Doctor of Philosophy degree with a major in pharmacology and toxicology. See the entry under Committee on Pharmacology and Toxicology elsewhere in this catalog for details on admission and degree requirements.

471a-471b. Fundamentals of Pharmacology (4-4) GC Comprehensive study of the biochemical, physiological, and therapeutic effects of drugs, including mechanisms of drug action and drug toxicity, and drug literature evaluation. 3R, 3L. P, Anat. 401, Bioc. 460, Psio. 480, 481; CR Ph.Pr. 475a-475b and Ph.Sc. 437a-437b. (Identical with Tox. 471a-471b)

472. Applied Pharmacology (3) GC I II Pharmacodynamics, pharmacology, and adverse effects of commonly used drugs, with emphasis on clinical applications. Not available for elective credit in the College of Pharmacy or graduate credit in pharmacology-toxicology doctoral programs. P. Ecol. 159b.

474. Clinical Toxicology (2) GC II Prevention, characteristics, diagnosis and rational management of diseases caused by drug overdose, toxic household products, poisonous plants, venomous animals, environmental and industrial toxicants. P. 472 or 471b, Ph.Sc. 407. (Identical with Tox. 474)

475a-475b-475c. Pharmacotherapeutics (2-3-6) GC (Identical with Ph.Pr. 475a-475b-475c)

561a-561b. Introduction to Pharmacological and Toxicological Literature (1-1) (Identical with Phcl. 561a-561b)
The Department of Pharmacology and Toxicology in the College of Pharmacy offers a curriculum leading to the Master of Science degree with a major in toxicology. Prerequisite to admission is the completion of a bachelor's degree including one year each of analytical chemistry, biological science, and organic chemistry and a semester of instrumental analysis. Two letters of recommendation and adequate scores on the Graduate Record Examination are also required for admission. Required courses for the graduate program are 462a-462b, 480, 481 (or Psio. 601), 471a-471b (or Phcl. 501), 474 (or 423R and 423L), 596a, 596b, 601, and 602. A thesis is required.

423R. General Pathology (3) GC II (Identical with V.Sc. 423R)
423L. General Pathology Laboratory (1) GC II (Identical with V.Sc. 423L)
462a-462b. Biochemistry (4-3) GC (Identical with Bioc. 462a-462b)
463a-463b. Human Physiology Laboratory (1-1) GC (Identical with Ecol. 463a-463b)
464a-464b. Human Physiology (3-3) GC (Identical with Ecol. 464a-464b)
465. Statistics for the Medical Sciences (4) GC I (Identical with Stat. 465)
471a-471b. Fundamentals of Pharmacology (4-4) GC (Identical with Pcol. 471a-471b)
474. Clinical Toxicology (2) GC II (Identical with Pcol. 474)
480. Human Physiology (4) GC II (Identical with Psio. 480)
481. Physiology Laboratory (1) GC II (Identical with Psio. 481)
486. Fundamentals of Industrial Hygiene (3) GC I (Identical with O.S.H. 486)
487. Advanced Industrial Hygiene and Safety (3) GC II (Identical with O.S.H. 487)
501. The Pharmacological Basis of Therapeutics (6) II (Identical with Phcl. 501)
508. Insecticide Toxicology (3) II 1987-88 (Identical with Ento. 508)
550. Drug Disposition and Metabolism (2) II (Identical with Phcl. 550)
554. Industrial Toxicology and Chemical Exposures (2-4) I Principles of toxicology related to industry; dose response; mechanisms of toxicity; hazard evaluation principles; toxicology of major classes of industrial compounds. P. 6 units each of biological science, and organic chem.
576. Environmental Toxicology (3) I Toxicity of natural toxins and of agricultural and industrial chemicals, with emphasis on air and water pollutants; decision-making in environmental issues. P. 6 units of biology and of organic chemistry; Chem. 325, 326. (Identical with Ento. 576 and Phcl. 576)
582. Immunotoxicology (2) I 1987-88 Broad overview of the immune system, with emphasis on how chemicals affect the immune system (immunomodulation) and the role of the immune system in chemical-induced tissue injury/allergic responses. P, 602, Micr. 419, 567. (Identical with Micr. 582, Phcl. 582)
596. Seminar
a. Advanced Toxicology (1-2) [Rpt./3] I
b. Current Concepts in Toxicology (1-2) [Rpt./3] II
601. **Analytical Instrumentation and Techniques (4)** I Lecture and laboratory in the qualitative and quantitative determination of toxic substances in the environment and body fluids. Modern instrumental techniques will be employed whenever appropriate. Lecture may be taken separately by non-majors. 2R, 6L. P. Chem. 400a. (Identical with Phcl. 601)

602a-602b. **Biotoxicology (3-1)** I 602a: Lecture. Mechanisms of organ directed toxicities in animals. Chemical carcinogenesis, teratogenesis and mutagenesis. Open to non-majors. P, two semesters of ecol. II 602b: Laboratory. Proper use of animals in toxicology and pharmacology research; focuses on organ specific toxicities. (Identical with Phcl. 602a-602b)

610. **Topics in Advanced Toxicology (1-3)** I II Current developments in toxicology including: chemical carcinogenesis, mutagenesis and teratogenesis; behavioral toxicology; inhalation toxicology; toxicokinetics; metabolism and environmental toxicology. P, 471b, 474.

653. **Neuropharmacology (3-4)** II (Identical with Pool. 653)

**PHARMACOLOGY AND TOXICOLOGY**

Committee on Pharmacology and Toxicology (Graduate)

Professors I. Glenn Sipes, Chairperson, Klaus Brendel, Thomas F. Burks, Diane H. Russell
Associate Professors Dean E. Carter, David L. Kreulen, Hugh E. Laird, II, David L. Nelson

The Department of Pharmacology in the College of Medicine and the Department of Pharmacology and Toxicology in the College of Pharmacy cooperate, through the Committee on Pharmacology and Toxicology, in offering programs leading to the Master of Science with a major in pharmacology and the Doctor of Philosophy with a major in pharmacology and toxicology. Concentrations are available in neuropsychopharmacology; in biochemical, molecular, behavioral, cardiovascular, endocrine, gastrointestinal, and autonomic pharmacology; and in biochemical, occupational, inhalation, and environmental toxicology.

Admission requires the completion of a bachelor's degree with a major in chemistry, biology, pharmacy, or other related science. Minimal prerequisites include one year each of biology, organic chemistry, and physics and course work in mathematics through integral calculus. Applicants must submit scores on the Graduate Record Examination. Correspondence may be directed to the Chairperson, Graduate Committee on Pharmacology and Toxicology.

Graduate study programs are individually planned after consideration of the student's preparation and professional objectives. A thesis is required.

For course descriptions, see Pharmacology (College of Medicine) and Pharmacology and Toxicology (College of Pharmacy) elsewhere in this catalog.

**PHARMACY PRACTICE**

Professor Theodore G. Tong
Associate Professors J. Lyle Bootman, Head, William F. McGhan
Assistant Professor Lon N. Larson

The Department of Pharmacy Practice offers a program leading to the Master of Science degree with a major in pharmacy with concentrations in hospital pharmacy and pharmacy administration. Graduate study in pharmacy administration leading to the Doctor of Philosophy degree with a major in pharmacy is offered in this department.

A bachelor's degree in pharmacy or a Doctor of Pharmacy degree is prerequisite to admission to the hospital pharmacy concentration. Admission preference for graduate study in pharmacy administration is given to applicants who hold the degree of Bachelor of Science in Pharmacy or its equivalent. Applicants with bachelor's degrees in areas other than pharmacy will also be considered.

Teaching is a part of the graduate learning process, and one year of teaching or more is generally required of all graduate students. A thesis is required for the master's degree. Acceptable minor fields for doctoral students include anthropology, biostatistics, computer science,
266  DEPARTMENTS AND COURSES OF INSTRUCTION

economics, educational psychology, management, marketing, management information systems, psychology, public administration, or sociology.

419.  Parenteral Preparations  (2) GC Principles and procedures in the preparation, stability, and administration of parenteral products. 1R, 3L. P. Ph.Sc. 302b or CR.

424.  Antibiotics  (2) GC I Principles of antibiotic chemotherapy and the properties of the antibiotics employed in therapeutics. P. 437b, Micr. 110, Pcol. 471b. (Identical with Ph.Sc. 424)

440.  Perspectives in Health Care Services  (3) GC I Consumers, providers, financiers, and regulators of health care and medicines in the U.S. and exploration of controversies in relation to these components.

442.  Professional Practice Management  (3) GC I Management of professional situations and the interaction among patients, colleagues, and other health-care providers, with application to institutional, community, and clinical pharmacy practice. P. 445.

445.  Psychosocial Aspects of the Drug Use Process  (3) GC I An overview of the drug-use process, including an examination of social, behavioral, and economic factors associated with the prescribing, dispensing, and use of drugs. (Identical with Coun. 445)

447.  Perspectives in Geriatrics Laboratory  (1) GC II Open to nonmajors. P, CR 448. (Identical with Gero. 447 and N.F.S. 447)

448.  Perspectives in Geriatrics  (2) GC II Multidisciplinary approach to the health-care needs of the elderly, including medication use and nutrition, through didactic training, a team project, and clerkship experiences. Open to nonmajors. P. CR 447 for nonmajors. (Identical with Gero. 448 and N.F.S. 448)

475a-475b-475c.  Pharmacotherapeutics  (2-3-6) GC Common diseases that afflict humans. Their management based on pharmacotherapeutic considerations of epidemiology, etiology, diagnosis, pathophysiology, and prognosis. P, Bioc. 460, Psio. 480 (Identical with Pcol. 475a-475b-475c and Ph.Sc. 475a-475b-475c)

483.  Perspectives of Cancer Care for Health Professionals  (3) GC S (Identical with Nurs. 483)

489.  Clinical Pharmacotherapy of Mental Disorders  (2) GC I II A multidisciplinary approach to clinical psychopharmacology, therapeutics, and diagnosis of mental disorders for health professionals.

503.  Clinical Clerkship

a. Externship  (4) I II S P, grad. students consult department before enrolling.
b. Adult Pharmacy Practice  (4) I II S P. grad. students consult department before enrolling.
c. Ambulatory Pharmacy Practice  (4) I II S P. grad. students consult department before enrolling.
d. Drug/Poison Information  (4) I II S P. grad. students consult department before enrolling.

Note: 503a-d are six-week courses.

511.  Pharmacy Management  (3) I History, organization and administration of pharmaceutical services within the institutional environment.

512.  Advanced Pharmacy Management  (3) II Application of management principles to problem-solving and decision-making techniques in the provision of pharmaceutical services within the institutional environment. Field trips. Open to majors only. P. 511.

557.  Physical Parameters for Monitoring Drug Therapy  (1) II Introduction to physical assessment skills required of pharmacists for monitoring, assessing, and consulting on drug therapy. 3L. P. CR 575.

561.  Research Methodology and Drug Literature Evaluation  (3) II Skills and principles of clinical research design and biostatistics needed for evaluation of the medical literature and writing of research proposals. P. CR 575.

575.  Advanced Pharmacotherapeutics  (8) II Advanced concepts for the rational use of drugs in the management of diseases based on pathophysiological, pharmacokinetic, or pharmacologic and toxicologic considerations. 4R, 6L. P, 303e, 410, 475, CR 557. (Identical with Ph.Sc. 575 and Pcol. 575)

585.  Advanced Clinical Pharmacokinetics  (3) II For description, see 885.

596.  Seminar

a. Pharmacy Administration  (1) [Rpt/5] I II
b. Pharmacy Administration Research  (1) [Rpt/5] I II

611a-611b.  Pharmacy and Its Environment  (3-3) 1987-88 Cultural, social, behavioral, and organizational foundations of pharmacy, including the development of the present state of practice.

612a-612b.  Issues in Pharmacy Practice Research  (3-3) 1988-89 Survey of research methodology for studying social and behavioral aspects of health care and pharmacy practice; strategy for selecting and modifying existing research tools for particular purposes.

621.  Pharmaceutical Marketing  (3) I II Socioeconomic factors in the development, production, and distribution of drugs.
694. **Practicum**
   a. Clinical Clerkship (1-15) [Rpt.] I II
   b. Administrative Clerkship (1-15) [Rpt.] I II

695. **Colloquium**
Research in Gerontology (1) I II (Identical with Gero. 695a)

800. **Pharmacy Practice Project** (1) II Individual pharmacy practice research not related to a thesis or dissertation. Open only to students enrolled in Doctor of Pharmacy program.

803. **Pharmacy Clinical Clerkship**
   
   Note: 803a-d are six-week courses.

810. **Pharmacy Clerkship**
   a. Internal Medicine (3-10) I II S P, 803b.
   b. Surgery (3-10) I II S P, 803b.
   d. Geriatrics/Gerontology (3-10) I II S P, 803b.
   e. Outpatient Practice (3-10) I II S P, 803b.
   f. Emergency Services (3-10) I II S P, 803b.
   g. Acute Care (3-10) I II S P, 803b.
   h. Clinical Pharmacokinetics (3-10) I II P, 803b.
   i. Psychopharmacy/Neurology (3-10) I II S P, 803b.
   
   Note: 810a-i are three to six week courses.

815. **Pharmacy Subspecialty**
   a. Hematology/Oncology (3-10) I II S P, 10 units of 810 or CR.
   b. Cardiology (3-10) I II S P, 10 units of 810 or CR.
   c. Pulmonary (3-10) I II S P, 10 units of 810 or CR.
   d. Endocrine (3-10) I II S P, 10 units of 810 or CR.
   e. GI/Renal (3-10) I II S P, 10 units of 810 or CR.
   f. OB/GYN/Neonatal (3-10) I II S P, 10 units of 810 or CR.
   g. Infectious Disease (3-10) I II S P, 10 units of 810 or CR.
   h. Rheumatology/Immunology (3-10) I II S P, 10 units of 810 or CR.
   i. Dermatology (3-10) I II S P, 10 units of 810 or CR.
   j. Poison Information/Toxicology (3-10) I II S Open to majors only. P, 10 units of 810 or CR.
   k. Administrative (3-10) I II S 15-30L P, 10 units of 810 or CR.
   l. Research (3-10) I II S 15-30L P, 10 units of 810 or CR.
   
   Note: 815a-i are three to six week courses.

857. **Physical Parameters for Monitoring Drug Therapy (Pharmacy)** (1) P CR 875.

861. **Methodology in Pharmacy Research and Drug Literature Evaluation** (3) P CR 875.

875. **Advanced Pharmacotherapeutics (Pharmacy)** (8) P, 303e, 410, 475. (Identical with Ph.Sc. 875 and Pcol. 875)

885. **Advanced Clinical Pharmacokinetics** (3) II Advanced pharmacokinetic principles emphasizing the application of mathematical relationships to patient care situations. P, Ph.Sc. 407, 409, or consult department before enrolling.

896. **Seminar**
   a. Pharmacy Practice (1) I
   b. Pharmacy Practice Research (1) II
   c. Infectious Disease (2) [Rpt./1] II Open to majors only. P, 875 or consult department before enrolling.

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**PHILOSOPHY**


Associate Professor Holly M. Smith, *Head*

Assistant Professor Vann McGee
The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in philosophy. In addition to the traditional areas of philosophy, concentrations are available that bridge philosophy with other disciplines such as law or cognitive science.

Applicants for the graduate program should normally have completed 30 units of undergraduate work in philosophy. In addition to application materials required by the Graduate College, applicants should submit to the department a copy of their completed application, copies of transcripts (these need not be official), three letters of recommendation from philosophy instructors, GRE general aptitude scores, and a sample of their written philosophy work.

**Degrees**

**MASTER OF ARTS** — A student must demonstrate proficiency in logic, and in addition must pass at least one course in each of the following three areas: history of philosophy, metaphysics and epistemology, and moral philosophy. A final examination must be passed, based on a research paper in an area chosen by the student. The student's program of study is designed individually. No thesis is required.

**DOCTOR OF PHILOSOPHY** — A student must pass two courses in each of the following four distribution areas: (1) logic (required), philosophy of language, and philosophy of science; (2) history of philosophy; (3) epistemology and metaphysics; and (4) moral, social, and legal philosophy. A substantial proportion of one's courses must be at the seminar level. Students must pass a qualifying exam, based on a research paper. In addition, a preliminary exam must be passed in areas of the student's choice, and a doctoral dissertation is required. Further details about requirements and procedures can be obtained from the department. Teaching assistantships are available for qualified students.

403. Foundations of Mathematics (3) GC II 1988-89 (Identical with Math. 403)
414. Philosophical Logic (3) GC 1987-88 Introduction to modal logic; problems of interpretation and application; extensions to such areas as tense logic, epistemic logic, deontic logic.
419. Induction and Probability (3) GC 1988-89 Basic philosophical problems concerning justification of induction, confirmation of scientific hypotheses, and meaning of probability concepts.
421. Philosophy of the Biological Sciences (3) GC 1987-88 Laws and models in biology, structure of evolutionary theory, teleological explanations, reductionism, sociobiology. (Identical with Ecol. 421)
422. Linguistic Semantics and Lexicology (3) GC II 1988-89 (Identical with Ling. 422)
423. Philosophy of the Physical Sciences (3) GC Philosophical problems regarding space, time, motion, relativity, causality, measurement, theoretical entities.
430a-430b. Ethical Theory (3-3) GC 1987-88 430a: Meta-ethics—meaning of moral terms, relativism, subjectivism, ethics and science, social contract theory. 430b: Normative ethics—Utilitarianism, egoism, rights, natural law, justice, deontological duties, blameworthiness and excuses.
433. Aesthetics (3) GC Classical and contemporary theories of art; the esthetic experience, form and content, meaning, problems in interpretation and criticism of works of art.
434. Social and Political Philosophy (3) GC Fundamental concepts of politics; leading social and political theories, such as anarchism, social contract, Marxism.
438a-438b. Philosophy of Law (3-3) GC 438a: Nature and validity of law; law and morality, judicial reasoning, law and liberty. 438b: Problems about justice, compensation and contracts and/or responsibility and punishment. (Identical with Pol. 438a-438b)
440. Metaphysics (3) GC Topics include free will and determinism; causation; personal identity; necessity and essence; truth, realism and ontology.
441. Theory of Knowledge (3) GC Critical examination of some of the major problems concerning evidence, justification, knowledge, memory, perception and induction.
443. **Knowledge and Society** (3) GC I II Social and interpersonal processes affecting the acquisition and diffusion of knowledge. Emphasis on philosophical perspectives, with interdisciplinary borrowings.

450. **Philosophy of Mind** (3) GC Topics include the nature of mental states; the relation between mind and brain; and analysis of perception, emotion, memory and action.

451. **Philosophy of Psychology** (3) GC 1987-88 Investigation of philosophical issues arising from current work in psychology including perception, reasoning, memory, motivation and action.

452. **Philosophy of Action** (3) GC Topics include the explanation of human action; the nature of intentional action; practical reason and deliberation; and the mental antecedents to action, especially desire and belief.

453. **Minds and Machines** (3) GC 1987-88 Philosophical problems arising from current work in artificial intelligence and cognitive psychology.

456. **Philosophy of Language** (3) GC Survey of basic issues in the philosophy of language such as: speech acts, reference, meaning, logical form.

457. **Pragmatics** (3) GC 1987-88 (Identical with Ling. 465)

463. **Frege and the Rise of Analytic Philosophy** (3) GC The writings of Frege on logic, language, and mathematics and their influence on contemporary philosophical thought.

470. **Greek Philosophy** (3) GC [Rpt./1] Topics in Greek philosophy. May be selected from the pre-Socratics, Socrates, Plato, Aristotle and post-Aristotelian philosophy. (Identical with Clas. 470).


473. **Natural Language Processing** (3) GC II 1988-89 (Identical with Ling. 473)

596. **Seminar**
   a. Ethics (3) [Rpt./2]
   b. Metaphysics (3) [Rpt./2]
   c. Epistemology (3) [Rpt./2]
   d. Logical Theory (3) [Rpt./2]
   e. Social and Political Philosophy (3) [Rpt./2]
   f. Philosophy of Law (3) [Rpt./2]
   g. Philosophy of the Physical Sciences (3) [Rpt./2]
   h. Philosophy of the Behavioral Sciences (3) [Rpt./2]
   i. Philosophy of Mind (3) [Rpt./2]
   l. Philosophy of Language (3) [Rpt./2]
   m. Theory of Value (3) [Rpt./2]
   p. History of Philosophy: Classical (3) [Rpt./2]
   q. History of Philosophy: Recent (3) [Rpt./2]
   r. Philosophical Psychology (3) [Rpt./2]
   s. Philosophy of Mathematics (3) [Rpt./2]
   t. Special Problems (3) [Rpt./2]
   v. Philosophy and Cognitive Science (3) [Rpt./2]

**PHYSICAL EDUCATION**

(See Exercise and Sport Sciences)

**PHYSICS**


Associate Professors Adam S. Burrows, Ke-Chiang Hsieh, Stephan W. Koch, Jay E. Treat (Emeritus)
The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in physics. Some interdisciplinary programs such as chemical physics, optics, and astrophysics are also available. Further information regarding these programs may be obtained from the department. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in physics. For information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

Prerequisites for admission to full graduate standing are thirty semester units of undergraduate work in physics. These will normally include the following work beyond introductory physics: appropriate laboratory work; one semester each of mechanics, thermodynamics, and optics; two semesters of electricity and magnetism; and two semesters of modern physics including quantum mechanics. All applicants must submit scores on the aptitude and advanced tests of the Graduate Record Examination.

An adviser is assigned to each graduate student to help plan a program for the advanced degree. Students without deficiencies are required to take, during the first week of classes, a qualifying comprehensive examination. As many as three attempts to pass this examination are permitted, but all students must pass it during the first four semesters of residence. Experience in teaching is an essential part of graduate training in physics. Graduate students are required to teach to an amount determined on an individual basis by the graduate adviser and the department as a whole. Graduate students are required to take 695 until the preliminary examination is passed.

Degrees

**MASTER OF SCIENCE** — At least fifteen of the required thirty units of graduate work must be in physics and must include 436, 511 and 515a or the equivalent. Also, each student must satisfy one of the following options: (1) write a thesis (for which up to six units may be allowed) and pass an oral examination on the thesis; (2) take 21 of the 30 required graduate units in physics and pass a comprehensive final oral examination; (3) pass the written and oral parts of the preliminary examination for the Doctor of Philosophy degree.

**DOCTOR OF PHILOSOPHY** — Each student must complete at least 36 units of graduate work in physics exclusive of the dissertation and the supporting (minor) work. Courses will be chosen in consultation with the graduate adviser. Each student must complete three of the following courses: 535, 550, 560, 581, 583a, and 685. The preliminary examination will cover classical mechanics, electromagnetic theory, relativity, statistical mechanics, experimental physics, quantum mechanics, modern physics, and questions on current developments. The courses 470a-470b, 511, 515a-515b, 528, and 570a-570b indicate the areas covered in the examination and the level of understanding expected of the student. The preliminary examination must be taken, at the latest, during the fifth semester (excluding summer sessions) of residence. It is expected that the dissertation, based upon original research, will be published in a refereed journal. The minor work may be satisfied within the Department of Physics and, in this case, some courses taken in other departments may be used as well. An additional twelve units of work, chosen in consultation with the graduate adviser, are required for the minor in physics. Proficiency in one foreign language is required. Information on methods of demonstrating proficiency may be obtained from the Department of Physics.

Students intending to minor in physics (to supplement a major in another department) should consult the physics minor adviser early in their graduate work.

Experimental research is conducted in the following areas: elementary particle physics, cosmic rays and space physics, solid state physics, atomic and molecular physics, nuclear physics, carbon dating, surface science, quantum optics, biophysics, and general relativity. Theoretical research is conducted in: solid state physics, atomic physics, nuclear physics, elementary particles, field theory, general relativity, cosmology, satellite and planetary dynamics, and nonequilibrium statistical mechanics. Prospective students should write to the department for information about specific research programs, the faculty involved, the facilities available, and the research and teaching assistantships or fellowship support which can be offered. It is the policy of the department to award financial aid in the form of teaching assistantships solely on the basis of the student's academic record and financial needs. Fellowships are also available to first-year graduate students.
402. Medical Physics (3) GC I CDT Basic physics of the human body: the principles of mechanics, electricity, sound, light, and radiation as they apply to physiology, with emphasis on instrumentation for diagnosis and treatment. P, 102b.


412. Theoretical Mechanics II (3) GC II CDT Continuation of 410; mechanics of the continuum; introduction to variational principles; Lagrange's equations. P, 410, Math. 254.

415a-415b. Electricity and Magnetism (3-3) GC CDT Electromagnetic phenomena; Maxwell's equations. P, 410 or Math. 422a.

420. Optics (3) GC I II CDT Electromagnetic waves; rays, interference, diffraction, scattering; applications to imaging systems, Fourier methods, holography, and crystal optics. P, 116, 121, Math. 223.

425. Thermodynamics (3) GC I II CDT Basic laws of thermal equilibrium; heat engines; ideal and non-ideal gases; phase transitions; introduction to irreversible processes, kinetic theory, and statistical mechanics. P, 110, 121, Math. 223.

430. Introduction to Biophysics (2) GC I CDT Concepts and experimental techniques of molecular biophysics; physical properties of biological macromolecules and cell organelles, optical interactions, macromolecular transitions, molecular mechanism or regulation. P, 102b, Chem. 103a-103b. (Identical with Micr. 430)

433. Physics Demonstrations (1-3) GC II Introduction to teaching materials and laboratory demonstrations illustrating principles of classical and modern physics, with emphasis on inexpensive techniques and direct experience. Advanced degree credit available for nonmajors only. P, two semesters of physics.

435. Introductory Quantum Theory and Atomic Spectra (3) GC I II CDT Introductory quantum mechanics; solutions of the Schroedinger equation for hydrogen-like atoms; perturbation theory; atomic structure; spectra of one and many electron systems; Zeeman-Faschen-Bach effects; hyperfine structure. P, 330, 410, Math. 254; CR 470a or Math. 413 recommended.

436. Applications of Introductory Quantum Theory (3) GC II CDT Applications of quantum theory to molecules, atomic nuclei, elementary particles and simple solids. P, 435.

440a-440b. Atomic and Molecular Spectroscopy for Experimentalists (3-3) GC CDT Experimental techniques to generate, analyze and detect photons from X-ray to IR; interpretation of spectra from gases, liquids, solids and biological macromolecules; light scattering, polarization. P, 330. (Identical with Opti. 440a-440b)

450. Introductory Nuclear Physics (3) GC II CDT Basic concepts of nuclear physics; structure and stability of the nucleus and its components, nuclear forces, nuclear reactions; energy loss of nuclear radiations. P, 330, Math. 254. (Identical with N.E.E. 450)

460, Introductory Solid-State Physics (3) GC I II CDT Properties of solids from molecular, atomic, and electronic theory; electric, magnetic, and thermal properties of metals, insulators, and semiconductors; free electron and band theories. P, 330.

470a-470b. Methods of Mathematical Physics (3-3) GC CDT Vector and tensor analysis; differential and integral equations; Green's functions; variational techniques; linear operator theory, with emphasis on physical applications. P, 410, Math. 254, CR 415a-415b.

482. Techniques in Particle Physics (3) GC II 1988-89 Classification of elementary particles and their interactions with matter, relativistic kinematics, detectors, data acquisition techniques, statistical techniques, analysis of experiments, cosmic radiation, and accelerators.

504. Introduction to Quantum Optics (3) II (Identical with Opti. 504)

511. Analytical Mechanics (3) I Laws of motion as developed by Newton, d'Alembert, Lagrange and Hamilton; dynamics of particles and rigid bodies. P, 410.


525. Advanced Thermodynamics and Kinetic Theory (3) II 1987-88 First and second laws of thermodynamics and their applications; Boltzmann transport equation; H-theorem; mean free path methods applied to viscosity, thermal conductivity, and diffusion. P, 425.

528. Statistical Mechanics (3) I Physical statistics; the connection between the thermodynamic properties of a macroscopic system and the statistics of the fundamental components; Maxwell-Boltzmann, Fermi-Dirac, Einstein-Bose statistics. P, 470b.

530. Biophysical Theory (2) II Physical concepts and theories describing biomolecular structure and function, molecular evolution, limits to structure, symmetry, oligomer and virus structure, organelle structure and function. (Identical with Micr. 530)
Advanced Atomic Physics (3) II 1988-89 Details of atomic structure; interactions of atoms with electromagnetic fields, electrons and ions; techniques for calculating unperturbed and perturbed energy levels, transition probabilities, and atomic interaction cross sections. P, 511, 515b, 570b.

Laser Physics (3) I (Identical with Opti. 543)

Nuclear Physics (3) I 1987-88 Theory of nuclear systems, including stability, decay, nuclear forces, scattering, reactions, structure, and interaction with electromagnetic radiation. P, CR 570a-570b.

Satellite and Planetary Perturbation Theory (3) II (Identical with Pty.S. 551)

Electrodynamics of Conducting Fluids and Plasmas (3-3) 1988-89 (Identical with Pty.S. 556a-556b)

Physics of the Solid State (3) II Elementary excitations in solids, phonons, electrons and holes, excitons, biexcitons, interaction of light with semiconductors, polaritons, high excitation phenomena, dielectric formalism of optical response, many-body effects in a Coulomb system. P, 460, 570, or Opti. 507 recommended but not formally required. (Identical with Opti. 560)

Quantum Mechanics (3-3) Principles of quantum mechanics; wave mechanics and matrix mechanics; applications to atomic structure and spectroscopy. P, 470a-470b suggested but not required.

Symmetry Groups in Physics (3) I Algebraic results of the theory of groups which find repeated applications in atomic, molecular, nuclear and particle physics. Continuous groups, Lie algebras, discrete groups, irreducible tensors. P, 570a-570b.

Theory of Relativity (3-3) 1987-88 Special theory of relativity and its application to mechanics and electrodynamics; tensor calculus and general relativity; relativistic astrophysics and cosmology. P, 470b.

Advanced Relativistic Quantum Mechanics (3-3) 1988-89 Continuous groups; scattering theory; relativistic wave equations; quantum electrodynamics, Feynman diagrams, dispersion theory, renormalization; strong and weak interactions. P, 515b, 570b.

Quantum Field Theory (3-3) 1988-89 Meaning of quantized fields; symmetry principles, free fields; general properties of interactions and peculiarities of electrodynamics and gravity. P, 570b, 577a.

Elementary Particle Physics (3) II 1987-88 Production, interaction, and decay of mesons, baryons and leptons; high energy scattering of elementary particles; particle classification and symmetries; theoretical interpretation. P, 436.

Plasma Physics and Thermonuclear Theory (3-3) 583a: II. 583b: I. (Identical with N.E.E. 583a-583b)

Stellar Pulsation (1-3) [Rpt./5] III Stellar pulsation, the solar atmosphere, solar seismology and long-term solar variability related to climate.

Seminar
a. Current Problems in Molecular Biophysics (1) [Rpt.] I II (Identical with Micr. 596a)

Quantum Optics (3) III 1988-89 (Identical with Opti. 643)

Graduate Physics Laboratory (3) [Rpt./2] II Introduction to modern research methods and experiments. Problems in low-temperature physics; solid-state, atomic, and nuclear spectroscopy; computer-based data acquisition and analysis; solar-energy physics; and others.

Colloquium
a. Current Problems in Physics (1) [Rpt.] I II

PHYSIOLOGY

(College of Medicine)

Associate Professors Andrew M. Goldner, Ziaul Hasan, Marc E. Tischler (Biochemistry)
Assistant Professors Janis M. Burt, Roger M. Enoka (Exercise and Sport Sciences), Patricia B. Hoyer, Richard J. Lemen (Pediatrics), Timothy W. Secomb, Stephen H. Wright
The department offers a program leading to the Doctor of Philosophy degree with a major in physiology. A Master of Science degree is offered only in rare instances when individuals who have already qualified to study for the Doctor of Philosophy are forced to terminate their graduate education.

In addition to the courses listed below, the Department of Physiology offers temporary courses in the following areas, subject to faculty availability and student interest: neurophysiology, renal physiology, physiology of muscle, endocrinology, peripheral vascular physiology, respiratory physiology, gastrointestinal and developmental physiology, membrane transport processes in physiology, and cardiac physiology.

Applicants must have completed the undergraduate major in the physical or biological sciences, in engineering, or in mathematics. Undergraduate preparation should include a minimum of one year of physics (including laboratory), mathematics through calculus (two semesters), a course in statistics, a course in organic chemistry, familiarity with microcomputers and BASIC language, and an introductory course in biology or zoology. In addition, physical chemistry and differential equations are highly desirable but not required. The Graduate Record Examination and three letters of recommendation are required to assist in evaluation of applicants.

Graduate study programs are individually planned after consideration of the student's preparation and special interests. Research facilities are available for studies of the dynamics and control of microcirculation, contraction of muscle and its membrane phenomena, reflex regulation of muscle activity, comparative renal tubule transport and water balance, cellular aspects of transport, reproductive endocrinology and hormone action, development of the gastrointestinal system, cellular and membrane aspects of cardiac function, and the dynamics of respiratory function. In special circumstances, dissertation research may be done outside the department.

Due to the specialized nature of the material and equipment required, some limitation of course enrollments may be necessary. Medical students will be given preference in those courses which are required for the Doctor of Medicine degree program. All other students must consult the department before enrolling. Students already admitted to graduate degree programs in departments of the College of Medicine will be given preference.

418. Physiology for Engineers (4) GC I Designed to bring to engineering students an awareness of the structure and function of whole organisms, their component organs, and organ systems. Open to nonmajors only. (Identical with A.M.E. 418, Ch.E. 418 and E.C.E. 418)

419. Physiology Laboratory (2) GC I Lab. experiments in physiology intended to provide experience with organ systems and measurement techniques. Designed for engineering students enrolled in the clinical engineering and biomedical engineering options. 6L. Open to nonmajors only. P, 418 or CR. (Identical with A.M.E. 419, Ch.E. 419 and E.C.E. 419)

480. Human Physiology (4) GC II Principles of physiology with emphasis on the human; designed primarily for students in pharmacy and health related sciences. Open to pharmacy majors; others consult dept. before enrolling. P, Chem. 243b, Math. 123, Phys. 102b, CR 481. (Identical with Tox. 480)

481. Physiology Laboratory (1) GC II Experiments intended to reinforce principles of physiological phenomena; designed primarily for students in pharmacy and health related sciences. Open to pharmacy majors; others should consult department before enrolling. P, Chem. 243b, Math. 123, Phys. 102b, CR 480. (Identical with Tox. 481)

495. Colloquium a. Introduction to the Neurosciences I (2) GC (Identical with Med. 495a, which is home) b. Introduction to the Neurosciences II (2) GC (Identical with Med. 495b, which is home)

503. Cellular Physiology (3) I Fundamental responses of living organisms to environmental changes. Mechanisms which operate at the cell level, including transmembrane homeostasis, energy metabolism maintenance, cell volume regulation and responses to environmental stimuli. P, Chem. 103b, 104b, 241b, 243b; Phys. 102b; Math. 125a-125b.

600. Mathematical Techniques in Physiology (3) I Application of quantitative and analytical mathematical techniques to selected areas of physiology; introduction to mathematical approaches commonly used in physiology. Open to majors and minors; others consult department before enrolling. P, Math. 125a-125b, 160.

601. Human Physiology (8) II Principles of physiology, with emphasis on that of the human. P, Chem. 103b, 104b, 241b, 243b; Phys. 102b. Consult department before enrolling.

602. Readings in Physiology (2) II Designed to provide students with more detailed consideration of various organ systems than can be provided in 601. Open to majors and minors only. P, Chem. 103b, 104b, 241b, 243b, Phys. 102b, CR Psio. 601.
DEPARTMENTS AND COURSES OF INSTRUCTION

605. **Neurosciences (6) II** (Identical with Anat. 605)

606. **Readings in Neuroscience (4) II** Essentials of mammalian neural structure and function. Open to majors and minors, others by permission of instructor. Not recommended for students whose major interests lie in the neurosciences.

610. **Research Methods in Physiology (1 - 3) [Apt] I II** Lab. course stressing the principles of physiological research.

695. **Colloquium**
   a. **Motor Control (2) [Rpt./8 units] II** (Identical with Ex.S.S. 695a)

696. **Seminar**
   a. **Advanced Mammalian Physiology (1 to 4) [Rpt./1] II** Open to majors and minors, others by permission of instructor. P, 600, 601, 602; 606 or Anat. 605.
   b. **Literature (1) [Rpt./5] I II** Open to majors only. P, 600, 601, 602; 606 or Anat. 605.

801. **Human Physiology (8) II**

805. **Neurosciences (6) II** (Identical with Anat. 805)

891. **Preceptorship**
   a. **Physiology (3 to 12) [Rpt./12 units] II**

PLANETARY SCIENCES


Associate Professors William V. Boynton, Robert B. Singer

Assistant Professors Jonathan I. Lunine, Timothy D. Swindle

The department offers multidisciplinary programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in planetary sciences. Areas of specialization include experimental, observational, and theoretical study of planetary atmospheres; the interiors of the planets and satellites; asteroid and cometary astronomy and physics; the surfaces of the moon, terrestrial planets, and outer-planet satellites; meteoritics, lunar science, and problems of plasma physics associated with cosmic rays; the solar wind and its interaction with solar system bodies. Students are normally admitted to the doctoral program only. In certain circumstances, however, the Master of Science degree may be an appropriate intermediate or terminal degree.

Applicants should have completed the undergraduate major in a physical science such as astronomy, atmospheric sciences, chemistry, geology, or physics. Applicants must submit scores on the aptitude and advanced (chemistry, geology, or physics) tests of the Graduate Record Examination and names of three references. When possible, personal or telephone interviews are desirable.

The minor shall consist of at least 12 units in one of the following departments: mathematics, physics, chemistry, geosciences, or optical sciences. The majority of the courses should be 500 level or above and a “B” average must be maintained.

**Degrees**

**MASTER OF SCIENCE** — This program is available only in special circumstances. At least eighteen units in the major core program and a thesis suitable for publication are required.

**DOCTOR OF PHILOSOPHY** — All students must complete the fifteen-unit core program consisting of 505a-505b, 510, 517, and 554 (though exceptionally well-prepared students may have a portion of this requirement waived). An additional minimum of 21 units must be completed in a specialized area of planetary sciences. A specified competence in a modern foreign language is required. Students are expected to complete all requirements for the degree within three to four years following successful completion of the preliminary examination.

The Department of Planetary Sciences and the Lunar and Planetary Laboratory are active participants in many missions of the NASA space science program. The laboratory's
Space Imagery Center contains one of the most extensive collections of lunar and planetary photography in the world, including Ranger, Surveyor, Orbiter, and Apollo photography of the Moon; Mariner and Viking imagery of Mars; Mariner 10 imagery of Venus and Mercury; and Pioneer 10 and 11 and Voyager results for Jupiter and Saturn — all of which are available to students for research purposes. Also available for student research are the facilities of the University of Arizona's observatories, including 154cm, 1.5m, 1.0m, and 0.7m reflectors in the Santa Catalina Mountains north of Tucson, and 229cm, 0.9m, and 0.5m reflectors on Kitt Peak west of Tucson, as well as the Multiple Mirror Telescope on Mt. Hopkins, which is a joint project of the University of Arizona and the Smithsonian Astrophysical Observatory. Laboratory facilities for cosmochemistry and geochemistry include a scanning electron microscope, an experimental petrology laboratory, a radiochemistry separation laboratory, and a neutron activation analysis laboratory. The laboratory also maintains a state-of-the-art VICOM digital image processing system. A nuclear reactor located on campus and counting facilities in the Lunar and Planetary Laboratory are available for isotope research and activation analysis.

The University has a well-equipped computer center with CDC Cyber, VAX 11/780, and DECSystem-10 computers. The Lunar and Planetary Laboratory maintains a number of special-purpose computers, which can be used interactively for such special applications as inversion of Fourier interferograms and reduction of data from various space programs, and other student research projects.

403. **Introduction to the Solar System** (3) GC I Survey of planetology; origin of planets; asteroids; meteorites; interplanetary dust and gas; planetary interiors; geophysics; planetary atmospheres; origin of life. Advanced degree credit available only with departmental permission. P, Phys. 103a-103b. (Identical with Astr. 403 and Geos. 403)

404. **Exploration of the Solar System** (3) GC I S Primitive astronomy to modern space exploration; planetary science fundamentals, solar system physical properties; planetarium demonstrations, classroom projects. Field trip. Advanced degree credit available only with departmental permission. (Identical with Astr. 404)

419. **Global Tectonic Processes** (3) GC II (Identical with Geos. 419)


510. **Principles of Cosmochemistry** (3) I 1988-89 Chemical compositions of solar system objects; equilibrium and nonequilibrium chemical processes applied to planets; cosmochronology. P, 403, 480a-480b. (Identical with Geos. 510)

517. **Planetary Atmospheres** (3) I 1987-88 Survey of compositions, temperature and density profiles, chemistry, condensation products, spectroscopic evidence; circulations and heat budgets; evolution and origin of planetary atmospheres. P, 403.

518. **Remote Sensing Techniques in Astronomy and Planetary Science** (3) I 1987-88 Nature of radiant energy; optical and infrared detectors; error analysis; ultimate limits to system performance; photometry, polarimetry, and spectroscopy; high angular resolution. 2R, 3L. P, introductory physics and calculus. (Identical with Atmo. 518 and Astr. 518)

520. **Meteorites** (3) II 1988-89 Classification; chemical, mineralogical and isotopic composition; cosmic abundances; ages; interaction with solar and cosmic radiation; relation to comets and asteroids. P, 510. (Identical with Geos. 520)

527. **Advanced Geochemistry** (3) I (Identical with Geos. 527)

528. **Nuclear Geology** (3) II 1988-89 (Identical with Geos. 528)

544. **Physics of the High Atmosphere** (3) II 1987-88 Physical properties of the upper atmosphere, including gaseous composition, temperature and density, ozonosphere, and ionosphere, with emphasis on chemical transformations and eddy transport. (Identical with Atmo. 544)


554. **Evolution of Planetary Surfaces** (3) II 1988-89 The geologic processes and evolution of terrestrial planet and satellite surfaces including the Galilean, Saturnian and Uranian satellites. Course includes one or two field trips to Meteor Crater and other locales. P, 511, 403. (Identical with Geos. 554)

565. **Jovian Planets and Satellites** (3) I 1988-89 Observational data; atmospheric structure and composition; thermal balance; mass, radius, flattening; physics of light elements at high pressures; structure of rotating planets; origin of magnetic fields. P, 403.

567. **Inverse Problems in Geophysics** (3) I 1988-89 (Identical with Geos. 567)

571. **Constitution and Evolution of the Terrestrial Planets** (3) I 1987-88 Composition and evolution of terrestrial planets; includes the Moon, asteroids, meteorites, other evolved rocky satellites; geophysical/geochemical techniques used to deduce histories. (Identical with Geos. 571)

596. **Seminar**

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**PLANNING**

_Committee on Planning (Graduate)_

Professors Arthur L. Silvers (Management and Policy), Chairperson, Lay J. Gibson (Geography), Robert Giebner (Architecture), Frank Gregg (Renewable Natural Resources), David A. King (Renewable Natural Resources), James S. Lincoln (Management and Policy), Kirby W. Lockard (Architecture), Lawrence D. Mann (Geography), Fred S. Matter (Architecture), Richard L. Medlin (Architecture), Thomas F. Saarinen (Geography)

Associate Professors Stanley K. Brickler (Renewable Natural Resources), Harry der Boghosian (Architecture), Theodore H. Koff (Management and Policy), Gordon F. Mulligan (Geography), Ronald J. Vogel (Management and Policy)

Assistant Professors Robert Itami (Renewable Natural Resources), David Plane (Geography)

The Committee on Planning offers graduate professional programs leading to the Master of Science degree with a major in planning. Concentrations are offered in the fields of policy and planning (Management and Policy; College of Business and Public Administration), regional planning (Geography; Faculty of Social and Behavioral Sciences) and community design (College of Architecture). All students pursuing the M.S. with a major in planning are required to complete a basic core program consisting of fifteen units. The core includes PIng. 457, 602, 605, 609 and 612b.

The concentration in policy and planning provides training for a variety of staff-level careers in state and local government. Competence in problem solving in the public sector is strengthened by combining analytic, computer, financial and social science courses with hands-on experience through workshops and field internships. Areas of specialization are land use and the environment, health care, services for the elderly and public facility planning. In addition to the basic core, students in the concentration in policy and planning must complete M.I.S. 501, PIng. 608 and 612a, Econ. 500a, M.A.P. 610a and 693g.

The concentration in regional planning provides a strong grounding in location and spatial analysis, environmental behavior, and in legal/political institutions for regional infrastructure and development planning. Students are involved in actual field applications and are exposed to professional and faculty expertise. Areas of specialization are land use and the environment, regional development, techniques for regional analysis, and transportation and human interaction. In addition to the basic core, students in the program in regional planning must complete PIng. 503, 556, 557, 608 and 659.

444. **Site Planning** (2) GC II (Identical with Arch. 444)

453. **Location Analysis** (3) GC II (Identical with Geog. 453)

456. **Urban Geography** (3) GC I (Identical with Geog. 456)

457. **Statistical Techniques in Geography and Planning** (3) GC I (Identical with Geog. 457)

461. **Population and Resources** (3) GC I (Identical with Geog. 461)

463. **Community Agencies and Human Services** (3) GC II (Identical with M.A.P. 463)
468. Urban Transportation Planning (3) GC II CDT. (Identical with C.E. 468)
471. Problems in Regional Development (3) GC I II (Identical with Geog. 471)
473. Geology and the Urban Environment (3) GC II (Identical with Geos. 473)
474. Planning the Built Environment (2) GC I (Identical with Arch. 474)
476. Metropolitan Land Development (3) [Rpt./1] GC I II S (Identical with Geog. 476)
481. Computer Cartography (3) GC II (Identical with Geog. 481)
483. Geographic Applications of Remote Sensing (3) GC II (Identical with Geog. 483)
485. Zoning Fundamentals (3) GC I (Identical with M.A.P. 485)
497. Workshop
   i. Community Design for Non-Designers (3) GC I (Identical with Arch. 497i which is home)
506. Fundamentals of Physical Planning (3) I (Identical with M.A.P. 506)
507. Social Service Planning (3) I (Identical with M.A.P. 507)
510. Development of Regional Planning (3) I (Identical with Geog. 510)
511. Metropolitan and Regional Planning (3) I (Identical with Geog. 511)
556. Urban Systems Analysis (3) II (Identical with Geog. 556)
557. Spatial Analysis (3) II (Identical with Geog. 557)
561. Resource Management (3) I (Identical with Geog. 561)
563. Perception of Environment (3) III (Identical with Geog. 563)
565. Quick Response Transportation Planning Methods (3) II 1987-88 (Identical with C.E. 565)
575. Housing and Residential Areas (3) II (Identical with M.A.P. 575)
596. Seminar
   u. Interdisciplinary Environment-Behavior-Design (3) I (Identical with Idis. 596u, which is home)
597. Workshop
   a. Architecture (3 to 8) [Rpt.] II (Identical with Arch. 597a, which is home)
602. Analytic Methods in Planning and Management (3) II Methods and models for program planning and policy analysis; forecasting, service demand, facility location in capital investment programming, task sequencing, program analysis and evaluation. P. 457 or M.A.P. 552. (Identical with M.A.P. 602)
605. Planning Theories and Perspectives (3) I (Identical with Geog. 605)
608. Planning Law (3) II (Identical with Geog. 608)
609. Policy Problems in Structure and Change (3) II (Identical with M.A.P. 609)
611. Projects in Regional Planning (1 to 5) [Rpt./5 units] II (Identical with Geog. 611)
612a-612b. Projects in Policy and Planning (2-3) (Identical with M.A.P. 612a-612b)
651. Health and Public Policy (3) II (Identical with M.A.P. 651)
655. Efficiency Analysis in Health Administration (3) II (Identical with M.A.P. 655)
659. Growth Controls (3) II (Identical with Geog. 659)
662. Aging and Public Policy (3) I (Identical with M.A.P. 662)
669. Preservation of Historic Environments (3) II 1987-88 Current planning and legal methods to enhance the preservation of historic urban areas and structures; concentrated analysis of selected case studies. Field trips. (Identical with Law 669)
693. Internship
   g. Policy and Planning (1 to 4) S (Identical with M.A.P. 693g, which is home)
696. Seminar
   h. Land-Use Regulation (3) I II (Identical with M.A.P. 696h, which is home)
   i. Legal Inquiry in Policy and Planning (3) II (Identical with M.A.P. 696i, which is home)
   j. Environmental Planning (3) I II (Identical with M.A.P. 696j, which is home)
   k. Planning Administration (3) I II (Identical with M.A.P. 696k, which is home)
   o. The General Plan (3) [Rpt./6 units] II (Identical with Geog. 696o, which is home)
   p. The Land Development Process (3) [Rpt./6 units] II (Identical with Geog. 696p, which is home)
PLANT PATHOLOGY

Associate Professors H. Earl Bloss, Iraj J. Misaghi
Assistant Professors Martha C. Hawes, Alan J. Howarth

The department offers programs leading to the Master of Science and Doctor of Philosophy degrees with a major in plant pathology. Concentrations are available in bacteriology, mycology, nematology, virology, physiology of parasitism, genetics of pathogens, diseases of economically important plants, and in soilborne fungi.

Applicants should have a background in the botanical sciences and undergraduate credit in college algebra, trigonometry (calculus is also recommended), statistics, microbiology, genetics, physics, and two years of organic chemistry.

At least fifteen units in plant pathology must be completed for the master's degree. A decision to require or waive the requirement for a master's degree thesis will be made after consideration of the student's preparation, proposed graduate program, and professional objectives.

For information concerning the Doctor of Philosophy degree see *Requirements for Doctors' Degrees/Doctor of Philosophy* elsewhere in this catalog.

402. **Introduction to Pesticides and Their Use** (2) GC II Overview of pesticide use, with emphasis on interaction of technical, societal, individual, and regulatory aspects of the choices; specific control recommendations are not stressed. (Identical with Ento. 402, Pl.S. 402, and S.W. 402)

407. **Methods in Plant Pathology** (4) GC I Techniques used in the study of bacterial, fungal, nematode, and virus diseases of plants. 2R, 6L. P, 206, Micr. 110.

451. **Diagnosis and Control of Plant Diseases** (3) GC I Field and lab. course designed to give students familiarity with diagnosis of plant diseases and plant disease control concepts. 2R, 3L. All-day field trips. P. 206. (Identical with Micr. 451)


516. **Plant Nematology** (3) II 1988-89 Comprehensive course in plant nematology, including the nature, ecology, and classification of plant parasitic nematodes. Diagnosis and control of nematode diseases of plants. 2R, 3L. P, 205.

520. **Analytical Techniques for Phytopathological Research** (4) II Techniques, including chromatography, electrophoresis, spectroscopy, and immunology. 2R, 6L. P, 206.

575a-575b. **General Mycology** (3-3) 1988-89 Comprehensive study of fungi, including their structure, function, classification, genetics, and ecological importance. 575a: Basidiomycetes and Fungi Imperfecti. 575b: Myxomycetes, Phycomycetes, and Ascomycetes. 2R, 3L. P, Ecol. 104 or Pl.S. 100. 575a is not prerequisite to 575b.

596. **Seminar**
   a. Current Research (1-3) II


611. **Plant Virology** (3) I 1987-88 Comprehensive study of the physiology, epidemiology, pathology and classification of viruses attacking plants. 2R, 3L. P, 205, Bioc. 460.


694. **Practicum**
PLANT PROTECTION

Committee on Plant Protection (Graduate)

Professors Thomas C. Tucker (Soils, Water and Engineering), Chairperson, Stanley M. Alcorn (Plant Pathology), Keith C. Hamilton (Plant Sciences), Michael E. Stanghellini (Plant Pathology), Theo F. Watson (Entomology)

Associate Professors Paul M. Bessey (Plant Sciences), Dennis L. Larson (Soils, Water and Engineering)

The Committee on Plant Protection, an interdepartmental committee in the College of Agriculture, offers a program leading to the Master of Science degree with a major in plant protection.

Concern in contemporary society for the quality of our environment has led to legislation on the use and applications of many chemicals used in the management of agricultural pests. The program provides the broad training that will be needed by individuals to apply and make recommendations for chemicals used to control insects, diseases, and weeds in integrated systems of pest management. The primary objective of this program is to impart the philosophy that plant protection is based on the integration of all known control measures (biological, cultural, chemical) designed to maintain pest densities below economically damaging thresholds while producing a minimal impact on the environment.

Successful applicants may be from any undergraduate discipline provided that they have an appropriate background in the physical and biological sciences. Financial assistance is not available through the Committee on Plant Protection.

Students will be assigned to an adviser in one of the participating departments, chosen on the basis of the student’s interest and area of concentration. All students are required to complete Ento. 410, 430 and one additional unit; PI.P. 402 and 451; 405; S.W. 602; three units of biometry; three to six units of either 599/699, 900, or 910; and one to three units of either 595, 596, or 696.

In addition, the student’s guidance committee may approve additional courses such as Agri. 493; M.C.B. 460; Ecol. 472, 432, 436, and 438; Pl.S. 408; or A.En. 450 and A.En. 451.

PLANT SCIENCES


Associate Professors Kaoru Matsuda, Hiroshi Muramoto (Emeritus)


The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in agronomy and plant genetics or in horticulture. Research areas include agronomy, plant breeding, plant genetics, horticulture, plant physiology, and plant molecular biology.

Preference will be given to applicants with undergraduate majors in agriculture or biological sciences. Prospective applicants should consult the graduate coordinator, Department of Plant Sciences, for specific requirements in their major.

Applicants should arrange to have three letters of recommendation sent to the graduate coordinator, Department of Plant Sciences. The decision to require or waive the requirement for
the master's thesis will be made by the department after consideration of the student's preparation, proposed graduate program, and professional objectives. The Master of Science thesis requirement may be fulfilled for a student who is a senior author of a manuscript published or accepted for publication in a refereed professional journal approved by the graduate student's committee.

402. Introduction to Pesticides and Their Use (2) GC II (Identical with PI.P. 402)

405. Weed Control (3) GC I Principles and effects of controlling agronomic and horticultural weeds, with emphasis on chemical control methods; weed identification. 2R, 3L. P, 6 units of plant sciences. Hamilton

408. Crop Ecology (3) GC II Physical and biotic environment of crops in relation to crop culture, production, and geographical distribution; relations among the human population, crop productivity, and man's environment. P, 110.

421. Research Methods in Plant Sciences (3) GC I Principles and techniques used in the design and evaluation of experiments including hypothesis development, plot design, and data collection and evaluation. 2R, 3L. P, Math. 117e. Hofmann

452. Advanced Vegetable Crops (3) GC II 1988-89 Environmental factors affecting germination, growth, development, maturation, and quality of vegetable crops; physiological problems unique to vegetables; presentation and interpretation of recent research progress. P, 351, Ecol. 260 or M.C.B. 460. Kobringer Coons

466. Postharvest Physiology (1) GC II 1987-88 Biochemical and biophysical changes associated with the maturation, ripening and senescence of harvested horticultural plants. P, Chem. 241a, Ecol. 260 or M.C.B. 460. (Identical with N.F.S. 466)


472. Seed Physiology (1) GC II 1987-88 Physiology of seed development, germination and dormancy. P, Ecol. 260 or M.C.B. 460. Lehle

482. Plant Cell and Tissue Culture (3) GC II Principles and theory of callus induction, embryoid and plantlet regeneration, nutrient transport, protoplast culture and fusion and cell suspension. 2R, 3L. P, Ecol. 260. Katterman

509. Information Sources for Agricultural Scientists (1) I Information systems and retrieval techniques, with particular reference to concepts, uses and limitations; emphasis on abstracts, indexes, alerting services, journals and government documents. (Identical with Li.S. 509) McDaniel

528. Plant Microtechnique (4) II 1987-88 Theory and practice of plant histological technique, including the use of light and electron microscopes and accessory equipment. P, twelve units of plant sciences or biology. Bartels


562. Plant Intermediary Metabolism (3) II 1988-89 (Identical with M.C.B. 562)

564. Plant Growth and Development (3) II 1987-88 (Identical with M.C.B. 564)

609. Scientific Communication and Research Funding Methods (1) II 1987-88 Techniques and limitations of written, oral, and visual scientific communication; procedures and policies for research funding sources. McDaniel

627. Advanced Genetics (3) I 1988-89 Strand and tetrad analysis; chromosome structure and organization; recombination at the molecular level and gene conversion; mutation classifications and origins; genetic complementation and its relation to a genetic unit and its function. P, 312 or Ecol. 320. (Identical with Gene. 627) Ray


635. Advanced Cytogenetics (4) II 1987-88 Fundamental principles that illustrate the correlation of genetic and cytological features involving intra- and interchromosomal structural changes, heteroploidy and species hybrids. 3R, 3L. P, 6 units of gene. (Identical with Gene. 635) McCoy

696. Seminar
a. Plant Science (1) [Rpt./4] I II
POLITICAL SCIENCE


Assistant Professor Lyn Ragsdale

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in political science. Concentrations are available in political theory, American political institutions, public policy, political behavior, international relations, and comparative politics. The Master of Arts degree is designed as a basis for students who plan to continue into a Ph.D. program. In addition, the department also designs programs for students interested in government careers, community college teaching, or specialization in selected areas such as policy and environment or for self-improvement. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree. For information concerning this degree, see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

Applicants must submit scores on the Graduate Record Examination, two letters of recommendation, and the personal data called for on the department’s information form. Applicants are also invited to submit any other evidence, including published materials, which they believe to be relevant to admission.

Programs are planned, in consultation with an advisory committee, around the student’s principal area of interest, emphasizing one or more of the areas of concentration listed above.

Degrees

MASTER OF ARTS — Each student must specialize in either one or two of the six fields of concentration listed above and complete at least 30 units of course work with at least 24 units at the 500 and 600 levels. A supervised research paper is required and, depending upon the student’s principal interest, reading knowledge of a foreign language may be required. The final master’s examination will be based upon the chosen area or areas of concentration.

DOCTOR OF PHILOSOPHY — In addition to an area of concentration, each student must prepare in two additional fields prior to the preliminary examination. Either two foreign languages or one foreign language at high proficiency or advanced training in methodology are required. Finally, each student must complete two supervised original research papers prior to taking the preliminary examination. The department may waive the requirement for a qualifying examination for a student who has received the master’s degree at the University of Arizona.

406. Bureaucracy (3) GC I Analyses of legal, political, cultural, and behavioral aspects of public organizations, bureaucratic typologies, and methods of public control.

407. Congress and American Politics (3) GC I II Examination of election politics, personalities, and career patterns of congressional members, the organization and structure of Congress, and the role of Congress in policy leadership and representation of the public.

409. Struggle for the Presidency (3) GC I Examination of the campaign strategies and tactics of those seeking the nation’s most powerful office from 1960 to the present through films and readings.

412. Local Government and Administration (3) GC I II Examination and analysis of local decision-making structures and their policy outputs. P. 103.

421. Ancient and Medieval Political Theory (3) GC I Development of Western political theory from the Greeks to Machiavelli.

422. Early Modern Political Theory (3) GC II Western political theory from Machiavelli to Marx.

423. Recent Political Thought (3) GC II Political theory from Marx to the present.
282 DEPARTMENTS AND COURSES OF INSTRUCTION

426. **American Political Thought** (3) GC II American political ideas from colonial times to the present.

431. **Political Culture and the Dynamics of Change in American Society** (3) GC I Examination of the manner in which attitudes about politics and political problems are acquired from exposure to music and television, and the manner in which such attitudes lead to political action.

432. **Pressure Groups** (3) GC I II Formation, structure, and place of pressure groups in the democratic society; the function of interest groups in the political process; problems of leadership, internal organization, and membership loyalties.

434. **Quantitative Analysis of Political Problems** (3) GC I Introduction to the use of statistics on political data, with emphasis on statistical manipulation; evaluation and interpretation of statistical explanations of political phenomena.

435. **Public Opinion and Voting Behavior** (3) GC I II Attitude and opinion formation and socialization; public opinion in the political process; the relationship between attitudes, opinion, and voting behavior in American politics. (Identical with SOC. 435)

436. **Personality and Politics** (3) GC II Examination of the theories and concepts associated with the psychological basis of various types of political behavior.

437. **Democracies, Emerging and Evolving** (3) GC I Causal analysis of conditions of stability and breakdown of democratic regimes with particular emphasis on the developing democracies of the third world.

438a-438b. **Philosophy of Law** (3-3) GC (Identical with Phil. 438a-438b)

440. **Politics and Mythology** (3) GC I The role of the non-rational/irrational in politics: cults, utopias, crusades, conspiracies, cultural revitalization movements.

441. **Arab-Israeli Conflict** (3) GC I II Traces the birth and growth of the Arab-Israeli conflict since 1948 with particular attention to the internal impediments to conflict resolution on both the Arab and Israeli sides. Also surveys the role of the Great Powers in Middle East politics generally. (Identical with Or.S. 441)

442. **Transformation of Agrarian Societies in the Middle East** (3) GC II (Identical with Or.S. 442)

443. **Soviet Politics** (3) GC I Revolution and contemporary ideology; state, party, and mass organizations; economic and social planning; civil liberties; models of authoritarianism.

444. **East European Politics** (3) GC II Divergent models of Communist development, from East Germany to Yugoslavia; political, economic, social, and cultural reform.

445. **Comparative Political Revolution** (3) GC I Examination of the causes and consequences of 20th-century revolutions and the revolutionary process, with emphasis on contemporary events.

446. **Politics of Developing Areas** (3) GC II Survey of politics and problems in Asia, Africa, and Latin America, including political violence, elections, bargaining, elites, parties, the military, and ideology.

447. **Latin-American Political Development** (3) GC II Presentation of strategies for development in Latin America; examination of case studies from Cuba, Brazil, Chile, Guatemala, and other countries.

448. **Government and Politics of Mexico** (3) GC I Description and analysis of Mexico's political economy, its political system, and its foreign policy, with emphasis on Mexican-U.S. relations. (Identical with M.A.S. 448)

449. **The Politics of Cultural Conflict** (3) GC II Comparative examination of the approaches of different types of political systems to domestic conflict of a racial, religious, linguistic, and/or ethnic nature.

451. **Soviet Foreign Policy** (3) GC I Ends and means of Soviet foreign policy; the decision-making process; Soviet relations with the West and developing nations.

452. **Communist Foreign Relations** (3) GC II Interrelations of fourteen Communist-party states, with emphasis on cooperation and conflict in such organizations as the Comecon and the Warsaw Pact.

454. **Theories of International Relations** (3) GC I Introduction to theories of international relations on the levels of man, the nation-state, and the international system, with a logical and empirical evaluation of approaches and theories.

455. **American Foreign Policy** (3) GC I II Analysis of the Cold War; Congressional-Executive clashes over foreign policy control; approaches to policy analysis.

456a-458b. **International Law** (3-3) GC 456a: The international state system; legal-political problems, including territory, environment, seas. 456b: The international system and the individual; the war system, including use of force, laws of war. 456a is not prerequisite to 456b.

457. **Inter-American Politics** (3) GC I Survey and analysis of the leading political and economic issues at controversy between the United States and Latin America.

458. **Government and Politics of the Middle East** (3) GC II (Identical with Or.S. 458)
Problems of World Order (3) GC II Analysis of complex, interrelated global problems, threats to survival, quality of life, and exploration of past and present policies and future worlds. Course is value-oriented and prescriptive.

Modern Chinese Foreign Relations (3) GC II Survey of the developments and trends in Chinese foreign relations in the modern period, focusing mainly on the relationship between the theoretical and actual objectives of China's foreign policies from 1949 to the present. (Identical with Or.S. 460)

International Relations of East Asia (3) GC II National interests, issues and conflicts, relations, and influence of domestic politics in interstate relations in East Asia. (Identical with Or.S. 464)

Population and Development in the Middle East (3) GC I (Identical with Or.S. 467)


Constitutional Law: Civil Liberties (3) GC I II Analysis of the constitutional guarantees of civil liberties in the U.S.

Administrative Law (3) GC I Law governing the organization, powers, and procedures of the executive and administrative establishment, with emphasis on the limitations imposed by the American constitutional system.

Concepts in Criminal Law (3) GC II Focus on questions such as what constitutes a crime; when is killing murder; what makes punishment just; what distinctions exist between justifiable and excusable crimes.

Women and the Law (3) GC I 1988-89 Legal status of women in America, including constitutional protections, marriage and family relationships, educational and vocational opportunities, political rights, criminal law. (Identical with W.S. 476)

Formation of Public Policy (3) GC I Needs and demands for public action on policy issues; organization and nature of political support; processes and problems of decision making in the formation of public policy at the national, state, and local levels.

Environmental Policy (3) GC II Role of government in management of energy, natural resources and environment; process and policy alternatives; special attention to the Southwest. (Identical with W.R.A. 481 and R.N.R. 481)

Urban Public Policy (3) GC I II Analysis and discussion of social, economic, and political problems and proposed solutions in changing urban environments.

Development of Federal Indian Policy (3-3) GC 484a: European colonial precedents through the treaty-making period. 484b: End of treaty-making to the present. 484a is not prerequisite to 484b. (Identical with A.In.S. 484a-484b)

National Security Policy (3) GC I Decision-making structures, processes, and outcomes relevant to American security policy; comparison with major foreign powers.

Political Systems of India and Pakistan (3) GC II (Identical with Or.S. 486)

Race and Public Policy (3) GC I Examination of the race issue in the context of American politics, from historical, behavioral, and comparative perspectives. (Identical with A.In.S. 487 and B.I.S. 487)

The Politics of National Policymaking (3) GC I II Analysis of institutional and political basis for cooperation and conflict between Congress, the President, and the Court in different policy areas.

Research Design (3) I Introduction to experimental and quasi-experimental research design; survey research; the use of aggregate statistics; historical documents and life-history materials; participant observation; unobtrusive methods.

Methods of Political Inquiry (3) I II Systematic examination of problems of scope and methods of inquiry in the discipline of political science; intended to acquaint students with the discipline and to prepare them for scholarly research in the field.

Research and Methodology (4) II Quantitative techniques and computer applications in political science.

Political Risk and Intelligence Analysis (3) II Examination of political risk and intelligence analysis with emphasis on forecasting political developments in nations.

Colloquium
a. American Political Institutions (3) I II
b. Political Behavior (3) I II
c. Survey of Political Theory (3) I II
d. Comparative Politics (3) I II
e. International Relations (3) I II
596. Seminar
   a. American Political Institutions (3) [Rpt./2] I II
   b. Political Behavior (3) [Rpt./2] I II
   c. Political Theory (3) [Rpt./2] I II
   d. Comparative Politics (3) [Rpt./2] I II
   e. International Relations (3) [Rpt./2] I II
   f. Public Law and the Judicial Process (3) [Rpt./2] I II
   g. Public Policy (3) [Rpt./2] I II
   h. American Indian Law and Policy (3) [Rpt./2] I II (Identical with A.In.S. 596h)
   i. Water and Equity in the Southwest (3) I II (Identical with R.N.R. 596i)

610a-610b. Fiscal and Budgetary Administration of Public Agencies (3-3) (Identical with M.A.P. 610a-610b)

PORTUGUESE
(See Spanish and Portuguese)

PSYCHOLOGY


Associate Professors Harold S. Arkowitz, Wayne R. Carroll, Lewis Hertz, Alfred W. Kaszniaik, Ronald H. Pool, Rosemary A. Rosser, Linda Swisher (Speech and Hearing Sciences), William H. Thweatt, Elizabeth B. Yost

Assistant Professor Jeff L. Greenberg

The department offers programs designed for students seeking completion of the Doctor of Philosophy degree with a major in psychology. Concentrations are available in clinical psychology (clinical neuropsychology, psychopathology and affective disorders, health psychology and cross-cultural psychology), cognitive psychology (perception and attention, psycholinguistics, cognitive neuropsychology, environmental cognition), psychobiology (neurobiology, psychobiology, animal behavior, cognitive neuroscience), and law, psychology and policy (law and social science, mental health policy, and health policy).

Applicants should contact the department early to obtain departmental application materials since the deadline for receipt of completed materials is February 1. Applicants must submit scores on the aptitude and advanced (psychology) tests of the Graduate Record Examination. Law, psychology and policy concentration applicants interested in concurrently pursuing the J.D. degree must apply separately to the College of Law.

400. Methods of Neurological Psychology (3) GC I II Group discussion, demonstrations and experiments on current problems in neuropsychology. Problems selected to permit students to integrate laboratory techniques, research literature, and anatomical and physiological knowledge with behavioral theory. P, 101, 255, 302.

401. Body Chemistry and Behavior (3) GC I Biochemical compounds related to life and the role of behavior in life; chemical processes occurring within organisms and how they interact with behavior. P, 101; and 302 or 8 units of biological lab. science.

402. Principles of Neuroanatomy (4) GC II (Identical with Anat. 402)


412. **Animal Learning** (3) GC II Animal learning with emphasis on interspecies comparisons. P, 255.

414. **Personality and Social Development** (3) GC I II Research and theory in developmental psychology with an emphasis on social cognition, social and emotional growth. P, 255, 313.

415. **Cognitive Development** (3) GC II Introduction to major theories, methods, and research findings associated with the development of cognition and intelligence. P, 255, 313.

416. **Advanced Personality** (3) GC I II Advanced study of theories of personality; methods and results of personality study. P, 255, 316.

418. **Abnormal Psychology** (3) GC I II Nature and etiology of various forms of behavior disorder, mental deficiency, and other deviations; critical evaluation of current theories. P, 255.

421. **Psychology of Death and Loss** (3) GC I II Basic concepts in a psychology of death and loss, with emphasis on both the adjustment to death and loss, and the underlying phenomenal, humanistic and current social considerations. P, 255 or graduate standing.

428. **Field Methods in Environmental Psychology** (3) GC II Behavior in man-made or managed environments, with emphasis on objective methods; designed for students having a professional interest in environmental design or management. P, 371 or graduate standing. (Identical with Arch. 428 and L.Ar. 428)

430a-430b. **Psychology, Law and Social Policy** (3-3) GC Critical review of theory, methods and research in the psychology, law and social policy interface. P, 255, 300, 6 units of a social science, or graduate standing. 430a is not prerequisite to 430b.

435. **Psychological Problems of the Aged** (3) GC I Cognitive, intellectual, personality, and behavioral correlates of aging; relates general psychological theory to the problems of aging. P, 255; or 101 and two courses on gerontology; or graduate standing. (Identical with Gero. 435)

450. **Psychological Assessment and Testing** (3) GC I II Evaluation of assessment processes and of measurements of intelligence, aptitudes, personality, and interests; test theory; social implications. P, 255.

454. **Culture and Mental Health** (3) GC I Mental health in cross-cultural perspective; universal and culture specific disorders, traditional and western psychotherapy, cultural values in treatment methods and in research. P, 101, 418.

458. **Psychopathology** (3) GC II In-depth study of current theoretical and research formulations in behavior deviancy; various approaches to behavior change. P, 255.

472. **Human Memory and Cognition** (3) GC II Human learning, memory, and cognition; emphasis on information-processing approach to results and theory. P, 255, 370; or grad. standing.

473. **Natural Language Processing** (3) GC II (Identical with Ling. 473)

474. **Cognitive Neuroscience** (3) GC II Neural mechanisms of higher mental function, including learning, memory, thought, and consciousness. P, 255, 302.

475. **History of Psychology** (3) GC I Growth of psychology as a science; major schools and theories; contributions of famous investigators and major advances; psychology as an art and a science today. P, 255 and 6 upper-division units in psychology.

481. **Topics in the Biological Bases of Behavior** (3) [Rpt./1] GC I II Variable content (consult schedule): physiological, neurological, sensory, and motor systems; comparative psyc., others. P, 255 and 6 units upper-division psychology; or graduate standing.

482. **Topics in the Cognitive and Affective Bases of Behavior** (3) [Rpt./1] GC I II Variable content (consult schedule): learning, cognition, perception, psycholinguistics, emotion, others. P, 255 and 6 units of upper-division psychology; or grad. standing.

483. **Topics in Social Bases of Behavior** (3) [Rpt./1] GC I II Variable content, including developmental psychology, personality, psychopathology, and others. Consult schedule. P, 255 and 6 units of upper-division psychology; or grad. standing.

484. **Topics in Individual Bases of Behavior** (3) [Rpt./1] GC I II Variable content (consult schedule): developmental psychology, personality, psychopathology, others. P, 255 and 6 units of upper-division psychology; or grad. standing.

485. **Contemporary Issues in Psychology** (3) [Rpt./1] GC I II Variable content (consult schedule): major topical problems in psychological research, theory, and applications. P, 255 and 6 units of upper-division psychology; or graduate standing.
500a-500b. Current Issues in Psychological Theory and Research (3-3) Intensive examination of a range of content areas addressed in contemporary psychological theory and research. Open to psychology graduate students only.

507a-507b. Statistical Methods in Psychological Research (3-3) 507a: Research design, application of analysis of variance, multiple comparisons, and computer techniques in psychological research. 507b: Selected methodological issues and multivariate methods in psychology, with coverage of computer applications. Open to psychology majors only.

509. History of Psychological Theories and Research (3) II Development of psychology as a science; schools, systems, theories, major advances, famous investigators.

520. Neurobiology (3) [Rpt. /1] II Recent advances in neurobiology, with a strong emphasis on cellular and molecular mechanisms of nervous system function.

522. Psychobiology (3) [Rpt. /1] II Recent advances in psychobiology, with a strong emphasis on the neural bases of sensation, perception, motivation, emotion, and action.

524. Animal Behavior (3) [Rpt. /1] II Recent advances in the study of behavior from an ethological/evolutionary perspective.

528. Cognitive Neuroscience (3) [Rpt. /1] II Recent advances in analysis of the neural bases of cognitive functions, such as learning, memory, and thinking.

540. Perception and Attention (3) [Rpt. /1] II Recent advances in the areas of perception and attention, with an emphasis on visual process.

542. Psycholinguistics (3) [Rpt. /1] II Recent advances in the area of psycholinguistics, with an emphasis on sentence processing and the contribution of linguistic theory to an understanding of psychological mechanisms.

544. Cognitive Neuropsychology (3) [Rpt. /1] II Recent advances in the area of cognitive neuropsychology, with an emphasis on the brain to cognitive activities including memory, thinking, learning, and perceiving.

546. Environmental Cognition (3) [Rpt. /1] II Recent advances in the area of environmental cognition, with an emphasis on cognitive aspects of environmental psychology.

560. Law and Social Science (3) [Rpt. /1] II Major issues in the relationship between law and social (behavioral) science in general, and law and psychology in particular.

562. Mental Health Policy (3) [Rpt. /3] II Major issues in law and mental health, including law and policies relating to the clients and providers of mental health services, and the organization/structure of the system for delivering these services.

564. Health Policy (3) [Rpt. /3] II Major issues in law and health, including laws and policies relating to clients and providers of health services, and the organization/structure of the system for delivering these services.

566. Crime, Behavior, and Policy (3) [Rpt. /3] II Major issues in law, crime and victimization, including laws and policies relating to criminals, victims, the criminal justice system, and legal personnel working in that system.

580. Clinical Neuropsychology (3) [Rpt. /1] II Cognitive and affective sequelae of human central nervous system disease/damage, with emphasis on clinical evaluation, management and rehabilitation.

582. Psychopathology (3) [Rpt. /1] II Advanced survey of current theory and research in symptoms, causes and treatment of the major psychological disorders.

584. Psychology and Health (3) [Rpt. /1] II Current research and theory concerning psychological contributions to health maintenance, illness prevention and treatment, and the organization of health services.

586. Cross-Cultural Psychology (3) [Rpt. /1] II Current research and theory in cross-cultural psychology, with a particular emphasis on the cultural context of symptoms, causes and treatments of psychopathology and behavior disorders.

596. Seminar
a. Social Psychology (3) [Rpt. /1] II
b. Personality Psychology (3) [Rpt. /1] II
c. Developmental Psychology (3) [Rpt. /1] II
d. Environmental Psychology (3) [Rpt. /1] II
e. Biopsychology (3) [Rpt. /1] II
f. Cognitive Psychology (3) [Rpt. /1] II
g. Clinical Psychology (3) [Rpt. /1] II
h. Law, Psychology, and Policy (3) [Rpt. /1] II
i. Quantitative Methods (3) [Rpt. /1] II
j. Interdisciplinary Environment-Behavior-Design (3) [Rpt. /1] I (Identical with Ids. 596u, which is home)
621. **Clinical Assessment Methods** (3) II Theory and practice in interview techniques and cognitive and personality assessment. Open to majors only.

625. **Clinical Community Psychology** (3) II Expanding role of psychology in innovative mental health functions, with emphasis on consultation, program development, primary prevention and social system modification. Open to majors only.

628. **Psychotherapy** (3) [Rpt./2] II Current research and theory in psychotherapy. Alternate semesters will emphasize individual insight, behavioral, and treatment approaches.

694. **Practicum**
   a. Clinical Interviewing and Assessment (1-3) [Rpt./1] II Open to clinical psychology students only.
   b. Psychotherapy (1-3) [Rpt./1] II Open to clinical psychology students only.
   c. Community Mental Health (1-3) [Rpt./1] II Open to clinical psychology students only.

695. **Colloquium**
   a. Motor Control (2) II (Identical with Ex.S.S. 695a)

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**PUBLIC ADMINISTRATION**
(See Management and Policy)

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**PUBLIC MANAGEMENT**
(See Management and Policy)

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**PUBLIC POLICY, PLANNING AND ADMINISTRATION**
(See Management and Policy)

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**RANGE MANAGEMENT**
(See Renewable Natural Resources)

---

**READING**
(See Language, Reading and Culture)

---

**REAL ESTATE**
(See Finance and Real Estate)

---

**REGIONAL DEVELOPMENT**
(See Geography and Regional Development)

---

**REHABILITATION**
(See Special Education and Rehabilitation)

---

**RELIABILITY ENGINEERING**
(See Systems and Industrial Engineering)
REMOTE SENSING

Committee on Remote Sensing

Professors Philip N. Slater (Optical Sciences), Chairperson, Victor R. Baker (Geosciences), Dinshaw N. Contractor (Civil Engineering), Benjamin N. Herman (Atmospheric Sciences), Donald F. Post (Soil and Water Science), John A. Reagan (Electrical and Computer Engineering), Richard W. Reeves (Geography and Regional Development)

Associate Professors Charles E. Glass (Mining and Geological Engineering), Robert A. Schowengerdt (Electrical and Computer Engineering; Arid Lands Resource Sciences)

Assistant Professors Alfredo R. Huete (Soil and Water Science), John W. Olsen (Anthropology), William O. Rasmussen (Renewable Natural Resources)

Remote sensing concerns the collection of information related in some way to the earth's natural resources or environment. Data are primarily collected by satellite and aircraft systems in conjunction with localized ground-based surveys and measurements. The data are processed by digital computer or optical techniques to extract information of value to earth scientists and resource and environment managers at the local, state, and federal levels.

The Committee on Remote Sensing offers no graduate major at the present time but minor programs are available for doctoral students with majors in disciplines within the colleges of Agriculture, Business and Public Administration, Engineering and Mines, Arts and Sciences; and in the Office of Arid Lands Studies and the Optical Sciences Center. Emphases are available in applied remote sensing or in remote sensing techniques.

Students electing the emphasis in applied remote sensing are required to complete at least twelve graduate units or Geog. 330 (without graduate credit and described in the General Catalog only) and ten graduate units. The program must include Opti. 550 and E.C.E. 531 and either Geog. 330, G.En. 407 or Ws.M. 420. The remaining units may be selected from Ws.M. 422, Agri. 453, C.E. 454, Geog. 483, or G.En. 507.

Students electing the emphasis in techniques of remote sensing must complete twelve graduate units including Opti. 550 and E.C.E. 531. The remaining units may be selected from Opti. 524, 539, 552, 558, 559, 567; Atmo. 561, 656a-656b, 683.

Students are urged to discuss the program with members of the Committee on Remote Sensing before selecting the courses to be taken. The program selected must be approved in advance by the committee.

RENEWABLE NATURAL RESOURCES


Assistant Professors Robert M. Itami, Ann M. Lynch, R. William Mannan, Mitchel P. McClaran, E. Gregory McPherson, Bruce A. Roundy, Frank W. Telewski (Tree-Ring Laboratory)

The School of Renewable Natural Resources offers programs leading to the Master of Science and the Doctor of Philosophy degrees with majors in watershed management, range management, wildlife and fisheries science, and renewable natural resources studies. The school also offers a program leading to the Master of Landscape Architecture degree. For information concerning this degree see Requirements for Master's Degrees/Master of Landscape Architecture elsewhere in this catalog.
Applicants for the Master of Science and the Doctor of Philosophy degree programs are required to submit three letters of recommendation and scores on the Graduate Record Examination. For information concerning the doctor's degree, see Requirements for Doctor's Degrees/Doctor of Philosophy elsewhere in this catalog.

Graduate programs are individually planned after consideration of the student's preparation, area of interest, and career objectives. The purpose of the programs is to train people (1) for research and teaching in the area of natural resource management and planning, and (2) for land management positions requiring specialization in one of the available majors. All students are urged to gain a broad understanding of the social and political institutions as they affect fundamental relations of humans and their environment, particularly those involving plants, animals, soil, and climate.

**Majors**

**WATERSHED MANAGEMENT or RANGE MANAGEMENT** — Concentrations are available in watershed hydrology, natural resource recreation, forest-watershed management, dryland forestry, and range science. Applicants should normally have completed an undergraduate major in watershed management, range management, natural resource recreation, or forestry with training in the biological, physical, and social sciences equivalent to that required for the bachelor's degree at the University of Arizona. Applicants lacking these prerequisites will be required to complete additional units in established watershed management, range management, or natural resource recreation courses.

Students working toward the Master of Science degree may select either of two plans: (1) complete at least thirty units including a thesis for which as many as five units may be earned, or (2) complete at least 36 units including an acceptable professional paper for which as many as three units may be earned.

**WILDLIFE AND FISHERIES SCIENCE** — This major includes specializations in wildlife ecology and fisheries science. Both programs require the completion of at least 30 units including a minimum of fifteen units of course work and an acceptable thesis focusing on original research that addresses a wildlife and fisheries management topic, for the master's degree. With the approval of the student's advisory committee, students may elect to use the professional paper option which requires at least 36 units including a minimum of 30 units of course work plus preparation of an acceptable professional paper for which six units of credit may be earned.

**RENEWABLE NATURAL RESOURCES STUDIES** — Graduate work in this major provides training and research opportunities in natural resources in combination with studies in areas such as planning, policy, administration, economics and behavioral science. This interdisciplinary program is appropriate for continuing students and mid-career professionals interested in careers in natural resources policy administration, planning, management and research. Students should have academic training in one of the resource disciplines within the school or a related area. The master's degree requires at least 36 units including a thesis or professional paper for which six units may be earned.

Renewable Natural Resources

417. *Introduction to Geographic Information Systems* (3) GC II Computer techniques for capture, processing, analysis and display of geographic information, with emphasis on applications in land resources management and planning. 2R, 3L. P, basic knowledge of computer operations. (Identical with S.W. 417, Geog. 417)


477. *Economics of Water and Land Resources* (3) GC I (Identical with A.Ec. 477)
481. Environmental Policy (3) GC II (Identical with Pol. 481)

546. Principles of Research (3) II Philosophy of science and research, the scientific method, problem selection, problem analysis, study plans, scientific communications. Klemmedson

595. Colloquium
   a. International Renewable Resource Issues (2) I 1988-89
   b. Public Natural Resource Management (2) II 1988-89
   c. Human Dimensions in Renewable Natural Resources (3) II 1987-88
   d. Topics in Forest and Range Ecology (2) II 1988-89

596. Seminar
   i. Water and Equity in the Southwest (3) I II (Identical with Pol. 596i)

597. Workshop
   a. Natural Resource Conservation Workshop (1) [Rpt./2] I II S Field trips.

696. Seminar
   a. Renewable Natural Resources (1-2) [Rpt.] I II

**Landscape Resources**

Ervin H. Zube, Chairperson of the Division

*Landscape Architecture*

401. Urban/Rural Landscape Planning and Design (4) GC I Planning and design problems at the urban/rural interface; issues of growth and change. 1R, 8L. P, 302.

402. Regional Landscape Planning and Design (4) GC II Planning and design problems of regional scope and emphasis. 1R, 8L. P, 401.

407. The American Landscape (3) GC II (Identical with Geog. 407)

428. Field Methods in Environmental Psychology (3) GC II (Identical with Psyc. 428)

441. History and Theory of Landscape Architecture (3) GC I Examination of the historical background and theoretical basis of landscape architecture.

451. Site Engineering (4) GC I Grading, road layout, utilities, and other site engineering considerations. 2R, 6L. Field trips. P, 250.

452. Landscape Construction (4) GC II Construction materials and methods in landscape architecture; introduction to working drawings and specifications. 2R, 5L. P, 451.

460. Professional Practice (2) GC II Professional services, contract documents, contract administration, office organization, ethics, professional registration, roles of the landscape architect, the practice of landscape architecture. P, 401.

497. Workshop
   i. Community Design for Non-Designers (3) GC I (Identical with Arch. 497i, which is home)

522. Advanced Landscape Design (4) II Planning and design in the urban landscape; human needs, processes and responses; urban landscape systems. 2R, 6L.

523. Advanced Landscape Planning (4) I Advanced techniques in planning and designing of regional landscape resources; visual simulation, computer map overlay, video applications; application of research in perception and behavior. 2R, 6L. Field trip fee: $100.

533. Landscape Planning (2) I Theories and models in landscape planning; planning issues, methods, and case studies.

595. Colloquium
   a. Systems Ecology for Planners and Designers (3) II
   c. Urban Forestry (2) II 1988-89 (Identical with Ws.M. 595c, which is home)
   d. Landscape Architecture Research (3) I

596. Seminar (3) I
   u. Interdisciplinary Environment-Behavior-Design (Identical with Idis. 596u, which is home)

694. Practicum
   a. Landscape Architecture Teaching (1-2) I II

696. Seminar (1-3) I II
   a. Landscape Architecture (1) [Rpt.]
Range Resources

E. Lamar Smith, Chairperson of the Division

Range Management


436. Grazing Management (2) GC II Effects of grazing animals on plants and soils; diet, nutrition and behavior of grazing animals; management of grazing to meet livestock production and multiple use objectives. P, 305, CR 416.

446. Range Improvements (3) GC I Range improvements through grazing systems, noxious plant control, cultural and mechanical elements of revegetation, runoff control, and specialized range and critical area treatments. 2R, 3L. Weekend field trips. P, 305; M.C.B. 181; Ecol. 182; S.W. 200.

456. Range Evaluation (3) GC II Methods of evaluating range vegetation, productivity, carrying capacity, utilization, condition and trend; measurement techniques and interpretation of data. 2R, 3L. P, 305, 382, 416, R.N.R. 321.

480. Forest Policy and Administration (3) GC II (Identical with Ws.M. 480)

486. Range Planning and Economics (3) GC I Principles of management planning for rangelands and economic analysis of management alternatives; includes case studies, linear programming, computer simulation. P, R.Ma. 305; Econ. 201b.

487. Ranch Planning (2) GC II Preparation of a range management plan for a ranch enterprise including field data collection, economic and environmental analysis of management alternatives. 6L. All-day field trips. P, 486, CR 456.

595. Colloquium
   a. Rangeland Policy (2) II 1988-89
   c. Range Herbivores (2) II 1987-88

696. Seminar
   a. Range Management (1) [Rpt.] II

Forest-Watershed Resources

Gordon S. Lehman, Chairperson of the Division

Watershed Management

408. Forest Fire Management (3) GC I Forest fire behavior, as influenced by fuels, weather, topography; ecological effects of fire; prevention, detection and control methods; fire danger rating and use of prescribed fire in forest management. Zwolinski

410. Silviculture (3) GC II Principles and technical procedures for reproducing, planting, and tending forest crops, with reference to watershed. P, 342 or Ra.M. 382; Ecol. 182.


420. Photogrammetry (1) GC II Aerial photographic planning for natural resource management; stereoscopic principles applied to planimetric and topographic mapping. 3L. P or CR 422.

422. Photointerpretation (2) GC II Reading and interpretation of aerial photographs; natural resource inventory from aerial photographs; remote sensing techniques. 1R, 3L. Lehman


427. Bioclimatology (3) GC II (Identical with Atmo. 427)

430. Forest Resource Management (3) GC I Decision making in the management of forest lands. 2R, 3L. P, 410, 415, 440.
<table>
<thead>
<tr>
<th>Course No.</th>
<th>Course Title</th>
<th>Units</th>
<th>GC</th>
<th>Pre-Requisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>440.</td>
<td>Forest Resource Economics</td>
<td>3</td>
<td>II</td>
<td>Forest lands; decision making in microforest resource management situations; supply and demand relationships for forest resources. P, Econ. 201a, 201b; Math. 123. (Identical with A.Ec. 440) King</td>
</tr>
<tr>
<td>460.</td>
<td>Watershed Hydrology</td>
<td>3</td>
<td>I</td>
<td>Application of fundamental principles to quantifying the basic hydrologic processes occurring on watersheds. P, Geos. 100a; S.W. 200, 201; Math. 160. (Identical with Hydr. 460) Gay</td>
</tr>
<tr>
<td>462.</td>
<td>Watershed Management</td>
<td>3</td>
<td>II</td>
<td>Evaluating hydrologic impacts of management activities on watersheds to include silviculture, range, mining, and recreation use.</td>
</tr>
<tr>
<td>464a-464b.</td>
<td>Introduction to Dendrochronology</td>
<td>3-3</td>
<td></td>
<td>GC (Identical with Geos. 464a-464b)</td>
</tr>
<tr>
<td>471.</td>
<td>Water Quality Control</td>
<td>3</td>
<td>II</td>
<td>(Identical with C.E. 471)</td>
</tr>
<tr>
<td>476.</td>
<td>Natural Resource Economics</td>
<td>3</td>
<td>II</td>
<td>(Identical with A.Ec. 476)</td>
</tr>
<tr>
<td>481.</td>
<td>Simulation of Renewable Natural Resources</td>
<td>3</td>
<td>II</td>
<td>Simulation of management impacts for multi-resource decision-making, including biologic, economic, and social factors. 2R, 3L. P, 430.</td>
</tr>
<tr>
<td>487.</td>
<td>Forestry in Arid Environments</td>
<td>4</td>
<td>S</td>
<td>Management and development of wood and other forest resources in developing nations. Designed for mid-level and upper-level resource professionals from developing nations. Field trip.</td>
</tr>
<tr>
<td>531.</td>
<td>Dryland Forest Management</td>
<td>2</td>
<td>II</td>
<td>1988-89 Utilization and management of forest resources in dry environments; biophysical and socio-economic issues related to the development of forest commodities and amenities. P, 6 units of upper-division Ws.M.</td>
</tr>
<tr>
<td>532.</td>
<td>Agroforestry</td>
<td>2</td>
<td>I</td>
<td>1987-88 Ecological and socioeconomic factors related to the planning and implementation of agroforestry systems. P, 6 units of upper-division Ws.M.</td>
</tr>
<tr>
<td>533.</td>
<td>Fuelwood Management in Dryland Ecosystems</td>
<td>2</td>
<td>II</td>
<td>1987-88 Technical practices and social implications of fuelwood management in dryland ecosystems of the world. P, 6 units of upper-division Ws.M.</td>
</tr>
<tr>
<td>534.</td>
<td>Nursery and Plantation Management</td>
<td>2</td>
<td>II</td>
<td>1988-89 Tree nursery and forest plantation establishment and management with emphasis on dryland ecosystems. P, 6 units of upper-division Ws.M.</td>
</tr>
<tr>
<td>535.</td>
<td>Water Management in Dryland Ecosystems</td>
<td>3</td>
<td>I</td>
<td>Hydrologic principles as applied to arid and semiarid ecosystems with water management applications in dryland resource management. P, A.Ec. 539, S.W. 201.</td>
</tr>
<tr>
<td>557.</td>
<td>Quantitative Dendrochronology</td>
<td>3</td>
<td>I</td>
<td>1988-89 (Identical with Geos. 557)</td>
</tr>
<tr>
<td>563.</td>
<td>Plant-Water Relations</td>
<td>3</td>
<td>II</td>
<td>(Identical with M.C.B. 563)</td>
</tr>
<tr>
<td>565.</td>
<td>Hydrochemistry</td>
<td>3</td>
<td>II</td>
<td>1987-88 (Identical with S.W. 565)</td>
</tr>
<tr>
<td>566.</td>
<td>Botanical Basis of Dendrochronology</td>
<td>3</td>
<td>II</td>
<td>1987-88 (Identical with Geos. 566)</td>
</tr>
<tr>
<td>576.</td>
<td>Advanced Natural Resource Economics</td>
<td>3</td>
<td>I</td>
<td>(Identical with A.Ec. 576)</td>
</tr>
<tr>
<td>577.</td>
<td>Natural Resource Economics and Public Policy</td>
<td>3</td>
<td>II</td>
<td>(Identical with A.Ec. 577)</td>
</tr>
<tr>
<td>595.</td>
<td>Colloquium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>595a.</td>
<td>Non-Point Source Pollution from Watersheds</td>
<td>3</td>
<td>II</td>
<td>P, 460.</td>
</tr>
<tr>
<td>595b.</td>
<td>Urban Forestry</td>
<td>2</td>
<td>II</td>
<td>1988-89 (Identical with L.Ar. 595c)</td>
</tr>
<tr>
<td>596.</td>
<td>Seminar</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>596a.</td>
<td>Watershed Management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>655.</td>
<td>Dendroclimatology</td>
<td>2</td>
<td>II</td>
<td>1988-89 (Identical with Geos. 655)</td>
</tr>
</tbody>
</table>
Wildlife, Fisheries and Recreation Resources

William W. Shaw, Chairperson of the Division

Wildlife and Fisheries Science

405. Aquatic Entomology (3) GC II 1988-89 (Identical with Ento. 405)
430. Principles of Nutrition (3) GC II (Identical with An.S. 430)
441. Limnology (4) GC I Study of lakes and streams; biological characteristics, as related to physical, chemical, geological, and historical processes operating on fresh waters. 2R, 6L. Weekend field trips. P, six units of chem. or phys. with lab. (Identical with Ecol. 441) Matter
444. Wildlife Management/Mammalian Species (4) GC I Management of wildlife as a resource; characteristics of wildlife species; principles of population dynamics in wildlife populations; techniques used in studying wildlife. 3R, 3L and field work. Weekend field trips. P, 325. Krausman
446. Wildlife Management/Avian Species (4) GC II Field and lab. methods used in avian species management; evaluation of avian habitats; census, productivity, diagnosis, and control of avian populations. 3R, 3L and field work. Weekend field trips. P, 325. Mannan
448. Current Problems in Wildlife Ecology (1) [Rpt.] GC I Discussions and assignments covering current problems, including the biological, economic, aesthetic, political, and sociological phases of wildlife management. P 444 or 446.
455R. Fishery Management (3) GC II Methods and concepts pertaining to fishery investigations and management; application of principles for production of optimum fisheries to benefit man. P, 441 or 444. Matter
455L. Fishery Management Laboratory (1) GC II Laboratory methods pertaining to fishery investigations and management. P, CR 455R, 482. Matter
482. Ichthyology (4) GC I (Identical with Ecol. 482)
484. Ornithology (4) GC II (Identical with Ecol. 484)
485. Mammalogy (4) GC I (Identical with Ecol. 485)
584. Selected Studies of Birds (2) [Rpt.] I (Identical with Ecol. 584)
595. Colloquium
a. Big Game Management (2) I 1988-89 P, 444.
b. Wildlife Habitat Analysis (2) II 1987-88.
649. Fishery-Water Quality Relationships (2) I Pertinent water quality parameters essential for fish life, and the effects of various substances and their interrelationships to fish and aquatic organisms. P, 441 or 455R; Chem. 241a. Ziebell
695. Colloquium
a. Advanced Issues in Fisheries and Wildlife Science (2) [Rpt./3] II
696. Seminar (1-3) I
a. Fish and Wildlife Ecology (1) [Rpt.]

Natural Resource Recreation

470. Economics of Outdoor Recreation (3) GC II 1987-88 Application of economic tools to recreation planning and management, including recreation demand and supply, recreation use projection methods, recreation resource valuation and policy issues. P, Econ. 201b or A.Ec. 204; Math. 160. (Identical with A.Ec. 470) King
489e-489b. Advanced Environmental Interpretation (2-2) GC Advanced training and experience in communication of natural history and environmental principles to the public. Students must be available for some weekend field work. Field trips. P, 12 units in biology or renewable natural resources.
595. Colloquium
ROMANCE LANGUAGES

Committee on Romance Languages (Graduate)

Professors Robert ter Horst (Spanish and Portuguese), Dana A. Nelson (Spanish and Portuguese)
Associate Professors Ingeborg Kohn (French and Italian), Henri Servin (French and Italian)

The committee offers a Master of Arts degree with a major in Romance languages. Administered by the Department of French and Italian and the Department of Spanish and Portuguese, it is primarily intended for future high-school or junior-college teachers and enables graduate students to acquire a sound foundation in fundamental aspects of two Romance languages. The degree requires 39 units of coursework in two of the following languages: French, Italian, Portuguese, and Spanish (21 units in one language and 18 in the other). For further information, please inquire in either department.

422. Introduction to Romance Philology (3) GC I 1988-89 (Identical with Span. 422)
429. Pedagogical Linguistics: Applied Linguistics for Teachers (3) GC II (Identical with Or.S. 429)

RUSSIAN AND SLAVIC LANGUAGES

Professors John Garrard, Head, Alex de Jonge, Joe Malik, Jr.
Associate Professors Adele Barker, Alexander Dunkel, Margaret Gibson, Boriss Roberts

The Department of Russian and Slavic Languages offers a diversified and balanced program of study including courses in literature, grammar, conversation, linguistics, and culture. All literature courses are conducted in Russian by native or near-native speakers. The emphasis is on the acquisition of practical skills as preparation for continued study, research, teaching, government service, and business careers. The program leads to a Master of Arts degree with a major in Russian. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in Russian. For information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

Prerequisite for admission is the completion of a bachelor's degree including at least sixteen acceptable units of upper-division work in Russian.

The degree program requires the completion of at least 32 units, 24 of which must be in Russian, including 581, either 583 or 685, and two seminars. All graduate teaching assistants must take 579. With the permission of the head of the department, the remaining units must be selected from appropriate supporting courses in other disciplines. The decision regarding the requirement for a thesis will be made by the department after consideration of the student's preparation, graduate study program, and professional objectives. No more than six units may be earned for the preparation of a thesis. Students who present a thesis must pass a final oral examination while those without a thesis must pass written and oral comprehensive examinations. Prior to taking the final examination, each student must give satisfactory evidence of proficiency in the use of the Russian language or of the English language if applicable.

405a-405b. Survey of Russian Literature (3-3) GC Historical survey of Russian literature from the earliest times to the Soviet period; designed to acquaint students with literary terminology and facilitate comprehension of lectures in Russ. Advanced degree credit available only with departmental permission. P, 301b or 305b.

450. Soviet Technology and Science (3) GC I (Identical with M.I.S. 450)
501a-501b. Russian Stylistics (3-3) Designed to improve the student's practical mastery and understanding of Russian at a higher and more sophisticated level. P, 301b.
579a-579b. Problems of Teaching Russian (1-1) Survey of modern methods of language teaching, with emphasis on the particular problems presented by Russian. All teaching assistants must be enrolled in this course while teaching Russian. Maximum of two units will be counted toward Master's degree requirements.

581. Russian Phonology and Morphology (3) II P, 301b or 305b.

583. History of the Russian Language (3) I P, 301b or 305b.


685. Old Church Slavic (3) A study of Old Church Slavic language and its relationship to Old Russian and Modern Russian. P, 301b or 305b.


696. Seminar
   b. Russian Literature: 18th Century (3)
   c. Russian Literature: 19th Century (3)
   d. Russian Literature: 20th Century (3)

SECONDARY EDUCATION
(See Teaching and Teacher Education)

SOCIOLOGY

Professors Harrison C. White, Head, Albert J. Bergesen, Raymond V. Bowers (Emeritus), Richard F. Curtis, Andrew M. Greeley, Robert L. Hamblin, Michael N. Hechter, Travis W. Hirschi, Gary F. Jensen, Robert C. Leonard, James R. Lincoln, Bruce D. Sales (Psychology), I. Roger Yoshino

Associate Professors James T. Borhek, Courtney B. Cleland, Robert R. Evans, Celestino Fernandez, Neil D. Fligstein, Patricia L. MacCorquodale, Douglas J. McAdam, Jerry L. L. Miller

Assistant Professors Roberto M. Fernandez, Debra Friedman, Joseph R. Hambenne (Emeritus), Trudy L. Mills, Richard B. Polley (Management and Policy), Kathleen C. Schwartzman, James Shockey

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in sociology. A brochure describing these programs is available from the department on request.

Potential applicants are urged to include strong courses in theory, methodology, and statistics in the undergraduate program. Applicants must submit scores on the aptitude test of the Graduate Record Examination and two letters of recommendation. The undergraduate record must show an average grade of "B" or higher in sociology and in all work completed during the last two years of college study. The average grade for all undergraduate work must be at least "B-" and, unless the student has a very strong undergraduate record, the student's scores on the Graduate Record Examination, both quantitative and verbal portions, must be very high. Applications must be received by January 15 if financial assistance for the following semester is desired.

Degrees

MASTER OF ARTS — For the master's degree, thirty units of credit for 500-level courses (those open to graduate students only), excluding independent study and including the following courses: 500a-500b, 570a-570b, 575; and three to six units of research seminar. For students who terminate their work at this institution with an M.A. degree, two research papers prepared for 500-level courses must be submitted. For students who continue toward the Ph.D. at this institution, a data-analysis paper must be submitted. Both require a final oral examination. There is no language requirement for the M.A.
DOCTOR OF PHILOSOPHY — For the Ph.D., a minimum of 69 units of course work, including eighteen units of dissertation and the minor, are required. All students are required to complete the statistics, methods, theory, and research seminar requirements set forth above for the M.A. In addition, students are expected to complete two of the following courses: 505, 510, 525, 530, 541, or 550, and two of the following: 521, 560, 580, 596. Written preliminary examinations must be completed in two areas: collective action/social movements, crime and deviance, gender, methods and statistics, organizations, race and ethnic relations, socialization/social interaction, stratification, theory, world systems. An oral preliminary examination must be taken when the written exams have been passed. The Ph.D. at this institution requires proficiency in any one of the following: a foreign language, mathematics, or computer science. Dissertations will generally be contributions to knowledge through original, empirical research.

402. Kinship and Social Organization (3) GC II (Identical with Anth. 402)
404. Sociology of the Southwest (3) GC I Populations, cultures, and social problems in their regional setting, with emphasis on the Southwest. P, 100 or 301; 6 additional units of sociology or anth. (Identical with Anth. 404, A.in.S. 404 and M.A.S. 404)
407. Peasant Communities (3) GC I (Identical with Anth. 407)
422. Complex Organizations (3) GC II Theories and research regarding large-scale organizations and their relations to the individual and society. P, 9 units of sociology.*
435. Public Opinion and Voting Behavior (3) GC I II (Identical with Pol. 435)
436. Social Structure and Personality (3) GC II Relation between the person and the group; social factors in character formation. P, 9 units of sociology.
442. Transformation of Agrarian Societies in the Middle East (3) GC II (Identical with Or.S. 442)
444. Group-Process Methods in Management (3) GC II (Identical with M.A.P. 444)
450. Social Stratification (3) GC I II Theories of social class, caste, and rank; social mobility in contemporary society. P, 9 units of sociology.* (Identical with Anth. 450)

*A major in another social science may substitute for 3 of these units.

457. Bio-Social Determinants of Socialization (3) GC II (Identical with C.D.F.R. 457)
459. Sociology of Gender (3) GC II Social construction, variation and consequences of gender categories across time and space. Topical (decision-making, deviance) and institutional (family, religion, politics) approaches. P, 100 or consult department before enrolling. (Identical with W.S. 459)
461. Race and Ethnic Relations (3) GC I II Social processes involved in minority groups in terms of race, caste, class, ethnicity, politics, and religion. P, 100 or 301; 6 additional units of sociology or anth. (Identical with Anth. 461, A.in.S. 461, Bl.S. 461 and M.A.S. 461)
486. Comparative Community Development (3) GC I Principles of social change applied to problems of community development, including analysis of specific programs. P, 6 units of social sciences. (Identical with Anth. 486)

505. World-System Theory and Research (3) I II Theory and research on the modern world-system.
510. Political Sociology (3) Basic approaches in political sociology, with emphasis on the relationship of economic and political processes.
525. Intermediate Complex Organizations (3) Basic review of classic and contemporary approaches to the study of complex organizations; formation, development, and internal processes. (Identical with M.A.P. 525)
530. Graduate Social Psychology (3) Basic study of classic and contemporary approaches with particular reference to socialization and the relationship between the individual and social structure.
541. Deviance and Social Control (3) Basic critical review of traditional and contemporary concepts and formulations of deviance and social control; evaluation of contemporary research bearing upon deviance theory and informal and formal mechanisms of social control. P, 201, 341 or 342.
550. Stratification and Class (3) Basic examination of concepts and research in the area of stratification, with emphasis on the classic statements and contemporary research.
560. **Intergroup Relations** (3) Analysis of recent research on the relations among racial and ethnic groups in society, with special attention to current empirical and theoretical issues. P, 461.

570a-570b. **Social Statistics** (3-3) 570a: Probability, distributions, estimation and hypothesis testing. 570b: Ordinary least squares regression, generalized least squares regression, structural equation models (path analysis and non-reursive systems).


580. **Population Studies** (3) I Theory and research in the fields of fertility, mortality, and migration, with emphasis on their relationships to social structure. An original research project is required.

585. **Advanced Sociological Theory** (3) I Sociological theories as alternative explanations. Classic and modern examples of working through the implications of alternative theories to formulate competing hypotheses for empirical tests. P, two courses in Social Science theory, preferably 500a-500b.

595. **Colloquium**
   a. Introduction to Graduate Study (1) I

596. **Seminar**
   a. Advanced Problems in Research (1-3) [Rpt.] I II
   b. Graduate Teaching (3) II 1988-89 2R,3L
   c. Advanced Problems in Deviant Behavior (1-3) I II
   f. Advanced Social Change (1-3) [Rpt.] I II
   g. Advanced Juvenile Delinquency (1-3) I II
   h. Macrosociology (1-3) I II

**SOIL AND WATER SCIENCE**


Associate Professors David M. Hendricks, Ian L. Pepper

Assistant Professors Alfredo Huete, Allan D. Matthias, Marti M. Minnich, James R. Simpson

The department offers opportunities for study toward the Master of Science and Doctor of Philosophy degrees with a major in soil and water science. Concentrations for soil and water science majors are available in soil fertility; soil chemistry; soil physics; soil microbiology; soil conservation; soil classification; water quality; irrigation; water resources development; waste management and pollution control in relation to soil, water, and air resources.

Students with adequate undergraduate preparation in engineering, physical sciences, or biological sciences will be considered for admission to an appropriate degree program. A thesis is normally required, but the requirement may be waived for a student who is a senior author of a manuscript published or accepted for publication in a refereed professional journal.

402. **Introduction to Pesticides and Their Use** (2) GC II (Identical with PI.P. 402)

405. **Hydrology of Unsaturated Media** (3) GC I (Identical with Hydr. 405)

411. **Soil Chemistry** (3) GC I CDT Soil chemical interactions with water, air, plants and pollutants. P, 200, Chem. 103b, 104b. Bohn

417. **Introduction to Geographic Information Systems** (3) GC II (Identical with R.N.R. 417)

431. **Soil Morphology, Classification and Survey** (3) GC I Theory and practice of describing characteristics of soils; principles of soil classification and the classification systems: methods and applications of soil surveys. 2R, 3L. Field trips. P, 200, 201, Geos. 101a. Post


453. **Remote Sensing in Agriculture** (3) GC II Remote sensing techniques and applications for improved natural resource utilization of soils, water, grasslands, and forest. Fundamental energy-matter interactions that influence the spectral characteristics of vegetation, soil, and water. 2R, 3L. Field trips. P, 330 or Phys. 102b.
298 DEPARTMENTS AND COURSES OF INSTRUCTION

461. **Soil and Water Conservation** (3) GC II 1988-89 Consideration of major world soil and water conservation problems and solutions; principles of soil erosion by wind and water and their effects on world food problems. 2R, 3L. Field trips. P, 200. Post

470. **Soil Physics** (3) GC II CDT Soil structure and physical constitution of soils; the physical properties of soil-water systems, movement and exchange of gases in the soil, and physical laws governing the movement and availability of soil water. 2R, 3L. P, 200, Phys. 102b, CR Math. 125a. Warrick

501. **Management of Arid Lands and Salt-Affected Soils** (3) II Principles and practices of soil, water and crop management under arid and semiarid conditions, the use of diagnostic procedures for evaluating soils and waters, reclamation, and economics of irrigation project development. 2R, 3L. Field Trip. Dutt

505. **Chemical Analysis of Soils and Plants** (4) II Principles and methods of chemical analysis of soils, water and biological materials with emphasis on instrumental techniques. 2R, 6L. P, Chem. 322, 323; Phys. 102b, 180b. Hendricks

520. **Evapotranspiration** (3) I Theories and concepts of potential and actual evapotranspiration in arid regions; measurement and estimation methods, and plant growth and evapotranspiration relations. P, Math. 125b, Phys. 102b.

541. **Soil Genesis** (3) II Physical and chemical processes and mineralogy of weathering and soil formation; quantitative pedology; the soil as part of the ecosystem. Field trips. P, Geos. 101a and Chem. 103b. (Identical with Geos. 541) Hendricks

565. **Hydrochemistry** (3) II 1987-88 Solute composition of naturally-occurring waters, chemical reactions affecting the solute content of water, relations and effects of above on water quality criteria and pollution, analytical procedures used by water testing laboratories. 2R, 3L. P, Chem. 322 or C.E. or 471. (Identical with Hydr. 565 and Ws.M. 565) Dutt


696. **Seminar**
   a. **Soils, Water and Engineering** (1) [Rpt./1] II (Identical with A.En. 696a)

**SOUTHWEST STUDIES**

Southwest studies are designed to bring new perspectives to regional subjects through an interdisciplinary approach. Courses on the Southwest are taught through many university departments and programs, including American Indian studies, anthropology, English, geography, history, Latin American studies, linguistics, Mexican American studies, political science, sociology, Spanish and Portuguese, and women's studies. For information, contact the Department of History or the Southwest Center.

**SPANISH AND PORTUGUESE**

Professors Charles M. Tatum, Head, Leo L. Barrow, A. Dolores Brown, Jack Emory Davis (Emeritus), John J. Gilabert, Lanin A. Gyurko, Ruth Lee Kennedy (Emerita), Richard P. Kinkade, John W. Martin, Miguel Méndez, Dana A. Nelson, José Promis, Eliana S. Rivero, Renato I. Rosaldo (Emeritus), Robert ter Horst

Associate Professors Gilbert E. Evans, Karl C. Gregg, H. Reynolds Stone

Assistant Professors Frances R. Aparicio, Karen L. Smith

The department offers programs leading to the Master of Arts and the Doctor of Philosophy degrees with a major in Spanish. In cooperation with the College of Education, the department also offers work leading to the Master of Education degree with a major in Spanish; for information concerning this degree see Requirements for Master's Degrees/Master of Education elsewhere in this catalog. Through the Committee on Romance Languages, the department...
participates in offering an M.A. with a major in Romance languages (see Romance Languages elsewhere in this catalog). Through the graduate Committee on Medieval Studies, the department also collaborates in a program for the Doctor of Philosophy minor in medieval studies (see pertinent section of this catalog). Finally, it offers doctoral minors in Spanish and in Portuguese.

Admission to all graduate programs requires the completion of a bachelor's degree with a strong major in the proposed field of study. Applicants must submit scores on the advanced Spanish test of the Graduate Record Examination. Admission to a doctoral program is dependent upon the completion of a Master of Arts degree with the same major.

**Degrees**

**MASTER OF ARTS** (Major in Spanish) — 33 units in one of four concentrations.

1. **Hispanic literature program leading to doctoral studies**: 33 units with equal concentration in Spanish and Spanish-American literature.

2. **Hispanic literature program with area of concentration (terminal)**: (a) concentration in Spanish literature — 24 units in Spanish literature, 9 units in Spanish-American literature; (b) concentration in Spanish-American literature — 24 units in Spanish-American literature, 9 units in Spanish literature.

3. **Spanish language and linguistics**: 9 units of pedagogy, 9 units of linguistics, 6 units of language, and 9 units of literature.

4. **Hispanic studies (available in Guadalajara Summer School only)**: 21 units of Hispanic literature and no more than 12 units from supporting fields.

**DOCTOR OF PHILOSOPHY** (Major in Spanish) — 33 units of graduate course work beyond the Master of Arts in addition to 18 units of dissertation credits and 15 units in the minor field. New students must pass a qualifying examination in Spanish and Spanish-American literature during the first semester of residency. Students are required to demonstrate knowledge of at least one foreign language other than Spanish at the third-year level of proficiency. All students must pass a comprehensive preliminary examination once course work is completed. Each candidate will write and defend a doctoral dissertation making an original contribution to total human knowledge.

**Spanish**

400a-400b. Survey of Spanish Literature (3-3) GC 400a: From the beginning through the 17th century. 400b: 18th-20th centuries. P, 320. 400a is not prerequisite to 400b.

401a-401b. Survey of Spanish-American Literature (3-3) GC 401a: From the beginning through the 18th century. 401b: 19th and 20th centuries. P, 320. 401a is not prerequisite to 401b.

402. Survey of Mexican Literature (3) GC S Major works by Mexican writers. Offered in Guadalajara only. P: five semesters of Spanish.

405. Advanced Composition and Conversation (3) GC II Study and practice in formal discussion and expository writing. P, 330.

414. Teaching of Modern Languages (3) GC II (Identical with T.T.E. 414)


422. Introduction to Romance Philology (3) GC I 1988-89 Survey of the development of the modern Romance tongues from the Latin language. P, knowledge of two Romance languages. (Identical with Fren. 422, Ital. 422, Port. 422, and R.Lg. 422)

423a-423b. Theory of Spanish Syntax (3-3) GC 423a: Introduction to grammar as a theoretical construct; principles of transformational generative grammar exemplified in Span.; examination of traditional grammatical concepts in the new framework. 423b: More detailed and further-ranging analysis of Span. grammar within the general theory. P, 329. (Identical with Ling. 423a-423b)

427. Applied Spanish Linguistics (3) GC I Pedagogical applications of syntactic theory; introduction to phonological theory of Span. for pedagogical purposes; applied phonetics. (Identical with Ling. 427)
300 DEPARTMENTS AND COURSES OF INSTRUCTION


432. **Pre-Columbian Culture and Myths (3)** GC II 1988-89 Cultural development of Aztec, Mayan and Incan civilizations and their artistic and mythic expression. P, 320. (Identical with M.A.S. 432)


435. **Cervantes' Don Quixote (3)** GC II P, 320.

441. **Children's Literature in Spanish (3)** GC I Survey of children's literature in Spanish, with special attention to the needs of American schools and libraries. P, 320. (Identical with U.S. 441 and M.A.S. 441)


447. **Contemporary Mexican Literature (3)** GC II S Major novelists of modern Mexico; their works, narrative perspective, characterization, language, time, space, and themes. P, 320. (Identical with M.A.S. 447)


450. **Spanish-American Short Story (3)** GC S Development of the modern short story in Latin America, with examples from various countries and authors. Offered in Guadalajara only. P, five semesters of college Spanish.


453. **Introduction to Medieval Studies (3)** I 1989-90 Historical, social, and cultural currents as background for the analysis of medieval Hispanic letters. P, 420.


455. **Fourteenth Century Spanish Literature (3)** I 1988-89 Traditional courtly and satiric literature; the Celestina. P, 420 or 503.

456. **Golden Age Theater I: Drama Before Lope de Vega (3)** I 1987-88 Drama from the late fifteenth century to the latter part of the sixteenth, including Enzina, Vicente, Torres Naharro, Rueda, plus the early auto sacramental. P, 400a.


<table>
<thead>
<tr>
<th>Course Code</th>
<th>Description</th>
<th>Time Frame</th>
<th>Notes</th>
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<tbody>
<tr>
<td>523.</td>
<td><strong>Hispanic Prose of the Enlightenment</strong> (3)</td>
<td>1990-91</td>
<td>Prose writers of the Neoclassical Period in Spain and the New World. P, 400b or 401b.</td>
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<tr>
<td>526.</td>
<td><strong>Realism and Naturalism</strong> (3)</td>
<td>1988-89</td>
<td>Major prose writers of the 19th century from Galdós to Blasco Ibáñez.</td>
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<td>527.</td>
<td><strong>The Generation of '98</strong> (3)</td>
<td>1987-88</td>
<td>Major literary expressions concerning the problems of Spain and the Spaniard from the late 19th century to 1936.</td>
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<tr>
<td>529.</td>
<td><strong>Contemporary Spanish Novel</strong> (3)</td>
<td>1988-89</td>
<td>The novel since the Civil War.</td>
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<tr>
<td>530.</td>
<td><strong>Contemporary Spanish Poetry</strong> (3)</td>
<td>1987-88</td>
<td></td>
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<tr>
<td>531.</td>
<td><strong>Contemporary Spanish Drama</strong> (3)</td>
<td>1988-89</td>
<td>Major Spanish theatrical trends from the Civil War (1936-39) to the present. P, graduate standing. 400b.</td>
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<tr>
<td>533.</td>
<td><strong>Spanish-American Baroque</strong> (3)</td>
<td>1987-88</td>
<td>Spanish-American works in the baroque or manerista literary current from the seventeenth and eighteenth centuries, largely in verse. P, 401a.</td>
</tr>
<tr>
<td>538.</td>
<td><strong>Hispanic Romanticism</strong> (3)</td>
<td>1987-88</td>
<td>Romantic discourse in the different genres as they appeared both in Spain and in Spanish-American, from the pre-Romantics through 1888. P, 400b or 401b.</td>
</tr>
<tr>
<td>540.</td>
<td><strong>Spanish-American Modernism: Poetry</strong> (3)</td>
<td>1988-89</td>
<td>Modernista poetic works from 1882 through 1911, with emphasis on Martí, Gutierrez Najera, Silva, Casal, Dario. P, 401b.</td>
</tr>
<tr>
<td>542.</td>
<td><strong>Hispanic-American Short Story</strong> (3)</td>
<td>1987-88</td>
<td>Masterworks of the short story in Hispanic-America during the twentieth century. P, 401b.</td>
</tr>
<tr>
<td>544.</td>
<td><strong>Spanish-American Contemporary Poetry</strong> (3)</td>
<td>1987-88</td>
<td>Contemporary authors and trends in Spanish-American poetry, mostly from the 1940's to the present. P, 401b.</td>
</tr>
<tr>
<td>545.</td>
<td><strong>Spanish-American Essay</strong> (3)</td>
<td>1988-89</td>
<td>Major essays from independence to the present.</td>
</tr>
<tr>
<td>546.</td>
<td><strong>Spanish-American Novel of the Twentieth Century</strong> (3-3)</td>
<td>575a: The 1920's. 575b: From 1930 to 1960. 575c: From 1960 to the present. Neither semester in this sequence is prerequisite to any other. P, 401b.</td>
<td></td>
</tr>
</tbody>
</table>
596. Seminar
   b. Methods of Literary Research (3) 1987-88

620. History of the Spanish Language (3) 1987-88

621. Spanish in the Americas (3) 1988-89

679a-679b. Techniques of Teaching College Spanish (1 to 3 - 1 to 3) Problems encountered in teaching basic language courses. Units cannot be used to satisfy departmental graduate degree requirements.

696. Seminar
   a. Philology and Linguistics (3) I II
   b. Spanish Literature (3) I II
   c. Spanish-American Literature (3) I II

Portuguese

400a-400b. Survey of Brazilian and Portuguese Literature (3-3) GC 1988-89 400a: Brazilian literature. 400b: Portuguese literature. P, 201b or 202b.

402a-402b. Brazilian Civilization (3-3) GC P, 201b or 202b.

405a-405b. Advanced Composition and Conversation (3-3) [Rpt./1] GC Two hours conversation, one hour composition. P, 201b or 202b.

422. Introduction to Romance Philology (3) GC I 1988-89 (Identical with Span. 422)

463. Studies in Brazilian Literature (3) GC I 1987-88 Major works, authors and tendencies in modern Brazilian literature. P, 201b or 202b.

464. Studies in Portuguese Literature (3) GC II 1987-88 Major works, authors and tendencies in the literature of Portugal. P, 201b or 202b.

696. Seminar
   a. Portuguese Literature (3) [Rpt.] I II
   g. Brazilian Literature: 16th-18th Centuries (3) I II
   h. Brazilian Literature: 19th Century (3) I II
   i. Brazilian Literature: 20th Century (3) I II

SPECIAL EDUCATION
(See Special Education and Rehabilitation)

SPECIAL EDUCATION AND REHABILITATION
Associate Professors Shirin D. Antia, Candace S. Bos, C. June Maker, S. Mae Smith, John Umbreit
Assistant Professors Nancy Eldredge, Anthony K. Van Reusen

The division offers a program leading to the Master of Science degree with a major in rehabilitation. The division also offers programs leading to the Master of Arts, Master of Education, and Educational Specialist with a major in special education. The Doctor of Education and Doctor of Philosophy degrees are offered with majors in rehabilitation and special education.

Concentrations are available within graduate majors offered in the division. Concentrations in special education are behaviorally disordered, hearing impaired, early childhood handicapped, learning disabilities, mental retardation, multiple and severely handicapped, gifted, visually handicapped, and special education administration. Concentrations in rehabilitation are general rehabilitation counseling, rehabilitation psychology, counseling the deaf, counseling the substance abuser, vocational evaluation, and rehabilitation administration.

An undergraduate grade-point average of at least 3.00 is required for admission to full standing in a graduate degree program. However, applicants with undergraduate grade-point averages of 2.50 to 2.99 may be admitted on a provisional basis. A master's degree (in education or a related discipline) is a prerequisite for admission to a specialist or doctoral program.
Beyond these minimal requirements, applicants must also meet the specific admission requirements for all majors offered in the division.

At the time the catalog was being edited, many programs in the College of Education were being redesigned. All current and prospective students should check with the Office of Student Services in the College of Education or the Division of Special Education and Rehabilitation for current admission and degree requirements in each major.

400. **Introduction to Learning Disabilities** (3) GC II Theories and history of programs for the learning-disabled — definition, characteristics, etiology. Degree candidates must complete 300 prior to taking 400.

401. **Diagnosis and Remediation of Learning Problems** (3) GC II Procedures, methods, strategies for informal diagnosis and remediation of children with learning problems in the academic areas of reading, spelling, handwriting, written expression, and mathematics. Strategies and adaptations appropriate for use in the regular elementary or the special classroom. P, 300 or CR. Not open to students in the learning disabilities concentration.

402. **Behavior Principles for the Handicapped** (3) GC II Use of behavior principles to modify the behavior of handicapped persons, especially moderately and severely handicapped. 3R, 1L. P, 300.

403. **The Special Services in the Schools** (3) GC II S Information to aid teachers in dealing with responsibilities and concerns in school settings with regard to PL 94-142, Education for All Handicapped Children Act Section 504 of the Rehabilitation Act, Family Education Rights and Privacy Act, and other legal issues.

410. **Mental Retardation** (3) GC II History and philosophy of educational programs for the mentally retarded and other developmentally disabled; etiology, classification, and characteristics, with consideration of educational, social, and psychological problems. P, 300 or CR.

420. **Vision and Visual Functioning** (3) GC I Anatomy and physiology of the eye; visual development, assessment and training; relationship of visual defects to learning and school experiences.

430. **The Sensory Impaired** (3) GC I Current and historical perspectives; educational and rehabilitation services; etiology, psychosocial, cognitive, and motor development and functioning of hearing impaired and visually impaired individuals.

431a-431b. **Advanced Sign Language** (3) GC II Advanced principles, methods and techniques of American Sign Language and Manually Coded English; idioms, receptive skills, regional variations. P, 370b.

432. **Interpreting for Deaf People** (6) GC II Introduction to theories, principles, and special settings of interpreting. Covers ethics, definitions and related topics of interpreting. Role playing and simulated interpreting experiences will be included in the course. Principles, methods, and techniques of interpreting for deaf people in rehabilitation and other settings. P, 431a or 370b with division permission.

433. **Interpreting in Special Settings** (1-12) GC II Classes will be offered on a rotating basis in areas such as educational, legal, medical, oral and MLC interpreting. P, 432.


450. **Introduction to Early Childhood Education for the Handicapped** (3) GC I This course will focus on the handicapping conditions impacting on preschool children, programs available to serve them and critical issues in this rapidly evolving field. P, 300.

460. **Principles of Rehabilitation** (3) GC I Principles underlying rehabilitation programs and interdisciplinary relationships of agencies engaged in rehabilitation services.

480. **Interviewing and Client Services** (3) GC II The development of essential interviewing skills for case management of rehabilitation clients. P, 300, 380a, 380b, 381.

482. **Rehabilitation of the Aged** (3) GC II Emphasis on aging from the viewpoint of the aging person and those working with the aged.

484. **Problems of Drug Abuse** (3) GC II Survey course for teachers, counselors, and agency workers concerned with drug abuse; examination of community, cultural, and educational approaches to drug use and abuse.

485. **Rehabilitating the Public Offender** (3) GC II Components in service delivery to the public offender, how the offender enters the criminal justice system, and treatment and rehabilitation services available.

501. Methods for Diagnosing Specific Learning Disabilities (3) I Educational and psychological assessment of academic areas and learning processes involving perception, integration, and expression, with emphasis on informal and formal assessment and diagnostic teaching. P, 400 or CR and permission of division; CR 593.

502. Methods of Teaching the Learning-Disabled (3) II Remediation of academic areas and cognitive processes involving perception, integration, and expression, with emphasis on strategies for planning and implementing instructional programs at the elementary level. P, 400, 501, and permission of division; CR 593 and 594.


511. Teaching the Mentally Retarded (3) II Methods of teaching and program development for the retarded and other developmentally disabled learners. P, 410.


521. Methods of Teaching the Visually Handicapped (3) II Curriculum development and adaptation in various educational programs; adaptation of classroom materials and procedures for use with blind and partially-sighted children and youth; emphasis on methods of teaching academic and non-academic skills and on educating students with nonhandicapped peers. CR 593, P, 420.

522. Orientation and Mobility of the Visually Handicapped (3) II Methods of teaching orientation and mobility skills to visually impaired and blind students. Emphasis on the school-aged child, with particular attention to concept development, orientation skills, pre-cane skills, personal safety, and independent ambulation, including an introduction to long-cane techniques.

530. Language Development for the Exceptional Child (3) I Pragmatic, semantic and syntactic aspects of language development in exceptional children and youth; cognitive and social bases for intervention.

531. Language Intervention for Hearing Impaired (3) II Receptive and expressive language assessment; techniques of teaching language intervention and remediation for hearing impaired children and youth. P, 530.

532. Speech for the Hearing Impaired (3) II Oral/aural communication development; methods for assessing and teaching speech and auditory skills. P, 430.


540. Teaching the Gifted: Hierarchical Models (3) I 1988-89 Introduction to general principles involved in providing a curriculum for the gifted. Overview of ten teaching-learning models commonly used with the gifted. Mastery of skills involved in using the hierarchical models with gifted students. P, 440.

541. Teaching the Gifted: Questioning Strategies (3) II 1988-89 Mastery of skills involved in developing abstract thinking abilities in gifted children by using the Hilda Taba Teaching Strategies. Emphasis on using these sequential questioning methods in all content areas and at all grade levels. P, 440.

542. Teaching the Gifted: Productive Thinking Models (3) I 1987-88 Mastery of skills involved in developing productive thinking abilities in gifted children by using teaching-learning models developed by Parnes, Williams, Taylor, Guilford, Renzulli and Treffinger at all grade levels and in all content areas. P, 440.

550. Teaching Children with Behavioral Disorders (3) II Assessment techniques, academic and behavioral intervention strategies, and classroom management with behavior disordered children and youth. P, 450.

560. Methods of Assessment for Preschool Handicapped Children (3) I Norm-referenced and criterion-referenced instruments for screening, diagnosis and assessment of preschool children will be reviewed. Emphasis will be placed on teacher involvement in the assessment process. P, 300.

561. Methods of Teaching Preschool Handicapped (3) II Deals with competencies required to teach all categories of handicapped preschool children except deaf/blind. Field trips. P, 460, 560, 575.

570. Administration of Special Education Programs (3) II Practical aspects of organization and development of special education programs, problems of public relations, personnel, case finding, evaluation, placement, and records. P, consult division before enrolling.

571. Supervision of Special Education (3) I Practical aspects of supervising special education programs and services; curriculum development, service delivery models, staff development, program development, and legal issues and requirements.

572. Policy Analysis in Special Education (3) I Practical aspects of policy analysis and development in schools and other social agencies which serve the handicapped and the gifted.
575. **Observation and Participation in Special Education Programs** (1-3) II Specific types of exceptional individual, psychological and educational implications and practices. Field trips, class observations and seminars. P. 300. Special sections in each category of the exceptionality to be arranged in the division office.

580. **Medical Aspects of Disability** (3) I Etiology, therapy, and prognosis of the major disabilities, including drug and alcohol; assessment of physical capacities and limitations; typical restorative techniques.

581. **Psychosocial Aspects of Disability** (3) I II Exploration of the psychological and sociological aspects of disability; analysis of somatopsychology, psychosomatics, and social psychology.

582. **Principles and Practices of Vocational Evaluation** (3) I II Understanding work skills and labor market conditions; process of vocational evaluation of rehabilitation clientele; collecting and synthesizing evaluation data and writing meaningful reports.

583. **Counseling Practices in Rehabilitation Setting** (3) I II Facilitation training of rehabilitation professionals in their implementation of counseling practices with varied ethnic, age, disability, and dependency populations. 3R, 3L. Open to majors only.

584. **Client Assessment in Rehabilitation** (3) I II Exploration of the world of work; critical review of vocational choice theories; experiences in the use and interpretation of individual assessment techniques. P. 480 or CR; Ed.P. 458.

585. **Vocational Planning and Placement** (3) I II Problems of physical, mental, social, and emotional disability, as they relate to the formulation of a rehabilitation plan; exploration of the various sources of occupational and career choice information, job placement and development. P. 480, 580, 584 or CR.

586. **Psychosocial Assessment of the Deaf Person** (3) II Selection, administration, and interpretation of various psychosocial evaluation instruments used with deaf persons. P. Ed.P. 673, 674a.

587. **Construction and Development of Assessment Samples** (3) I II Use of occupational information, career exploration and job analysis techniques; development, construction, standardization, and use of work samples and related vocational assessment techniques. P. 480, 582, 584.

588. **Professional Problems in Rehabilitation Psychology** (3) II Course will discuss professional problems such as research, publishing, membership in professional organizations, including participation and presentation, legislation, monitoring the profession and defining new professional issues. P. 480.

589. **Counseling and Case Practices with the Deaf** (3) II Principles, methods, and techniques of counseling and case practices with deaf people in rehabilitation settings. P. 583.

590. **Applied Research with Exceptional Learners** (3) II Review of principles and practices underlying applied research with exceptional learners; practice in preparation of research proposals; conduct of research emphasized.

593. **Internship** (1-10) II Note: Special sections in each concentration to be arranged in the division office.

594. **Practicum**
   a. Sign Language (1) [Rpt./4 units] II 2L. Open to majors only.
   b. Communication Development for Hearing Impaired Children (1-6) I P. 532, CR 593.

595. **Colloquium**
   a. Behavioral Disorders (3) Open to majors only.
   b. Language Learning and Reading Disabilities (3) II (Identical with L.R.C. 595b)
   c. Mental Retardation (3) P. 300.
   d. Recent Advances in Special Education (3) II

597. **Workshop**
   a. Creativity and Giftedness (3) [Rpt./9 units]

600. **Research in Rehabilitation Psychology** (3) II Identification and analysis of current problems in rehabilitation. P. 480; Ed.P. 640; Ed.A. 603.

695. **Colloquium**
   a. Issues and Trends in Special Education (3) II 1988-89
   b. Behavior Disorders (3) II 1988-89
   c. Rehabilitation Psychology (3) II
   d. Learning Disabilities (3) I 1987-88
   e. Mental Retardation (3) II 1988-89
   f. Sensory Impaired (3) II 1987-88
   g. Issues and Research in Educating the Gifted (3) [Rpt./9 units] II
   h. Rehabilitation Administration (3) II
   i. Vocational Evaluation (3) II
   j. Rehabilitation of the Deaf (3) I
   k. Group Processes (3) II
   l. Diagnosis in Rehabilitation Psychology (3) II
SPEECH AND HEARING SCIENCES

Associate Professors Kathryn Bayles, Linda Swisher

The department offers programs leading to the Master of Science and the Doctor of Philosophy degrees with a major in speech and hearing sciences.

Admission requirements include the completion of a minimum of 24 undergraduate units in speech and hearing sciences. Applicants must complete departmental application forms and submit three letters of recommendation. Scores on the aptitude test of the Graduate Record Examination are required of all applicants to the graduate program, and doctoral applicants must also submit a sample of their scholarly writing. Ordinarily, completion of the master's degree is prerequisite to admission to the doctoral program.

The Master of Science program requires the completion of 36 units of course work. Submission of a thesis as a part of the program is optional.

The Doctor of Philosophy degree is designed to provide the tools, knowledge, and experience in research and not to provide specialization in clinical pursuits.

402. Principles of Neuroanatomy (4) GC II (Identical with Anat. 402)
450. Structure of Speech and Language (3) GC I Study of the nature of language and linguistics; current approaches in linguistics.
451. Acquisition of Speech and Language (3) GC II Normal development of speech and language in the child; relationships with cognitive and social development. (Identical with Ling. 451)
458. Introductory Clinical Studies: Speech-Language Pathology (1-3) [Rpt./9 units] GC I II S Basic clinical procedures for managing a limited range of speech and language disorders. Includes observation and supervised practice. Open to majors only. P, 451 or CR 471.
459. Introductory Clinical Studies: Audiology (1-3) [Rpt./9 units] GC I I S Basic clinical procedures for identifying and managing a limited range of hearing losses in children and adults. Includes observation and supervised practice. Open to majors only. P, 483 or CR.
461R. Speech and Hearing Science Instrumentation (2) GC I Consideration of some common and specific instruments and methods employed in speech and hearing labs. and clinics. P, 260, 280 or CR.
461L. Speech and Hearing Science Instrumentation Laboratory (1) GC P, CR 461R.
471R. Articulation Disorders and Therapies (2) GC I Etiology, diagnosis, prognosis, and therapy for the articulatory aspects of communication problems. P, 370; 367; CR or subsequent registration in 471 L (for majors).
471L. Laboratory in Articulation Disorders (1) GC I Open to majors only. P, 471 R or CR.
479. Speech and Hearing Disorders for Related Professions (3) GC I II Recognition and management of language, speech and hearing problems for related professions such as education, nursing, psychology, and speech communication. Open to nonmajors only.
484. Audiologic Rehabilitation: Adults (3) GC II Speech reading; auditory training; problems encountered with amplification units; social, psychological, educational, speech, and language difficulties encountered by the hearing handicapped. P, 280, 483.
497. Workshop —
a. Speech, Language and Hearing Problems in Children and Adolescents (3) GC S Field trips.
500. Introduction to Graduate Study (3) II Introduction to the conduct of research and grad. study in speech and hearing sciences.
510. Counseling Techniques in Communication Disorders (3) II S Basic counseling techniques pertinent to clinical practice with the communication handicapped and their families.
553R. **Language Disorders in Preschool Children** (2) I Etiology, evaluation and therapy for children with delayed language and/or language disabilities; relationships with learning disabilities; dialect and bilingualism.

553L. **Laboratory in Preschool Language Disorders** (1) II

554R. **Adult Aphasia** (2) I Etiology, evaluation and therapy for language disorders associated with brain damage. P, 370; 450 or 451; CR or subsequent registration in 554L (for majors).

554L. **Laboratory in Adult Aphasia** (1) I P, 554R or CR.

558a-558b. **Intermediate Clinical Studies: Speech-Language Pathology** (1 to 3 - 1 to 3) [Rpt./9 units] I II S Under faculty supervision, students assess speech and language functioning, develop treatment plans, and carry out remedial programs based on empirical data and current technology. 558b is in an extern setting. Open to majors only. P, 451, 471.

559. **Intermediate Clinical Studies: Audiology** (1-3) [Rpt./9 units] I II S Under faculty supervision, students assess hearing impairments, formulate objectives, and carry out remedial programs with emphasis on the application of research data and current technology to clinical treatment. Open to majors only. P, 483.

560a-560b. **Experimental Phonetics** (3-3) 560a: Systematic examination of current experimentation and research in speech as motor behavior, with emphasis on physiological investigations of normal respiration, phonation, resonance, and articulation; critical evaluation of research design. P, 260. 560b: Systematic examination of current experimentation and research in speech as an acoustical phenomenon; critical evaluation of research design. P, 260, 461. 2R, 3L. 560a is not prerequisite to 560b.

565R. **Aerodynamic Evaluation and Management of the Speech Mechanism** (2) I Principles and clinical methods of aerodynamic evaluation and management of the disordered speech mechanism, with practical experience provided through case studies and class experiments. P, 260, 461, 560a.

565L. **Aerodynamic Evaluation and Management of the Speech Mechanism Laboratory** (1) P, CR 565R.

570R. **Evaluation Process** (2) I Study of principles, methods and selected procedures involved in the assessment of individuals with communication disorders; attention to skills in interviewing and preparation of reports. P, 370, 483; CR or subsequent registration in 570L (for majors).

570L. **Laboratory in Evaluation Process** (1) I II Open to majors only. P, 570R or CR.

571. **Cleft Palate, Other Craniofacial Disorders, and Communication** (2) I Communication disorders associated with cleft palate and other craniofacial defects. Speech assessment, evaluation and treatment; survey of dental and surgical services.

572R. **Disorders of Phonation** (2) I Etiology, diagnosis, prognosis, and therapy for disorders of voice; speech for the laryngectomized. P, 260.

572L. **Disorders of Phonation Laboratory** (1) II Open to majors only. P, 572R or CR.

573R. **Disorders of Fluency** (2) I Primarily a study of stuttering: identification, nature and assessment; theoretic considerations; management approaches; proportionate attention to other anomalies of fluency. P, 370; CR or subsequent registration in 573L (for majors).

573L. **Laboratory in Disorders of Fluency** (1) I Open to majors only. P, 573R or CR.


576. **Communicative Aspects of Aging** (2) I Hearing, speech, voice, and language changes in the elderly caused by aging and disease. Emphasis on management of these problems. (Identical with Gero. 576)


579. **Organization and Administration of Speech and Hearing Programs** (3) II Problems in organizing a speech and hearing program: philosophy, case load, space, staff, budget, interagency cooperation.

580. **Industrial Audiology** (2) II Auditory and non-auditory effects of noise, industrial hearing conservation, noise measurement and control.

581. **Evaluation and Selection of Hearing Aids** (3) I Development of hearing aid evaluations; circuitry of hearing aids and their physical characteristics; speech intelligibility and the electroacoustics of low-fidelity circuitry; patient evaluation and counseling. P, 483; CR or subsequent registration in 494b (for majors).

582. **Disorders of Hearing** (3) I Pathologies of the hearing mechanism and their auditory manifestations in both adults and children. P, 280, 483.

583. **Special Auditory Tests** (3) II Special audiologic procedures to differentiate conductive versus sensorineural, sensory versus neural, central versus peripheral, and organic versus functional hearing disorders. Open to majors only. P, 483, 582.
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DEPARTMENTS AND COURSES OF INSTRUCTION

584. **Audiologic Habilitation: Children** (3) I Amplification, room acoustics, auditory and visual processing, evaluation and remedial programming for children with mild to moderate hearing impairment. P, 483 or 589.

585. **Physiological Acoustics** (3) II Study of contemporary auditory theory and its historical development; theories related to the function of physiological and neurological mechanisms in the light of empirical findings; psychophysical findings related to physiological findings. P, 280.

586. **Electrophysiological Evaluation of the Auditory and Vestibular Systems** (3) II Techniques, normative data, and clinical interpretation of auditory-evoked potential and electronystagmography tests. 2R, 3L.

587. **Psychophysical Acoustics** (3) II Experimental procedures and instrumentation; study of psychoacoustics; stimulus integration, pitch and loudness limens and scales, masking, and auditory fatigue; binaural hearing; theory of signal detection. 2R, 3L. P, 260, 461.

589. **Principles of Audiology** (3) I Basic techniques of pure-tone audiometric testing; interpretation of audiograms; disorders of hearing; anatomy and physiology of the hearing mechanism; basic acoustics. Open to nonmajors only.

596. **Seminar**
   a. Experimental Phonetics (1-3) [Rpt./2 or 9 units] I II
   b. Clinical Audiology (1-3) [Rpt./2 or 9 units] I II
   c. Hearing—Physiology and Psychophysics (1-3) [Rpt./2 or 9 units] I II
   d. Language and Language Disorders (1-3) [Rpt./2 or 9 units] I II
   e. Speech Pathology (1-3) [Rpt./2 or 9 units] I II

658a-658b. **Advanced Clinical Studies: Speech-Language Pathology** (1 to 3 - 1 to 3) [Rpt./9 units] I II S With faculty consultation and supervision, students assume responsibility for all aspects of case management of children and adults. Exposure to clinical research methods and interdisciplinary staffings. 658b is in an extern setting. P, 471, 553.

659. **Advanced Clinical Studies: Audiology** (1-3) [Rpt./9 units] I II S With faculty consultation and supervision, students assume responsibility for all aspects of case management of adults and children. Exposure to clinical research methods and interdisciplinary staffings. Open to majors only. P, 483.

693. **Internship**
   a. Speech Pathology (1-6) I II Open to majors only. P, 494a.
   b. Audiology (1-6) I II Open to majors only. P, 494b.

695. **Colloquium**
   a. Motor Control (2) [Rpt./8 units] II (Identical with Ex.S.S. 695a)

**SPEECH COMMUNICATION**

(See Communication)

**STATISTICS**

Professors J. L. Denny (Mathematics), Acting Head, Jean E. Weber
Assistant Professor Michael Trosset

The department offers a program leading to the Master of Science degree with a major in statistics. A thesis is not required, but up to 6 units may be earned by writing one.

For the Master of Science degree, at least 18 of the 30 units must be taken within the department. Of the 18 units, at least 12 must be at the 500 level or above. For further information, consult the department.

461. **Elements of Statistics** (3) GC I II Advanced degree credit available for nonmajors only. (Identical with Math. 461)

464. **Theory of Probability** (3) GC I (Identical with Math, 464)

465. **Statistics for the Medical Sciences** (4) GC I Standard and nonparametric one- and two-sample procedures, ANOVA designs, linear and multiple regression, bioassay, probit analysis, and contingency tables. 3R, 3L. Not open to majors. P, two semesters of calculus. (Identical with Tox. 465)

466. **Theory of Statistics** (3) GC II (Identical with Math. 466)

468. **Applied Stochastic Processes** (3) GC II (Identical with Math. 468)

562. **Sampling Theory and Methods** (3) II Introduction to planning, execution, and analysis of surveys, methods of sampling, estimation of population values, estimation of sampling error and efficiency of methods. P, one course in statistics.
Nonparametric Statistics (3) I Distribution free statistics, chi-square tests, related samples, independent samples, correlations, tests of significance, confidence bands. P, one course in stat.

Statistical Inference (3-3) 1987-88 (Identical with Math. 567a-567b)

Seminar
a. Research Methods (1-4) [Rpt./6 units] I II


Advanced Statistical Methods (3) [Rpt.] I In-depth study of a selected body of statistical techniques. Consult department for current course content. P, 466.

Applied Multivariate Analysis (3) II Consideration of multivariate statistical analyses, with emphasis on applications, interpretation of computer printouts and effects of violations of model assumptions. P, 660.

Applied Time Series Analysis (3) (Identical with A.M.E. 406) Methods used in time series analysis, with emphasis on applications, including computer analysis of data and consideration of violations of model assumptions. P, 660.

SYSTEMS AND INDUSTRIAL ENGINEERING

Professors John S. Ramberg, Head, A. Terry Bahill, Lucien Duckstein, William R. Ferrell, Marcel F. Neuts, Donald G. Schultz, A. Wayne Wymore, Sidney J. Yakowitz

Associate Professors Ronald G. Askin, Robert L. Baker, Duane L. Dietrich

Assistant Professors John W. Giffin, Jeffrey B. Goldberg, Julia L. Higle, Thuruthickara C. John, Joseph J. Pignatiello, Jr., Suvrajeet Sen

The department offers programs leading to the Master of Science degree with majors in systems engineering, industrial engineering, and reliability engineering, and leading to the Doctor of Philosophy degree with a major in systems engineering.

Normally, the graduate student has a background in engineering, mathematics, or physics. In addition, a special program is available to students with bachelor's degrees in areas other than engineering or the physical sciences. Programs vary in length from one to two-and-one-half years, depending upon background.

The Master of Science degree consists of either thirty or thirty-three units. For the thirty-unit program, at least eighteen units must be taken within the department, and, of these, no fewer than twelve units must be in courses at the 500 level or above. Additional master's level options are available, including a six-unit thesis, a six-unit paper, or a three-unit report, each of which requires an oral examination. The thirty-three unit program requires only course work, subject to the stipulations above, with the further requirement of one 600 level course and an oral final examination. Additional details concerning the requirements of the master's and doctor's degree may be obtained on request from the department.

Digital Systems Simulation (3) GC (Identical with A.M.E. 408)

Engineering Quality Control (3) GC On-line statistical process control techniques for monitoring and improving the quality of manufactured products including an introduction to off-line Japanese methods. P, 320b or A.M.E. 413a or CR 420. (Identical with A.M.E. 406)

Reliability Engineering (3) GC (Identical with A.M.E. 406)


Human Interaction with Computers and Software (3) GC The interaction of technical requirements with the characteristics of computer users and programmers as they affect the design of software, and the physical and cognitive interfaces between people and computers. P, 310.

Engineering Statistics (3) GC Statistical methodology of estimation, testing hypotheses, goodness-of-fit, nonparametric methods and decision theory as it relates to engineering practice. Significant emphasis on the underlying statistical modeling and assumptions. P, 320a.

Engineering Decision Making under Uncertainty (3) GC Application of principles of probability and statistics to the design and control of engineering systems in a random environment. Methodology includes utility theory, prior probability assessment, risk analysis and Bayesian decision analysis. P, 320b or 420.

Models in Operations Research (3) GC Engineering applications of probabilistic models including Markov processes, queueing, inventory scheduling and decision theory. P, 320a.
DEPARTMENTS AND COURSES OF INSTRUCTION

453. **Deterministic Control Systems** (3) GC I The analysis and synthesis of deterministic linear control systems, with emphasis on design using both frequency-domain and state-variable approaches. P. 350.

455. **Introduction to Robotics** (3) GC I A study of the principles involved in the operation and design of robotics, including homogeneous transformations, kinematics, trajectory selection, dynamics, control and sensing. P. 350.

462. **Production Systems Analysis** (3) GC I Production systems, product and process design, quantitative methods for forecasting, aggregate planning, inventory control, materials requirement planning, production scheduling, manpower planning and facility design. P. 340a.

463. **Production Systems Design** (3) GC II Case studies emphasizing aspects of production systems design such as facility location, facility layout, group technology, product and process design, material handling, and automated assembly. The student will be required to work in groups. Solutions will be presented using both written and oral reports. P. 462.

465. **Modeling Manufacturing Systems** (3) GC II An intermediate level introduction to topics in hierarchical design, planning, and control of manufacturing systems and their applications. Topics include modeling automated transfer lines and flexible manufacturing systems. Attention will be given to the performance of manufacturing systems and operational issues such as the role of robots, flexible machines, computers, and material handling systems. P. 340b.

473. **Concepts in Information and Communication Systems** (3) GC II Introduction to signals and signal processing; signal representations; information measures and channels; modulation and demodulation, detection, estimation. P. 350.

474. **Expert Systems** (3) GC I Building, using and evaluating expert systems, computer systems that emulate the human and draw conclusions based on incomplete or inaccurate data.

475. **Computational Methods for Games, Decisions, and Artificial Intelligence** (3) GC II An introduction to automata, computer representation and optimal solution of games and decision problems. Principles of heuristic programming and machine learning. A programming project is to be selected from areas such as game strategies, graphics, recreational mathematics, and manufacturing simulation. Microcomputer experience is emphasized. P. 270 or C.Sc. 277.

476. **Numerical Analysis** (3) GC I An intermediate-level introduction to numerical methods and error analysis for function approximation and interpolation, integration, solution of linear and nonlinear equations, and differential equations. P. 170 or 172, Math. 254.

500. **Advanced Quality Control** (3) II Advanced statistical techniques for process control and improvement. Topics include multivariate quality control, economic design of process control charts, Japanese methods for quality and selected papers from the recent literature. P. 406 and 420. (Identical with A.M.E. 506)

508. **Advanced Reliability Engineering** (3) II (Identical with A.M.E. 508)

510. **Behavioral Judgment and Decision Making** (3) I Models and theories of human judgment and decision from an engineering perspective. Subjective probability, value and utility. Methods for aiding and supporting decision making. P. 310, 320b or 420.

513. **Risk Estimation and Evaluation** (3) I (Identical with W.R.A. 513)

518. **Reliability Testing** (3) II (Identical with A.M.E. 518)


535. **Computer Integrated Manufacturing Systems** (3) I Modern manufacturing systems with emphasis on information requirements and data management. Includes CDO, CAM, CAPP, real-time scheduling, networking and system justification.

536. **Experimental Design for Manufacturing Quality** I (3) I Design and analysis of industrial experiments for manufacturing quality. Topics include regression analysis, contrasts, ANOVA, and the philosophy of Japanese manufacturers. P. 320b or 420.

537. **Experimental Design for Manufacturing Quality** II (3) II Continuation of S.I.E. 536. Topics include fixed and random effects models, confounding, fractional factorial, nested designs and response surface methodology. P. 536.

540. **Queueing Theory** (3) I Application of the theory of stochastic processes to queueing phenomena; introduction to semi-Markov processes; steady-state analysis of birth-death, Markovian, and general single- and multiple-channel queueing systems. P. 520.
544. Linear and Integer Programming (3) I II Topics include linear and integer programming formulations, simplex method, geometry of the simplex method, sensitivity and duality theory, projective transformation methods, network flow problems, branch and bound algorithms, cutting plane algorithms, Lagrangian relaxation methods. P, 340a.


550. Theory of Linear Systems (3) II An intensive study of continuous and discrete linear systems from the state-space viewpoint, including criteria for observability, controllability, and minimal realizations; and optionally, aspects of optimal control and filter theory. P, 350.

554. Mathematical System Theory (3) I Mathematical theory of discrete systems and models for application to large-scale, complex, man-machine systems.

556. Finite State Methods in Water Resources Management (3) II 1988-89 (Identical with W.R.A. 556)


563. Facility Layout and Location (3) II Mathematical characterizations of single and multifacility location models as minimum norm problems; mathematical programming methods for facility layout; investigation of computer-aided design systems. P, 564.

565. Multi-Objective Analysis of Engineering Systems (3) I Systems design versus operation; multi-objective simplex; goal programming and other distance-based techniques; multi-attribute utility; techniques with qualitative criteria; interactive, quasi-interactive and dynamic approaches; model choice; resource and industrial engineering applications. P, 540b, CR 544.


575. Advanced Production Control (3) II Quantitative models in the planning, analysis and control of production systems. Topics include aggregate production planning, capacity planning, inventory control and flexible manufacturing. P, 340a-340b.


644. Numerical Methods for Nonlinear Programming (3) II Unconstrained and constrained optimization problems from a numerical standpoint. Topics include variable metric methods, quadratic programming, active set methods, penalty function methods and successive quadratic programming methods. P, 544.


695. Colloquium
   a. Motor Control (2) [Rpt./8 units] II (Identical with Ex.S.S. 695a)
The division offers advanced programs leading to the Master of Education, Master of Arts, Master of Teaching, Educational Specialist, Doctor of Education, and Doctor of Philosophy degrees with majors in elementary education and secondary education. The division offers programs leading to the Master of Education degree with a variety of majors relevant to secondary school teaching. Also, the division offers the Master of Education and the Educational Specialist degrees with a major in educational media. For information concerning these programs, see Requirements for Master's Degrees/Master of Education elsewhere in this catalog.

An undergraduate grade-point average of at least 3.00 is required for admission to full standing in a graduate degree program. However, applicants with undergraduate grade-point averages of 2.50 to 2.99 may be admitted on a provisional basis. A master's degree (in education or a related discipline) is a prerequisite for admission to a specialist or doctoral program. Beyond these minimal requirements, applicants must also meet the specific admission requirements for all majors offered in the division.

At the time the catalog was being edited, many programs in the College of Education were being redesigned. All current and prospective students should check with the Office of Student Services in the College of Education or the Division of Teaching and Teacher Education for current admission and degree requirements in each major.

405. **Mathematics in the Secondary School** (3) GC II Study and analysis of curriculum changes in school mathematics, with emphasis on the design and content of experimental programs such as SSMCIS. P: 3 units of education; Math. 125b. (Identical with Math. 405)

408. **English as a Second Language in Bilingual Education** (3) GC I II (Identical with Engl. 408)

410. **Teaching English Composition** (3) GC I II (Identical with Engl. 410)

411. **Teaching of Literature** (3) GC I II (Identical with Engl. 411)

412. **The Teaching of the English Language** (3) GC I II (Identical with Engl. 412)

414. **Teaching of Modern Languages** (3) GC II Specific methods, objectives, organization of subject matter and evaluation in modern languages. (Identical with Fren. 414, Ital. 414, Span. 414, Port. 414)

417. **Media in Instruction** (3) GC I II S Basic design and production of media for instruction; selection and integration of materials; equipment operation. (Identical with Li.S. 417)

429. **Pedagogical Linguistics: Applied Linguistics for Language Teachers** (3) GC II (Identical with Or.S. 429)

441. **Instructional Systems Curriculum Development** (3) GC I II S Basic skills and knowledge required for curriculum developers to analyze, design, construct and evaluate instructional programs.

442. **Implementing Systems Instruction** (3) GC I II S Management and evaluation of systems instructional environment; concentration on management styles and internal and external evaluations.

443. **Advanced Instructional Methods** (3) GC I II S Theory and application of instructional methodologies; development and implementation of units of instruction using the methodologies studied.

444. **Classroom Management for Training** (3) GC I II S Strategies and objectives used in managing the learning environment, controlling student problems, and implementing due process procedures.

449. **Techniques of Teaching Adults** (3) GC II Techniques and issues of adult learning and the dynamics of the teaching and learning processes.

471. **Office Procedures and Problems** (3) GC II Effective procedures in handling routine office duties, creativity in planning for innovation in the solution of office problems; emphasis on preparation for advancement to administrative positions.

472. **Office Administration** (3) GC I Analysis of functions of office departments; their organization and administration; development and use of office manuals; selection, training, and promotion of office employees, quality and quantity of office production.

474. **Word Processing Concepts** (3) GC II S Basic concepts of information/word processing with emphasis on proper utilization of people, procedures, and equipment.

482. **Teaching Vocational Office and Distributive Education** (3) GC I Development of vocational and career education; the organization and methods of teaching office and distributive education programs.
Cooperative Vocational Education Programs (3) GC II The role of the teacher-coordinator and the coordination, teaching, guidance, public relations, and administration of work-experience programs.

Workshop
a. Evaluating the Elementary School (1-3) GC I II S P, Ed.P. 301 or 310.
b. Educational Video in the Classroom (3) GC I
d. Evaluating the Secondary School (1-3) [Rpt./3 units] GC I II
e. Print Media in the Classroom (1-3) GC I II S P, Ed.P. 301 or 310.
f. Investigating the Environment (1-3) GC II S Field trips.

Coordination of Instructional Media Programs (3) II Study of organization and distribution practices of media utilization; budgeting, public relations, and implementation of media preparation and media-service programs. P, 417. (Identical with L.S. 516)

Preparation of Instructional Materials (3) II Study of techniques used in the development of instructional materials and processes. P, 417. (Identical with L.S. 517)

Research Trends in Instructional Technology (3) I Past and current trends in instructional technology.

Design of Instructional Media (3) II Principles of instructional design and development including systems approaches, module development, and integration of media. P, 417.

Science Curriculum in the Elementary School (3) I II Trends in the science curriculum of the elementary school, with emphasis on selection of content, concepts and activities, methods of teaching, needed equipment, and community resources. Primarily for in-service, public-school personnel. P, 12 units of teacher education.

Trends and Issues in Early Childhood Education (3) I II S 1988-89 Trends and issues in contemporary early educational programs with emphasis on changing needs in the home, school, and society.

Learning Through Play (3) I II S Play theories as they relate to early childhood development, parenting, and curriculum design.

Constructing the Elementary School Curriculum (3) I II The elementary school curriculum and its relationships; basic theories and techniques of curriculum construction discussed, evaluated and applied. P, 12 units of teacher education.

Mathematics Curriculum in the Elementary School (3) I II Emphasis on selection and placement of content, coordination of concepts with strategies of teaching, and selection and use of materials and resources. P, 12 units of teacher education.

Developing the Language Arts Curriculum in the Elementary School (3) I II Trends in the language arts curriculum of the elementary school, with emphasis on linguistic theory and its application to the instructional program. P, 12 units of teacher education.

Social Studies Curriculum in the Elementary School (3) I II Trends in the social studies curriculum of the elementary school, with emphasis on selection of content, grade placement of concepts and activities, methods of teaching, needed equipment, and community resources. Primarily for in-service, public-school personnel. P, 12 units of teacher education.

Parent Education and Involvement (3) I II S Study of models for parent education; exploration of alternative strategies for improving parent/teacher interactions and parent involvement in the learning process.

Curriculum in Early Childhood Education (3) I II Emphasis on selection of criteria to determine classroom organization, curriculum construction, and instructional programs. P, 12 units of teacher education.

Investigations in Elementary Education (3) I II Critical study and evaluation of the investigations and experimental evidence basic to the aims and instructional practices of the elementary school.

Classroom Communication and Interaction (3) II The teacher's role in promoting effective communication and interaction in the classroom situation.

Curricular Studies in School Mathematics (3) II 1988-89 Experimental programs in school mathematics, with emphasis on selection of content and on problems in design and evaluation.

Math Diagnosis and Remediation (3) II Techniques for identifying mathematical learning difficulties and strengths; strategies for designing systematic instruction for correcting identified difficulties. 3R, IL. P, 326.

Day Care Education (3) I History, types, goals, environments, planning for adults, standards and licensing requirements, understanding public responsibility of comprehensive child care. Field trips.

Analysis of Secondary School Teaching (3) I Analysis of the teaching process; preparation of behavioral objectives; study of recent methods, trends; analysis of current classroom evaluation techniques.
535. **Organization and Functions of the Secondary School** (3) I Secondary school; its organization, structure and operation; role and responsibilities of the teacher, the administrator and other personnel.

536. **Innovations in Secondary Education** (3) II Change process in education, with emphasis on those elements which support or hinder change in the schools; detailed study of current secondary school innovations on the national and local levels.

538. **Constructing the Secondary School Curriculum** (3) I Curriculum and its relationships; basic theories and techniques of curriculum construction discussed, evaluated, and applied.

539. **Investigations in Secondary Education** (3) I Critical study and evaluation of the investigations and experimental evidence underlying the aims and instructional practices of the various subject-matter fields of the secondary school.

542. **The Middle School / Junior High** (3) II History, purposes, curriculum, and administration of the middle school/junior high.


595. **Colloquium**
   b. Curriculum (1-3) I II P, 538.
   c. Instruction (1-3) I II P, 539.
   e. Master's Colloquium (1-3) I II

597. **Workshop**
   a. Classroom Teaching Innovations (1-3) I II
   b. Simulation and Gaming in the Classroom (1-3) I II
   c. Values Education in the Classroom (1-3) I II
   d. Educational Implications of Prejudice (1-3) I II
   e. Equality in Education (3) I II S
   f. Problems and Processes in Teacher Appraisal (1-3) [Rpt./6 units] I II
   g. Learning Centers in Elementary School Math (3) S

618. **Research on Teaching** (3) II To acquaint educational researchers with the models, paradigms, strategies, and empirical research that are the basis for understanding how classroom teaching and learning are related. P, Ed.P. 510, 541, 558.

696. **Seminar**
   a. Topics in Teacher Education (1) [Rpt./6] I II

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**TOXICOLOGY**

*(See Pharmacology and Toxicology, College of Pharmacy)*

**TURKISH**

*(See Oriental Studies)*

**URBAN PLANNING**

*(See Planning)*

**URDU**

*(See Oriental Studies)*

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**VETERINARY SCIENCE**


Associate Professors Ronald W. Hilwig, Lynn A. Joens, J. Glenn Songer, Charles R. Sterling
No advanced degree is offered in veterinary science. In cooperation with the Committee on Animal Physiology, the department offers course work and research direction for students working toward the Master of Science or the Doctor of Philosophy degree with majors in this discipline. In certain cases, similar cooperative arrangements may be made with the departments of Entomology, Ecology and Evolutionary biology, or Microbiology and Immunology. Students majoring in other disciplines may elect veterinary science as a doctoral minor with the approval of the major department.

400a-400b. Animal Anatomy and Physiology (3-3) GC Physiology, gross and comparative anatomy. 400a: Nervous, musculoskeletal, immune, hemolymphatic, circulatory, and respiratory systems of domestic animals. 400b: Urinary, digestive, endocrine and reproductive systems. 400a is not prerequisite to 400b. P, Ecol. 104, Chem. 103a-103b, 104a-104b.

403R. Biology of Animal Parasites (3) GC I Biology of host-parasite relationships with emphasis on parasites of veterinary and human importance. Parasite morphology and physiology, life cycles, epidemiology, pathogenesis and zoonotic potential. P, 8 units of biology or microbiology. (Identical with Ento. 403R, Ecol. 403R, Micr. 403R)

405. Animal Diseases (3) GC I Integration of management, husbandry, and preventive veterinary medicine, as related to animal diseases.

415R. Physiology of Reproduction (3) GC I (Identical with An.S. 415R)

415L. Physiology of Reproduction Laboratory (1) GC I (Identical with An.S. 415L)

419R. General Immunology (3) GC I (Identical with Micr. 419R)

419L. General Immunology Laboratory (2) GC (Identical with Micr. 419L)

420R. Pathogenic Bacteriology (3) GC II (Identical with Micr. 420R)

420L. Pathogenic Bacteriology Laboratory (2) GC II (Identical with Micr. 420L)

423R. General Pathology (3) GC II Pathogenesis, pathophysiology and morphologic changes of human and animal diseases. P, Micr. 420R. (Identical with Micr. 423R and Tox. 423R)

423L. General Pathology Laboratory (1) GC II Gross and histologic changes occurring in tissues and organs in selected human and animal diseases and disease processes. P, 423R or CR. (Identical with Micr. 423L and Tox. 423L)

438. Ecology of Infectious Disease (3) GC II 1987-88 (Identical with Micr. 438)

450. Medical Mycology (4) GC II (Identical with Micr. 450)

458. Comparative Vertebrate Anatomy (4) GC I Evolution and gross structure of vertebrate organ systems. 2R, 6L. P, 8 units of animal biology. (Identical with Ecol. 458)

459. Comparative Vertebrate Histology (4) GC II Structure, identification and function of normal vertebrate tissues. 2R, 6L. P, 8 units of animal biology. A vertebrate anatomy course is strongly recommended. (Identical with Ecol. 459)

601. Experimental Surgery (2) II 1987-88 Exercises in the surgical procedures commonly necessary in animal experimentation, including aseptic technique, anesthesiology, surgical operations, and care of the postsurgical patient. 1R, 3L. P, 3 units of mammalian anatomy.

630. Immunology (4) II 1988-89 (Identical with Micr. 630)

681. Biostatistical Methods in Microbiology (2) I 1988-89 (Identical with Micr. 681)
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