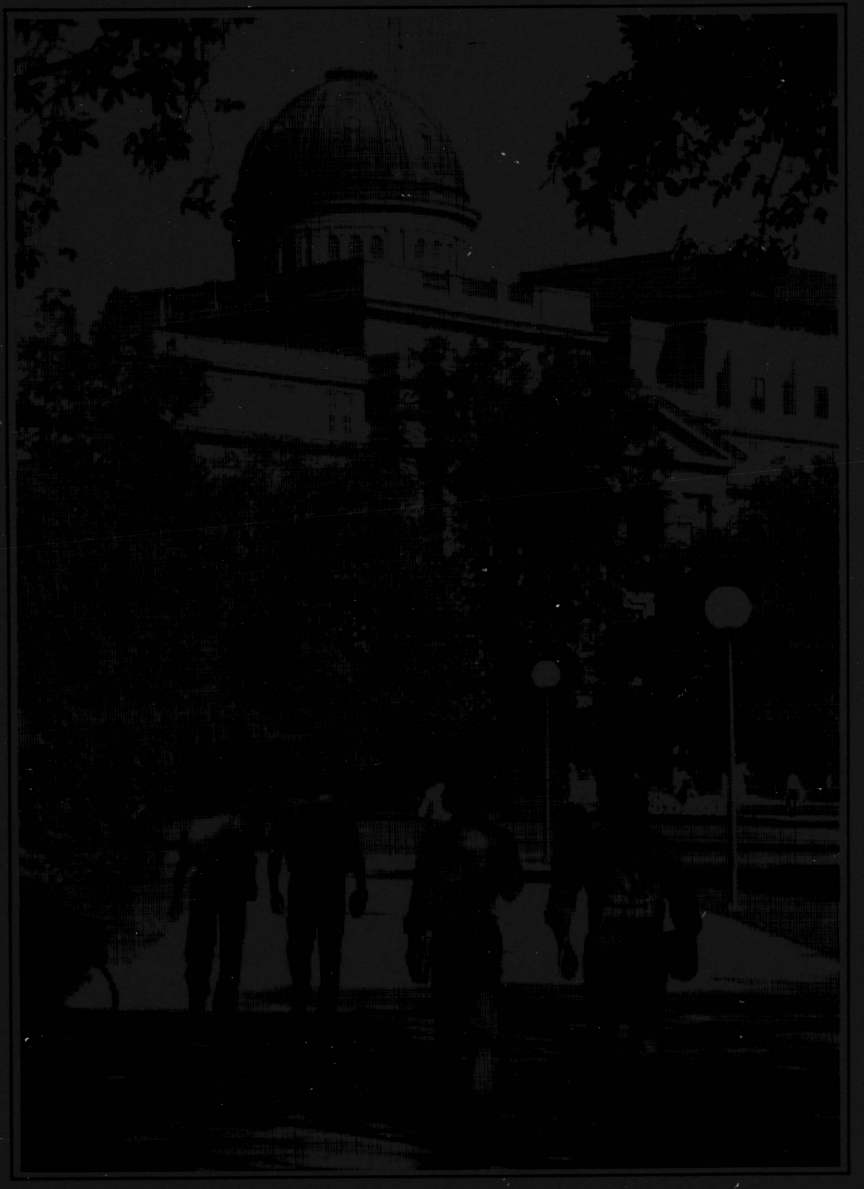

Texas A&M University

1982-83 Graduate Catalog

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Texas A&M University

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Announcements for 1982-83

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TEXAS A&M UNIVERSITY
1982-83 ACADEMIC CALENDAR

Summer Session 1982

May 31	Monday. Registration for first term and the 11-week semester.
June 1	Tuesday. First day of first term and 11-week semester classes.
June 3	Thursday. Last day for enrolling in the University for the first term and the 11-week semester and for adding new courses.
June 4	Friday. Last day for dropping courses with no record.
June 11	Friday. Last day for dropping courses with no penalty for the first term (Q-drop). Last day for applying for graduate and undergraduate degrees to be awarded in August for students completing degree requirements in July.
June 24	Thursday. Last day for dropping courses with no penalty for the 11-week semester (Q-drop).
July 5	Monday. Independence Day holiday.
July 6	Tuesday. Last day of first term classes. Beginning of first term final examinations, 7 p.m.
July 7	Wednesday. Last day of first term final examinations.
July 8	Thursday. Registration for the second term.
July 9	Friday. Beginning of second term classes.
July 13	Tuesday. Last day for enrolling in the University for the second term and for adding new courses.
July 14	Wednesday. Last day for dropping courses with no record.
July 16	Friday. Last day for applying for graduate and undergraduate degrees to be awarded in August for students completing degree requirements in August.
July 21	Wednesday. Last day for dropping courses with no penalty for the second term (Q-drop).
August 11	Wednesday. Last day of 11-week semester classes. Beginning of 11-week semester final examinations, 7 p.m.
August 12	Thursday. Last day of second term classes. Beginning of second term final examinations, 7 p.m. Continuation of 11-week semester final examinations, 7 p.m.
August 13	Friday. Last day of second term and 11-week semester final examinations.
August 14	Saturday. Commencement for first and second term and 11-week semester graduating students.

REGULAR SESSION
Fall Semester 1982

August 23-27	Monday through Friday. Delayed registration, adds and drops.
August 30	Monday. First day of fall semester classes.
September 3	Friday. Last day for enrolling in the University for the fall semester and for adding new courses.
September 10	Friday. Last day for applying for graduate and undergraduate degrees to be awarded in December.
September 14	Tuesday. Last day for dropping courses with no record.
October 1	Friday. Last day for dropping courses with no penalty (Q-drop).
October 18	Monday. Midsemester grade sheets due in Registrar's Office from faculty.
November 15-19	Monday through Friday. Preregistration for the 1983 spring semester.
November 25-28	Thursday through Sunday. Thanksgiving holidays.
December 10	Friday. Last day of fall semester classes. Commencement.

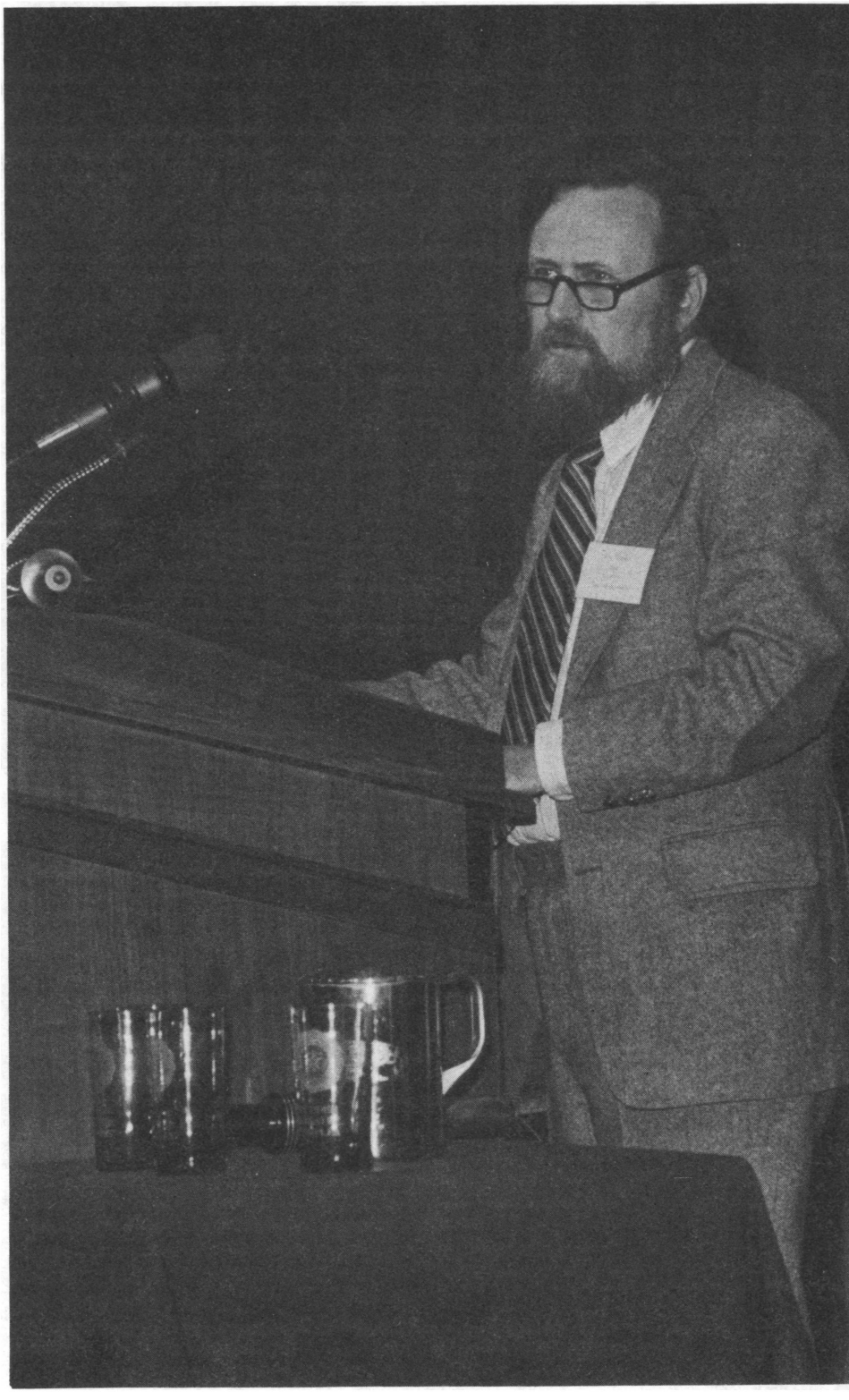
December 11 Saturday. Commencement.
December 13-17 Monday through Friday. Fall semester final examinations.

Spring Semester 1983

January 12-14 Wednesday through Friday. Delayed registration, adds and drops.
January 17 Monday. First day of spring semester classes.
January 21 Friday. Last day for enrolling in the University for the spring semester and for adding new courses.
February 1 Tuesday. Last day for dropping courses with no record.
February 4 Friday. Deadline for applying for graduate and undergraduate degrees to be awarded in May.
February 18 Friday. Last day for dropping courses with no penalty (Q-drop).
March 7 Monday. Midsemester grade sheets due in Registrar's Office from faculty.
March 14-20 Monday through Sunday. Spring break.
April 18-22 Monday through Friday. Preregistration for the 1983 fall semester.
May 6 Friday. Last day of spring semester classes. Commencement.
May 7 Saturday. Commencement and Final Review.
May 9-13 Monday through Friday. Spring semester final examinations.

Summer Session 1983

May 30 Monday. Registration for first term and the 11-week semester.
May 31 Tuesday. First day of first term and 11-week semester classes.
June 2 Thursday. Last day for enrolling in the University for the first term and the 11-week semester and for adding new courses.
June 3 Friday. Last day for dropping courses with no record.
June 10 Friday. Last day for dropping courses with no penalty for the first term (Q-drop). Last day for applying for graduate and undergraduate degrees to be awarded in August for students completing degree requirements in July.
June 23 Thursday. Last day for dropping courses with no penalty for the 11-week semester (Q-drop).
July 4 Monday. Independence Day holiday.
July 5 Tuesday. Last day of first term classes. Beginning of first term final examinations, 7 p.m.
July 6 Wednesday. Last day of first term final examinations.
July 7 Thursday. Registration for the second term.
July 8 Friday. First day of second term classes.
July 12 Tuesday. Last day for enrolling in the University for the second term and for adding new courses.
July 13 Wednesday. Last day for dropping courses with no record.
July 15 Friday. Last day for applying for graduate and undergraduate degrees to be awarded in August for students completing degree requirements in August.
July 20 Wednesday. Last day for dropping courses with no penalty for the second term (Q-drop).
August 10 Wednesday. Last day of 11-week semester classes. Beginning of 11-week semester final examinations, 7 p.m.
August 11 Thursday. Last day of second term classes. Beginning of second term final examinations, 7 p.m. Continuation of 11-week semester final examinations, 7 p.m.
August 12 Friday. Last day of second term and 11-week semester final examinations.
August 13 Saturday. Commencement for first and second term and 11-week semester graduating students.



GRADUATE FACULTY

(Listings of degrees and rank correct as of October 1, 1981. Listings of Graduate Faculty membership correct as of January 15, 1982. Figures in parentheses indicate date of first appointment on the University staff and date of appointment to present position, respectively.)

Abernathy, John R., *Associate Professor of Agronomy.* (1980) B.S., Oklahoma State University, 1967; M.S., 1969; Ph.D., University of Illinois, 1972.

Aberth, Oliver G., *Professor of Mathematics.* (1970) B.S., City College of New York, 1950; M.S., Massachusetts Institute of Technology, 1951; Ph.D., University of Pennsylvania, 1962.

Ables, John Roger, *USDA Scientist, Department of Entomology.* (1978) B.A., Erskine College, 1968; M.A., Appalachian State University, 1971; Ph.D., Clemson University, 1975.

Adair, Thomas W., III, *Secretary, Academic Council, and Professor of Physics.* (1966, 1978) B.S., Texas A&M University, 1957; M.A., Rice University, 1960; Ph.D., Texas A&M University, 1965.

Adams, Emory Temple, Jr., *Professor of Chemistry.* (1969, 1976) B.A., Rice University, 1949; M.S., Baylor College of Medicine, 1952; Ph.D., University of Wisconsin, 1962.

Adams, Henry R., *Visiting Member, Department of Veterinary Physiology and Pharmacology.* (1977) B.S., Texas A&M University, 1965; D.V.M., 1966; Ph.D., University of Pittsburgh, 1972.

Adams, Leslie Garry, *Professor of Veterinary Pathology.* (1969, 1978) B.S., Texas A&M University, 1963; D.V.M., 1964; Ph.D., 1968; Diplomate, American College of Veterinary Pathologists, 1970.

Adams, Ralph James Q., *Associate Professor of History.* (1974, 1979) B.S., Indiana University, 1965; M.A., Valparaiso University, 1962; Ph.D., University of California, Santa Barbara, 1972.

Adkisson, Perry Lee, *Deputy Chancellor for Agriculture, The Texas A&M University System, and Distinguished Professor of Entomology.* (1958, 1980) B.S., University of Arkansas, 1950; M.S., 1954; Ph.D., Kansas State University, 1956.

Aguilera, Jose M., *Assistant Research Scientist, Department of Agricultural Engineering.* (1981) Ind. Engr., Catholic University (Chile), 1971; M.S., Massachusetts Institute of Technology, 1973; Ph.D., Cornell University, 1976.

Aguirre, Benigno E., *Assistant Professor of Sociology.* (1977) B.A., Florida State University, 1970; M.A., Tulane University, 1971; Ph.D., Ohio State University, 1977.

Ahr, Wayne Merrill, *Associate Professor of Geology.* (1970, 1976) B.S., University of Texas at El Paso, 1960; M.S., Texas A&M University, 1965; Ph.D., Rice University, 1967.

Akgerman, Aydin, *Associate Professor, Chemical Engineering.* (1980, 1981) B.S., Robert College, 1968; M.S., University of Virginia, 1969; Ph.D., 1971.

Albanese, Robert, *Professor of Management.* (1971, 1976) B.S., Ohio State University, 1952; M.B.A., 1957; Ph.D., 1962.

Aldred, William Hughes, P.E., *Associate Professor of Agricultural Engineering.* (1953, 1976) B.S., University of Georgia, 1951; M.S., Texas A&M University, 1956.

Aldrich, David Virgil, *Professor of Marine Biology (Galveston), Department of Wildlife and Fisheries Sciences.* (1966, 1979) A.B., Kenyon College, 1950; M.A., Rice University, 1952; Ph.D., 1954.

Alexander, Richard M., P.E., *Associate Professor of Mechanical Engineering.* (1977, 1981) B.S., Texas A&M University, 1965; M.S., 1967; Ph.D., University of Texas at Arlington, 1975.

Allen, David H., *Assistant Professor, Aerospace Engineering.* (1981) B.S., Texas A & M University, 1972; M.Eng., 1977; Ph.D., 1980.

Allen, Graham Donald, *Associate Professor of Mathematics.* (1971, 1976). B.S., University of Wisconsin, 1965; M.S., 1966; Ph.D., 1971.

Allen, John William, *Professor of Economics.* (1967, 1978) B.S., University of Illinois, 1958; M.S., 1963; Ph.D., 1967.

Allen, Phillip E., P.E., *Halliburton Associate Professor of Electrical Engineering.* (1976, 1978) B.S., California State University, 1962; M.S., 1965; Ph.D., University of Kansas, 1970.

Allen, Roland E., *Associate Professor of Physics.* (1970, 1976) B.A., Rice University, 1963; B.A., University of Houston, 1965; Ph.D., University of Texas at Austin, 1969.

Alston, Jon P., *Professor of Sociology.* (1974, 1980) B.A., Emory University, 1960; M.S., Florida State University, 1962; Ph.D., University of Texas at Austin, 1971.

Amoss, Max St. Clair, Jr., *Associate Professor of Veterinary Physiology and Pharmacology.* (1975, 1980) B.S., Pennsylvania State University, 1962; M.S., Texas A&M University, 1965; Ph.D., Baylor College of Medicine, 1969.

Anderson, Carol Riggs, *Professor of Educational Psychology.* (1969, 1980) B.S., Texas Woman's University, 1958; M.A., 1962; Ed.D., Columbia University, 1966.

Anderson, Frank G., Jr., *Visiting Member, Department of Biology.* (1978) B.S., Texas A&M University, 1950; M.D., University of Texas Medical Branch, 1954.

Anderson, James Gilbert, Jr., *Professor of Veterinary Physiology and Pharmacology.* (1966, 1976) B.S., Texas A&M University, 1952; D.V.M., 1966; M.S., 1970.

Anderson, Richard Kenneth, *Associate Professor of Economics.* (1975, 1980) B.A., Rockford College, 1967; M.A.T., 1971; M.S., Purdue University, 1972; Ph.D., 1975.

Anderson, Warren Boyd, *Associate Professor of Agronomy.* (1964, 1971) B.S., Brigham Young University, 1958; M.S., Colorado State University, 1962; Ph.D., 1964.

Andreadis, Harriette, *Assistant Professor of English.* (1975) B.A., Temple University, 1961; M.A., 1966; Ph.D., University of Wisconsin, 1970.

Andrews, Wesley T., Jr., *Associate Professor of Accounting.* (1980) A.B., Duke University, 1956; C.P.A., North Carolina, 1959; M.B.A., University of North Carolina, 1960; Ph.D., 1976; C.P.A., Louisiana, 1979.

Anthony, Rayford Gaines, P.E., *Professor of Chemical Engineering.* (1966, 1974) B.S., Texas A&M University, 1958; M.S., 1962; Ph.D., University of Texas at Austin, 1966.

Anthony, Ted F., *Associate Professor of Business Analysis and Research.* (1976) B.B.A., North Texas State University, 1960; M.B.A., Texas A&M University, 1965; D.B.A., University of Colorado, 1971.

Appleberry, Mary Hilton, *Visiting Member, Department of Educational Curriculum and Instruction.* (1974) B.A., Pepperdine College, 1942; M.Ed., University of Houston, 1960; Ed.D., 1969.

Archer, Stanley Louis, *Professor of English.* (1962, 1970) B.S., Texas A&M University, 1959; M.A., University of Mississippi, 1961; Ph.D., 1965.

Arkin, Gerald F., *Associate Professor of Agricultural Engineering, Blackland Research Center (Temple).* (1976) B.S., Cornell University, 1966; M.S., University of Georgia, 1968; Ph.D., University of Illinois, 1971.

Armstrong, David Grant, *Associate Professor of Educational Curriculum and Instruction.* (1975, 1978) B.A., Stanford University, 1962; M.A., University of Montana, 1967; Ph.D., University of Washington, 1973.

Arnold, Keith Alan, *Professor of Wildlife and Fisheries Sciences.* (1966, 1978) A.B., Kalamazoo College, 1959; M.S., University of Michigan, 1961; Ph.D., Louisiana State University, 1966.

Arnold, Richard, K., *Visiting Member, Department of Forest Science.* (1978) B.S., University of California, Berkeley, 1937; M.S., Yale University, 1938; Ph.D., University of Michigan, 1950.

Ash, Michael James, *Associate Professor of Educational Psychology.* (1973, 1976) B.A., Arizona State University, 1969; M.A., 1973; Ph.D., 1974.

Ashcraft, Allan Coleman, *Professor of History.* (1956, 1975) B.A., Texas A&M University, 1950; M.A., Columbia University, 1951; Ph.D., 1960.

Ashworth-Tsutsui, Ethel, *Associate Professor of Biochemistry and Biophysics.* (1968) A.B., Keuka College, 1948; Ph.D., University of Rochester, 1954.

Asmuth, Charles A., *Assistant Professor of Mathematics.* (1977) B.A., University of Wisconsin, 1971; M.S., University of Chicago, 1972; Ph.D., 1976.

Auernheimer, Leonardo, *Associate Professor of Economics.* (1973, 1978) Lic. Econ., University of Buenos Aires, 1966; M.A., University of Chicago, 1970; Ph.D., 1973.

Aufderheide, Karl John, *Assistant Professor of Biology and of Genetics.* (1979) B.S., University of Minnesota, 1970; M.S., 1972; Ph.D., 1974.

Austin, Donald B., *Professor of Landscape Architecture.* (1974, 1977) B.S., Texas A&M University, 1953; M.A., University of Oregon, 1958; Registered Landscape Architect; A.S.L.A.

Austin, John C., *Visiting Member, Department of Educational Curriculum and Instruction.* (1974) B.S., Sam Houston State University, 1950; M.Ed., Stephen F. Austin State University, 1952; Ed.D., University of Houston, 1967.

Avery, Thomas Eugene, *Professor of Forest Science.* (1974) B.S.F., University of Georgia, 1949; M.F., Duke University, 1950; Ph.D., University of Minnesota, 1958.

Ayoub, Abdel-Kader, P.E., *Professor of Electrical Engineering.* (1968, 1978) B.S., University of Alexandria (United Arab Republic), 1948; M.S., University of Texas at Austin, 1952; Ph.D., 1955.

Bailey, Everett Murl, *Professor of Veterinary Physiology and Pharmacology.* (1970, 1981) D.V.M. Texas A&M University, 1964; M.S., Iowa State University, 1966; Ph.D., 1968; Diplomate, American Board of Veterinary Toxicology, 1972.

Bakelman, Ilya, *Visiting Professor of Mathematics.* (1981) B.A., University of Leningrad, 1951; Ph.D., 1954.

Baker, Glenn E., *Associate Professor of Industrial Education.* (1977) B.S., Texas A&M University, 1956; M.Ed., 1961; Ed.D., 1966.

Baker, Robert Donald, *Professor of Forest Science.* (1970, 1975) B.S.F., University of California, 1951; M.F., 1952; Ph.D., State University of New York College of Forestry at Syracuse, 1955.

Baldwin, Thomas O., *Associate Professor of Biochemistry and Biophysics.* (1981) B.S., University of Texas at Austin, 1969; Ph.D., 1971.

Barham, Warren S., *Professor of Horticultural Sciences.* (1976) B.S., University of Arkansas, 1941; Ph.D., Cornell University, 1950.

Barker, Donald Gene, *Professor of Educational Psychology.* (1959, 1967) B.A., Baylor University, 1952; M.A., 1954; Ph.D., University of Texas at Austin, 1961.

Barnes, George Edgar, *Assistant Professor of Medical Pharmacology and Toxicology.* (1975) B.S., Southwest Texas State University, 1967; M.S., 1969; Ph.D., University of Texas at San Antonio, 1973.

Barrow, David Lee, *Associate Professor of Mathematics.* (1973, 1979) B.S., Oklahoma State University, 1965; Ph.D., University of Michigan, 1973.

Barzak, Robert William, *Associate Professor of English.* (1955, 1962) B.A., Texas A&M University, 1949; M.A., University of Illinois, 1951; Ph.D., 1959.

Basco, David R., P.E., *Associate Professor of Civil Engineering and of Ocean Engineering.* (1969, 1974) B.S., University of Wisconsin, 1960; M.S., 1962; Ph.D., Lehigh University, 1970; Dipl. H.E. (Delft), 1976.

Bashaw, Elexis Cook, *USDA Scientist, Department of Soil and Crop Sciences.* (1951, 1967) B.S., Purdue University, 1947; M.S., 1948; Ph.D., Texas A&M University, 1954.

Basmann, Robert L., *Professor of Economics.* (1969) B.S., Iowa State University, 1950; M.S., 1953; Ph.D., 1955.

Bass, George F., *Alumni Professor, Distinguished Professor of Anthropology and Professor of Geography.* (1976, 1980) B.A., Johns Hopkins University, 1954; M.A., 1955; Ph.D., University of Pennsylvania, 1964.

Bassett, James Wilbur, *Professor of Animal Science.* (1963, 1972) B.S., Texas A&M University, 1948; M.S., Montana State University, 1957; Ph.D., Texas A&M University, 1965.

Bassichis, William H., *Associate Professor of Physics.* (1970) B.S., Massachusetts Institute of Technology, 1959; M.S., Case Western Reserve University, 1961; Ph.D., 1963.

Bastiaans, Glenn J., *Assistant Professor of Chemistry.* (1979) B.S., University of Illinois, 1969; Ph.D., Indiana University, 1973.

Batchelor, Bill, P.E., *Associate Professor of Civil Engineering.* (1976, 1981) B.A., Rice University, 1971; M.S., 1974; Ph.D., Cornell University, 1976.

Bateman, Thomas S., *Assistant Professor of Management.* (1981) B.A., Miami University, 1974; M.B.A., Indiana University, 1978; D.B.A., 1980.

Bates, George Winston, *Associate Professor of Biochemistry and Biophysics.* (1969, 1974) B.S., California State University, Los Angeles, 1963; Ph.D., University of Southern California, 1967.

Bates, Peter W., *Assistant Professor of Mathematics.* (1978, 1979) B.S., University of London, 1969; Ph.D., University of Utah, 1976.

Battalio, Raymond C., *Professor of Economics.* (1969, 1981) B.S., University of California, 1966; M.S., Purdue University, 1968; Ph.D., 1969.

Battle, Guy Arthur, III, *Assistant Professor of Mathematics.* (1979) M.A., Indiana University, 1970; M.S., Murray State University, 1973; Ph.D., Duke University, 1977.

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Bayliss, Garland Erastus, *Director, Academic Services, and Associate Professor of History.* (1956, 1979) B.S., University of Arkansas, 1951; M.A., University of Texas at Austin, 1953; Ph.D., 1972.

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Vance, John M., P.E., *Professor of Mechanical Engineering.* (1978, 1981) B.S., University of Texas at Austin, 1960; M.S., 1964; Ph.D., 1967.

Van Cleave, Horace William, *Professor of Entomology.* (1964, 1975) B.S., Texas A&M University, 1952; M.S., 1958; Ph.D., Olahoma State University, 1969.

Vanderzant, Carl, *Professor of Dairy Science.* (1953, 1962) B.S., State Agricultural University (Netherlands), 1947; M.S., 1949; M.S., Iowa State University, 1950; Ph.D., 1953.

Vandiver, Frank E., *President, Texas A&M University, and Professor of History.* (1981) M.A., University of Texas at Austin, 1949; Ph.D., Tulane University, 1951; M.A., by decree, Oxford University, 1963.

Van Domelen, John E., *Professor of English.* (1970, 1974) B.A., Calvin College, 1957; M.A., University of Michigan, 1960; Ph.D., Michigan State University, 1964.

van Doorninck, Frederick H., Jr., *Associate Professor of Anthropology and of Geography.* (1977) B.A., Princeton University, 1956; Ph.D., University of Pennsylvania, 1967.

Van Doren, Carlton Stevens, *Professor of Recreation and Parks.* (1968, 1974) A.B., University of Illinois, 1955; A.M., 1957; Ph.D., Michigan State University, 1967.

Van Fleet, David D., *Associate Professor of Management.* (1973, 1975) B.S., University of Tennessee, 1963; Ph.D., 1969.

Varma, Shailendra K., *Assistant Professor, Mechanical Engineering.* (1978, 1980) B.E., Roorkee University, 1964; M.S., Denver University, 1974; Ph.D., Georgia Institute of Technology, 1977.

Varner, Larry W., *Associate Professor of Range Science and of Wildlife and Fisheries Sciences, TAMU Agricultural Research and Extension Center (Uvalde).* (1975, 1977) B.S., Abilene Christian University, 1966; M.S., University of Nebraska, 1968; Ph.D., 1970.

Vastano, Andrew C., *Associate Professor of Oceanography.* (1962, 1969) B.S., North Carolina State University, 1956; M.S., University of North Carolina, 1960; Ph.D., Texas A&M University, 1967.

Vedlitz, Arnold, *Associate Dean for Research, College of Liberal Arts, and Associate Professor of Political Science.* (1973, 1981) B.A., Louisiana State University, 1968; M.A., 1970; Ph.D., University of Houston, 1975.

Veech, Joseph A., *USDA Scientist, Department of Plant Sciences.* (1978) B.S., Louisiana Tech University, 1962; M.S., University of Georgia, 1964; Ph.D., 1967.

Venezian, Giulio, P.E., *Associate Professor of Civil Engineering and of Ocean Engineering.* (1980) B.E., McGill University (Canada), 1960; Ph.D., California Institute of Technology, 1965.

Vernon, Ralph Jackson, P.E., *Professor of Safety Engineering.* (1951, 1971) B.S., Clemson University, 1950; M.Ed., Texas A&M University, 1951; Ph.D., University of Iowa, 1968.

VerWest, Bruce J., *Assistant Professor of Physics.* (1976) B.S., Michigan State University, 1971; M.A., State University of New York, 1973; Ph.D., 1974.

Vietor, Donald M., *Assistant Professor of Agronomy.* (1976) B.S., University of Minnesota, 1967; M.S., 1969; Ph.D., Cornell University, 1975.

Villalon, Benigno, *Associate Professor of Plant Pathology, TAES (Weslaco).* (1976, 1978) B.A., Texas A&M University, 1964; M.S., 1965; Ph.D., 1969.

Vinson, S. Bradleigh, *Professor of Entomology.* (1969, 1975) B.S., Ohio State University, 1961; M.S., Mississippi State University, 1963; Ph.D., 1965.

Von Gonten, William D., P.E., *Professor of Petroleum Engineering and Head of Department.* (1966, 1976) B.S., Texas A&M University, 1957; M.S., 1965; Ph.D., 1966.

Vrooman, Richard E., *Professor of Environmental Design.* (1949, 1960) A.B., Oberlin College, 1941; B.Arch., Case Western Reserve University, 1949; M.Arch., Texas A&M University, 1952; Registered Architect; F.A.I.A.

Wagner, Gerald C., *Associate Professor of Veterinary Microbiology and Parasitology.* (1977) B.S., Texas Tech University, 1963; M.S., University of Kansas, 1966; Ph.D., 1968.

Wagner, Jackson Wayne, *Professor of Anatomy and Head of Department.* (1974, 1978) A.B., Fresno State College, 1957; Ph.D., University of California, San Francisco, 1960; M.D., Baylor College of Medicine, 1973.

Walker, James Knox, Jr., *Professor of Entomology.* (1968, 1981) B.S., Texas A&M University, 1951; M.S., 1956.

Walther, Fritz, *Professor of Wildlife and Fisheries Sciences.* (1971, 1974) Physikum, Johann Wolfgang Goethe University of Frankfurt (Germany), 1944; Diplom, 1956; Dr. Phil., 1963.

Walton, Jay Robert, *Associate Professor of Mathematics.* (1973, 1979) B.A., DePauw University, 1968; M.A., Indiana University, 1970; Ph.D., 1973.

Want, E. Cleve, *Associate Professor of English.* (1966, 1974) B.A., Hendrix College, 1956; M.A., George Peabody College, 1957; B.D., Episcopal Theological Seminary of the Southwest, 1966; Ph.D., Vanderbilt University, 1968.

Ward, Joseph D., *Associate Professor of Mathematics.* (1974, 1980) B.S., Boston College, 1968; M.S., Purdue University, 1970; Ph.D., 1973.

Ward, Rodney G., *Visiting Member, Department of Range Science.* (1981) B.S., Texas Tech University, 1967; M.S., 1975; Ph.D., New Mexico State University, 1980.

Warner, Isiah M., *Assistant Professor of Chemistry.* (1977) B.S., Southern University, 1968; Ph.D., University of Washington, 1977.

Watson, Albert Theodore, Jr., *Assistant Professor, Chemical Engineering.* (1978) B.S., University of Texas at Austin, 1974; Ph.D., California Institute of Technology, 1978.

Watson, Rand Lewis, *Assistant Dean, College of Science, and Professor of Chemistry.* (1967, 1980) B.S., Colorado School of Mines, 1962; Ph.D., University of California, Berkeley, 1966.

Weaver, Dave, *Extension Specialist, Department of Soil and Crop Sciences.* (1977) B.S., Texas Tech University, 1961; M.S., 1963; Ph.D., 1970.

Weaver, Richard W., *Associate Professor of Agronomy.* (1970, 1976) B.S., Utah State University, 1966; Ph.D., Iowa State University, 1970.

Webb, Bill Dean, *USDA Scientist, TAMU Agricultural Research and Extension Center (Beaumont).* (1963) B.S., Texas A&M University, 1956; M.S., 1959; Ph.D., 1961.

Webb, Robert C., Sr., *Associate Professor of Physics.* (1980) B.A., University of Pennsylvania, 1968; M.A., Princeton University, 1970; Ph.D., 1972.

Wehrly, Thomas E., *Assistant Professor of Statistics.* (1976) B.S., University of Michigan, 1969; M.A., University of Wisconsin, 1970; Ph.D., 1976.

Weiner, Peter, D., P.E., *Professor of Mechanical Engineering.* (1978) B.S., Texas A&M University, 1954; M.S., 1961; Ph.D., 1968.

Weir, Glendon H., *Assistant Professor of Anthropology.* (1976) A.A., Eastern Arizona University, 1973; B.A., Texas A&M University, 1974; Ph.D., 1976.

Weitsman, Yechiel, P.E., *Professor of Civil Engineering.* (1977) B.S., Technion-Israel Institute of Technology, 1953; M.S., University of Connecticut, 1959; Ph.D., Rensselaer Polytechnic Institute, 1962.

Wellman, Paul J., *Assistant Professor of Psychology.* (1980) B.A., California State College-Bakersfield, 1975; M.S., Iowa State University, 1977; Ph.D., 1980.

Wells, Ward V., *Associate Professor of Architecture.* (1977, 1980) B.Arch., Kansas State University, 1973; M.Arch., University of Oklahoma, 1976; Associate Member, A.I.A.

Wendt, Charles W., *Professor of Soil Science, TAMU Agricultural Research and Extension Center (Lubbock).* (1966, 1975) B.S., Texas A&M University, 1951; M.S., Texas Tech University, 1957; Ph.D., Texas A&M University, 1966.

Weseli, Donald F., *Research Scientist, Department of Animal Science.* (1964, 1979) B.S., Ohio State University, 1953; M.S., 1954; Ph.D., 1958.

West, Philip T., *Professor of Educational Administration.* (1974, 1981) B.S., Boston University, 1962; M.S., Hofstra University, 1967; Ph.D., University of Iowa, 1971.

White, Kenneth L., *Assistant Professor of Geography.* (1976) B.A., California State University. 1969; M.A., 1970; Ph.D., University of California, 1976.

White, Larry D., *Extension Specialist, Department of Range Science.* (1981) B.S.F., Northern Arizona State University, 1963; M.S., University of Arizona, 1965; Ph.D., 1967.

White, Ralph E., P.E., *Associate Professor of Chemical Engineering.* (1977, 1981) B.S., University of South Carolina, 1971; M.S., University of California, Berkeley, 1973; Ph.D., 1977.

Whitehouse, Ulysses Grant, *Associate Professor of Biology.* (1953, 1968) B.S., University of Kentucky, 1940; M.S., 1941; M.S., University of Iowa, 1942; Ph.D., Texas A&M University, 1955.

Whiting, Robert Louis, P.E., *Director, Texas Petroleum Research Committee, and Professor of Petroleum Engineering.* (1946, 1976) B.S., University of Texas at Austin, 1939; M.S., 1943.

Whitney, N. G., *Associate Professor of Plant Sciences, TAMU Agricultural Research and Extension Center (Beaumont).* (1976, 1979) B.S., University of Houston, 1964; M.A., Sam Houston State University, 1967; Ph.D., Texas A&M University, 1972.

Wick, Robert Senters, P.E., *Professor of Aerospace Engineering and of Nuclear Engineering.* (1966) B.S., Rensselaer Polytechnic Institute, 1946; M.S., Stevens Institute of Technology, 1948; Ph.D., University of Illinois, 1952.

Wiersig, Donald Otto, *Professor of Veterinary Physiology and Pharmacology.* (1967, 1973) D.V.M., Iowa State University, 1949; Ph.D., 1967.

Wiese, Allen Franklin, *Professor of Agronomy, TAMU Agricultural Research and Extension Center (Amarillo).* (1966, 1967) B.S., University of Minnesota, 1949; M.S., 1951; Ph.D., 1953.

Wiggins, Charles W., *Professor of Political Science.* (1981) B.A., State University of Iowa, 1959; M.A., Washington University, 1963; Ph.D., 1964.

Wiggins, Steven N., *Assistant Professor of Economics.* (1979) B.A., Oklahoma State University, 1975; Ph.D., Massachusetts Institute of Technology, 1979.

Wild, James Robert, *Associate Professor of Biochemistry and Biophysics and of Genetics.* (1975, 1980) B.A., University of California, Davis, 1967; Ph.D., University of California, Riverside, 1971.

Wilding, Lawrence P., *Professor of Agronomy.* (1976) B.S., South Dakota State University, 1956; M.S., 1959; Ph.D., University of Illinois, 1962.

Wildt, David E., *Visiting Member, Department of Veterinary Physiology and Pharmacology.* (1978) B.S., Illinois State University, 1972; M.S., Michigan State University, 1973; Ph.D., 1975.

Wilhoit, Randolph C., *Associate Director, Thermodynamics Research Center, TEES.* (1964, 1968) B.A., Trinity University, 1947; M.A., University of Kansas, 1949; Ph.D., Northwestern University, 1952.

Wilkes, Lambert Henry, P.E., *Professor of Agricultural Engineering.* (1948, 1975) B.S., Clemson University, 1948; M.S., Texas A&M University, 1953.

Williams, Glen Nordyke, P.E., *Associate Professor of Computing Science.* (1969, 1975) B.S., Texas A&M University, 1960; M.Eng., 1961; Ph.D., 1965.

Williams, John Donald, *Associate Professor of Veterinary Microbiology and Parasitology.* (1974) B.S., Texas A&M University, 1955; M.S., 1957; Ph.D., 1961.

Willson, Victor L., *Associate Professor of Educational Psychology.* (1979) B.A., University of Colorado, 1968; Ph.D., 1973.

Wilson, David W., *Assistant Professor of Psychology.*(1977) B.S., Kansas State University, 1972; M.S., Iowa State University, 1974; Ph.D., 1976.

Wilson, Hugh D., *Assistant Professor of Biology.* (1977) B.A., Kent State University, 1970; M.S., 1972; Ph.D., Indiana University, 1976.

Wiseman, Donna Louise, *Assistant Professor of Educational Curriculum and Instruction.* (1979) B.S., Oklahoma State University, 1968; M.S., Arkansas State University, 1976; Ph.D., University of Missouri, 1979.

Witzel, Donald A., *Visiting Member, Department of Veterinary Physiology and Pharmacology.* (1974) B.S., University of Minnesota, 1953; D.V.M., 1957; M.S., Iowa State University, 1965; Ph.D., 1970.

Wolf, Harold William, P.E., *Professor of Civil Engineering.* (1970) B.S., State University of Iowa, 1949; M.S., 1950; Dr. P.H., University of California, Los Angeles, 1965.

Womack, James E., *Associate Professor of Veterinary Pathology.* (1977) B.S., Abilene Christian University, 1964; Ph.D., Oregon State University, 1968.

Wood, Randall D., *Professor of Biochemistry and Biophysics.* (1976) B.S., University of Kentucky, 1959; M.S., 1961; Ph.D., Texas A&M University, 1965.

Woodcock, David Geoffrey, *Professor of Architecture.* (1962, 1976) B.A., University of Manchester (England), 1960; Dip.T.P., 1966; Chartered Architect (United Kingdom); R.I.B.A.

Woodman, Richard W., *Assistant Professor of Management.* (1978) B.S., Oklahoma State University, 1968; M.B.A., 1969; Ph.D., Purdue University, 1978.

Woods, Calvin E., P.E., *Professor of Civil Engineering.* (1972) B.S., University of Houston, 1955; M.S., University of Colorado, 1959; Ph.D., University of Texas at Austin, 1964.

Woods, Donald L., P.E., *Professor of Civil Engineering.* (1963, 1973) B.S., Oklahoma State University, 1955; M.S., 1960; Ph.D., Texas A&M University, 1967.

Wootan, Charley V., *Director, Texas Transportation Institute, and Head, Transportation Economics Division.* (1966, 1976) B.S., Texas A&M University, 1950; M.S., 1951; Ph.D., 1965.

Wormuth, John Hazen, *Associate Professor of Oceanography.* (1972, 1977) B.A., Hope College, 1966; Ph.D., Scripps Institution of Oceanography, 1971.

Wright, Arthur L., *Associate Professor of Agricultural Economics.* (1972) B.S., Southern Illinois University, 1960; M.S., 1961; Ph.D., University of Missouri, 1970.

Wu, Ching H., *Professor, Petroleum Engineering.* (1981) B.S., Taipei Institute of Technology, 1957; M.S., Colorado School of Mines, 1964; Ph.D., University of Pittsburgh, 1968.

Wu, Hsin-I, *Associate Professor, Bioengineering.* (1977, 1981) B.S., Tunghai University (Taiwan), 1960; M.S., University of Missouri, 1964; Ph.D., 1967.

Yancey, Thomas E., *Assistant Professor of Geology.* (1980) B.A., University of California, Berkeley, 1966; M.A., 1969; Ph.D., 1971.

Yeager, Danny L., *Assistant Professor of Chemistry.* (1978) B.S., University of Iowa, 1968; B.A., 1968; Ph.D., California Institute of Technology, 1975.

Young, Beverly S., *Visiting Member, Department of Educational Curriculum and Instruction.* (1975) B.A., William Penn College, 1961; M.A., University of Northern Iowa, 1965; Ph.D., University of Iowa, 1968.

Young, Mark Francis, *Professor of Veterinary Large Animal Medicine and Surgery.* (1960, 1975) B.S, Utah State University, 1955; D.V.M., Iowa State University, 1958; M.S., Texas A&M University, 1964.

Young, Robert E., *Assistant Professor, Industrial Engineering.* (1979) B.S.E., University of California, 1970; M.S.I.E., Purdue University, 1972; Ph.D., 1977.

Young, Ryland F., III, *Assistant Professor of Medical Biochemistry.* (1978) B.S., Rice University, 1968; Ph.D., University of Texas at Dallas, 1975.

Young, Vaneica Y., *Assistant Professor of Chemistry.* (1978) B.A., University of Kansas, 1969; M.S., University of Missouri, Kansas City, 1972; Ph.D., 1976.

Youngblood, Dave Harper, *Professor of Physics.* (1967, 1976) B.S., Baylor University, 1961; M.A., Rice University, 1963; Ph.D., 1965.

Youngblood, Stuart A., *Assistant Professor of Management.* (1981) B.S., Purdue University, 1972; M.S., 1973; Ph.D., 1978.

Zardkoohi, Asghar, *Assistant Professor of Management.* (1981) B.A., Abadan Institute of Technology, 1968; M.S., Auburn University, 1973; Ph.D., Virginia Polytechnic Institute and State University, 1977.

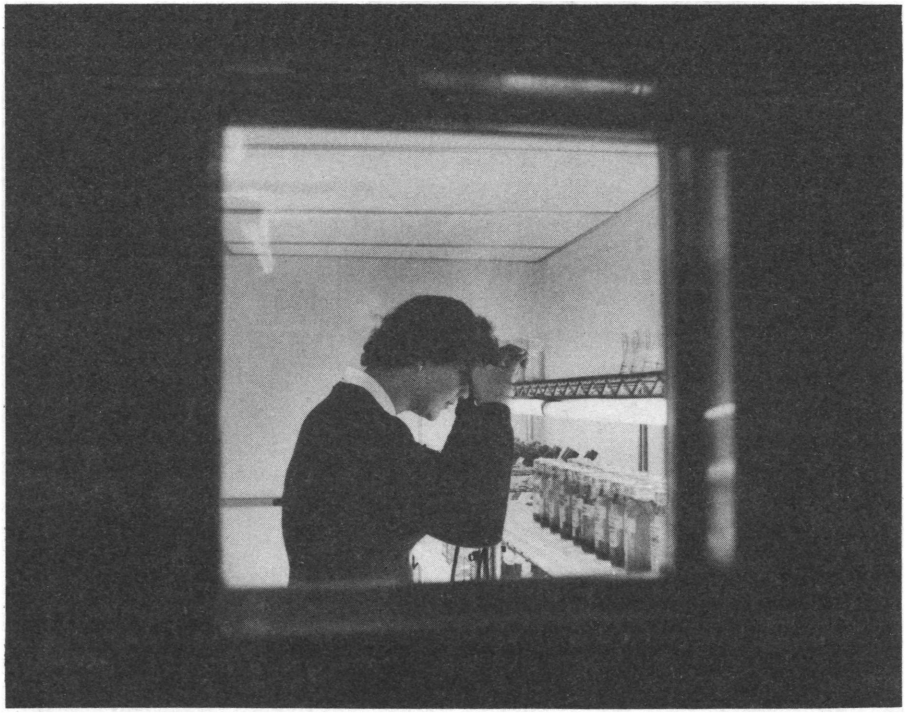
Zingaro, Ralph Anthony, *Professor of Chemistry.* (1954, 1964) B.S., City College of New York, 1946; M.S., University of Kansas, 1949; Ph.D., 1950.

Zingery, Wilbur Lewis, *Lecturer, Agricultural Engineering.* (1975) B.S., Texas A&M University, 1950; M.S., 1951.

Zinn, Joel, *Associate Professor of Mathematics.* (1981) B.A., Queen's College, 1966; M.A., University of Wisconsin, 1972; Ph.D., 1972.

Zuberer, David Alan, *Assistant Professor of Agronomy.* (1978) B.S., West Virginia University, 1969; M.S., 1971; Ph.D., University of South Florida, 1976.

Zwolinski, Bruno John, *Professor of Chemistry.* (1961, 1965) B.S., Canisius College, 1941; M.S., Purdue University, 1943; M.A., Princeton University, 1944; Ph.D., 1947.



DESIGNATED FACULTY MEMBERS

Adkisson, Perry L., *Distinguished Professor of Entomology.*

Allen, Phillip E., *Halliburton Associate Professor of Electrical Engineering.*

Bass, George F., *Alumni Professor and Distinguished Professor of Anthropology.*

Black, William E., *Roy B. Davis Professor of Agricultural Cooperation, Department of Agricultural Economics.*

Calhoun, John C., Jr., *Distinguished Professor of Petroleum Engineering.*

Chevalier, Howard L., *Dresser Industries Professor of Aerospace Engineering.*

Cook, Earl F., *Distinguished Professor of Geography and of Geology and Harris Professor of Geosciences.*

Cotton, F. A., *Distinguished Professor of Chemistry and Robert A. Welch Professor of Chemistry.*

Fraser, Donald R., *E. D. Brockett Professor of Finance.*

Grabo, Norman S., *Distinguished Professor of English.*

Greenhut, M. L., *Alumni Professor and Distinguished Professor of Economics.*

Handin, John W., *Distinguished Professor of Geology.*

Hopkin, John A., *Stiles Professor of Agricultural Economics.*

Hoskins, Earl R., *E. D. Brockett Professor of Geophysics.*

Kettleborough, Charles F., *Distinguished Professor of Mechanical Engineering.*

Kilby, Jack S., *Distinguished Professor of Electrical Engineering.*

McDermott, John J., *Distinguished Professor of Philosophy and Humanities.*

Martell, Arthur E., *Distinguished Professor of Chemistry.*

Maurice, S. Charles, *Rex B. Grey Professor of Economics.*

Morrison, Gerald L., *Halliburton Associate Professor of Mechanical Engineering.*

Norton, David J., *E. D. Brockett Professor of Aerospace Engineering.*

Parzen, Emanuel, *Distinguished Professor of Statistics.*

Reid, Robert O., *Distinguished Professor of Oceanography.*

Röller, Herbert A., *Alumni Professor and Distinguished Professor of Biology.*

Schapery, Richard A., *Alumni Professor and Distinguished Professor of Aerospace Engineering and of Civil Engineering.*

Schneider, Vernon E., *Distinguished Professor of Agricultural Economics.*

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THE GRADUATE COLLEGE

The principal objective of the Graduate College is to offer education beyond the baccalaureate level to those who aspire to become intellectual leaders in the professions and in various fields of teaching and research. It undertakes to assist graduate students in developing and pursuing individual educational programs requiring superior accomplishment through carefully directed intellectual activity.

GENERAL INFORMATION

Purpose. The purpose of this catalog is to provide information about the graduate programs of Texas A&M University to students and prospective students, as well as to the faculty and staff of the University. Included is information concerning requirements for admission to the Graduate College of Texas A&M University, services available to students, graduate course offerings and listings of the administrative officers and the graduate faculty of the University.

While every effort has been made to make this catalog as complete and accurate as possible, it should be noted that changes may occur at any time in requirements, deadlines, fees, courses, etc. listed in this catalog.

This catalog was prepared well in advance of its effective date; therefore the course descriptions may vary somewhat from actual course content due to advancements in the discipline, interests of individual professors, or decisions to change the scope of a course. Thus the descriptions that follow are not provided in the nature of a contractual obligation.

The Graduate Faculty. The faculty of the Graduate College consists of the President, the deans and selected members of the staff who are actively engaged in recognized scholarly activities, fundamental research or professional activity.

The Dean of the Graduate College is responsible for the academic programs of all graduate students. He is the representative of the graduate faculty and is the medium of communication between the graduate students and the University administration.

The Graduate Council is a standing committee of the Academic Council. It is an advisory body to the Dean of the Graduate College, who is the chief administrative officer of the graduate faculty. There is a Committee on Graduate Instruction in each of the several colleges. These committees are responsible for making recommendations for graduate work in the college concerned, for making recommendations regarding general policies, and for other matters pertaining to graduate work in their colleges.

Degrees Offered. The following advanced degrees are offered:

Master of Agriculture (M.Agr.)
Master of Architecture (M.Arch.)
Master of Arts (M.A.)
Master of Business Administration (M.B.A.)
Master of Computing Science (M.C.S.)
Master of Education (M.Ed.)
Master of Engineering (M.Eng.)
Master of Landscape Architecture (M.L.A.)
Master of Public Administration (M.P.A.)
Master of Science (M.S.)
Master of Urban Planning (M.U.P.)
Doctor of Education (Ed.D.)
Doctor of Engineering (D.Eng.)
Doctor of Environmental Design (D.E.D.)
Doctor of Philosophy (Ph.D.)

CURRENT GRADUATE DEGREE OFFERINGS (BY COLLEGES)

College of Agriculture

Agricultural Chemistry	M.Agr.		
Agricultural Development	M.Agr.		
Agricultural Economics	M.Agr.	M.S.	Ph.D.
Agricultural Education	M.Ed.	M.S.	
Agricultural Engineering	M.Eng.	M.S.	Ph.D.
Agronomy		M.S.	Ph.D.
Animal Breeding		M.S.	Ph.D.
Animal Science	M.Agr.	M.S.	Ph.D.
Biochemistry		M.S.	Ph.D.
Biophysics		M.S.	
Crops	M.Agr.		
Dairy Science	M.Agr.	M.S.	Ph.D.
Economic Entomology	M.Agr.		
Entomology		M.S.	Ph.D.
Fisheries Science	M.Agr.		
Floriculture	M.Agr.	M.S.	
Food Science and Technology	M.Agr.	M.S.	Ph.D.
Forestry		M.S.	Ph.D.
Genetics		M.S.	Ph.D.
Horticulture	M.Agr.	M.S.	Ph.D.
Mechanized Agriculture	M.Agr.		
Natural Resources Development	M.Agr.		
Nutrition		M.S.	Ph.D.
Physiology of Reproduction		M.S.	Ph.D.
Plant Breeding		M.S.	Ph.D.
Plant Pathology		M.S.	Ph.D.
Plant Physiology		M.S.	Ph.D.
Plant Protection	M.Agr.		
Plant Sciences	M.Agr.		
Poultry Science	M.Agr.	M.S.	Ph.D.
Range Science	M.Agr.	M.S.	Ph.D.

Recreation and Resources Development	M.Agr.	M.S.		Ph.D.
Rural Sociology	M.Agr.			
Soils	M.Agr.			
Soil Science		M.S.		Ph.D.
Wildlife Science	M.Agr.			
Wildlife and Fisheries Sciences		M.S.		Ph.D.

College of Architecture and Environmental Design

Architecture	M.Arch.		D.E.D.	
Construction Management		M.S.		
Landscape Architecture	M.L.A.		D.E.D.	
Urban and Regional Planning	M.U.P.			
Urban and Regional Science				Ph.D.

College of Business Administration

Accounting	M.B.A.	M.S.		Ph.D.
Business Administration	M.B.A.			
Business Analysis				Ph.D.
Business Computing Science	M.B.A.	M.S.		
Finance	M.B.A.	M.S.		Ph.D.
Management	M.B.A.	M.S.		Ph.D.
Marketing	M.B.A.	M.S.		Ph.D.

College of Education

Adult and Extension Education	M.Ed.	M.S.	Ed.D.	Ph.D.
Curriculum and Instruction	M.Ed.	M.S.	Ed.D.	Ph.D.
Educational Administration	M.Ed.	M.S.	Ed.D.	Ph.D.
Educational Psychology	M.Ed.	M.S.	Ed.D.	Ph.D.
Educational Technology	M.Ed.			
Health Education	M.Ed.	M.S.	Ed.D.	Ph.D.
Industrial Education	M.Ed.	M.S.	Ed.D.	Ph.D.
Physical Education	M.Ed.	M.S.	Ed.D.	Ph.D.
Vocational Education	M.Ed.		Ed.D.	Ph.D.

College of Engineering

Aerospace Engineering	M.Eng.	M.S.		Ph.D.
Agricultural Engineering	M.Eng.	M.S.		Ph.D.
Bioengineering	M.Eng.	M.S.		Ph.D.
Chemical Engineering	M.Eng.	M.S.		Ph.D.
Civil Engineering	M.Eng.	M.S.		Ph.D.
Computing Science	M.C.S.	M.S.		Ph.D.
Electrical Engineering	M.Eng.	M.S.		Ph.D.
Engineering	M.Eng.		D.Eng.	
Industrial Engineering	M.Eng.	M.S.		Ph.D.
Industrial Hygiene		M.S.		
Industrial Technology		M.S.		
Interdisciplinary Engineering		M.S.		Ph.D.
Mechanical Engineering	M.Eng.	M.S.		Ph.D.
Nuclear Engineering	M.Eng.	M.S.		Ph.D.
Ocean Engineering	M.Eng.	M.S.		Ph.D.
Petroleum Engineering	M.Eng.	M.S.		Ph.D.
Safety Engineering		M.S.		

College of Geosciences

Geography	M.S.	Ph.D.
Geology	M.S.	Ph.D.
Geophysics	M.S.	Ph.D.
Meteorology	M.S.	Ph.D.
Oceanography	M.S.	Ph.D.

College of Liberal Arts

Anthropology	M.A.	
Economics	M.S.	Ph.D.
English	M.A.	Ph.D.
History	M.A.	
History (American)		Ph.D.
Modern Languages	M.A.	
Political Science	M.A.	
Psychology	M.S.	
Public Administration	M.P.A.	
Sociology	M.S.	Ph.D.

College of Science

Biology	M.S.	Ph.D.
Botany	M.S.	Ph.D.
Chemistry	M.S.	Ph.D.
Mathematics	M.S.	Ph.D.
Microbiology	M.S.	Ph.D.
Physics	M.S.	Ph.D.
Statistics	M.S.	Ph.D.
Zoology	M.S.	Ph.D.

College of Veterinary Medicine

Epidemiology	M.S.	
Food Science and Technology	M.S.	Ph.D.
Laboratory Animal Medicine	M.S.	
Veterinary Anatomy	M.S.	Ph.D.
Veterinary Medical Sciences	M.S.	Ph.D.
Veterinary Medicine and Surgery	M.S.	
Veterinary Microbiology	M.S.	Ph.D.
Veterinary Parasitology	M.S.	
Veterinary Pathology	M.S.	Ph.D.
Veterinary Physiology	M.S.	Ph.D.
Veterinary Public Health		Ph.D.
Veterinary Toxicology	M.S.	Ph.D.

Graduate Courses. A graduate course is an advanced course requiring critical analysis and study. Such courses normally require frequent use of the library for reference to papers reporting original research. Five types of graduate instruction are recognized: (1) lecture courses requiring organization by the instructor of material on an advanced level; (2) supervised laboratory courses; (3) seminars for the critical study of an organized field through reports presented by students or instructors; (4) research by individual students under the direction of members of the Graduate Faculty; and (5) professional internships. Undergraduate level courses may be used only as specified in the following pages. Unless special approval is granted by the Dean of the Graduate College, no individual who is not a member of the graduate faculty of Texas A&M University is authorized to teach a graduate course.

Cooperative Graduate Programs. Texas A&M University has executed Memoranda of Agreement pertaining to cooperative graduate programs with the following institutions: Baylor College of Medicine, Lamar University, Sam Houston State University, Stephen F. Austin State University, Southwest Texas State University, Tarleton State University, and West Texas State University. Details concerning these cooperative graduate programs are available from the graduate deans of the institutions involved.

Texas A&M University and The University of Texas System have also entered into an agreement relating to cooperative use of courses and facilities in graduate education. See section on "Texas A&M University — Baylor College of Medicine, The University of Texas System" in the course description section.

ADMISSION

Admission to Texas A&M University and any of its sponsored programs is open to qualified individuals regardless of race, color, religion, sex, age, national origin, or educationally unrelated handicaps.

To be admitted to the Graduate College (except under double registration, which is restricted to Texas A&M University students), an applicant (1) must hold a four-year baccalaureate degree from a college or university of recognized standing; (2) must show promise of ability to satisfactorily pursue advanced study and research; (3) must have had adequate preparation to enter graduate study in the field chosen; and (4) must submit with the application acceptable scores on the Aptitude Test of the Graduate Record Examination (GRE), except as follows: The Graduate Management Admission Test (GMAT) is required for all applicants to the Master of Business Administration and Master of Science in Business Administration degree programs and may be substituted for the Graduate Record Examination for admission to the Doctor of Philosophy degree program of the College of Business Administration, the Master of Public Administration degree program, and the advanced degree programs offered by the Department of Agricultural Economics. These tests should be taken within five years of the date of application for admission to the Graduate College. With the approval of the department concerned, master's degree recipients from Texas A&M University who were unanimously recommended for doctoral study by their master's degree Advisory Committees will not be required to retake the Graduate Record Examination or Graduate Management Admission Test, where used. Approximately six weeks are required for scores to be received by the Graduate College after the tests are administered. Scores made on the GRE or GMAT more than five calendar years prior to application for admission to the Graduate College may not normally be used to satisfy admission requirements.

During 1982-83 the GRE and GMAT will be given at various centers, including Texas A&M University, throughout the United States and in other countries.

To determine the most convenient locations, prospective applicants should write to Graduate Record Examinations, Educational Testing Service, Box 955-R, Princeton, New Jersey 08541; or the Academic Counseling Center, Texas A&M University, College Station, Texas 77843. Students who must take the GMAT may write Educational Testing Service, Box 966-R, Princeton, New Jersey 08541.

Inquiries regarding admission to the Graduate College should be addressed to the Office of Admissions and Records, Texas A&M University, College Station, Texas 77843. Inquiries about facilities for advanced studies, research and requirements for graduate work in specific fields should be addressed to the department in which the principal work is offered.

A formal application is required of all persons seeking admission to the Graduate College. To allow time for processing, the application forms, which are available from the Office of Admissions and Records, should be filed at least six weeks prior to the

opening of the semester. Admission to the Graduate College cannot be completed until all the credentials enumerated on the application form have been filed and evaluated. The following application deadlines have been established for all international applicants:

June 15 for the fall semester
November 1 for the spring semester
March 15 for the summer session

In addition to the records sent to the Office of Admissions and Records, students should have in their possession a copy of their record for use in conference with members of the graduate faculty in planning their work.

Admission to the Graduate College may not be approved in instances where the facilities and staff available in the particular field are not adequate to take care of the needs of the student.

Admission to the Graduate College remains valid for two calendar years only, unless the student during this period engages in active graduate work at Texas A&M University.

Scholastic Record. The normal requirement for admission to the Graduate College is a record during at least the last two years of full-time academic study which gives evidence of ability to do successful graduate level work.

A student whose academic record is not satisfactory for this purpose or who is changing fields of study may be required to take additional work to strengthen his or her background and preparation for graduate study. Such work will normally be arranged in conference with the graduate advisor or the head of the student's major department.

Before accepting a student for graduate study, the department in which he or she expects to take work may require that the student pass a comprehensive examination covering the basic undergraduate work in that field.

Senior Citizens. Senior citizens, 65 years old or older, may audit courses with the permission of the instructor, if space is available in the assigned classroom. It is not necessary for these people to be admitted to the University and academic records of their attendance will not be maintained.

Graduate Students in Non-Degree Status. Students, other than international students (see following section), who hold baccalaureate and advanced degrees and who have not gained admission either to a master's or doctoral degree program may be permitted to enroll initially in Texas A&M University at the post-baccalaureate level for one semester or one summer session as non-degree graduate students. Admission of non-degree graduate students to departments and courses is subject to individual departmental policy.

Continued registration as a post-baccalaureate, non-degree graduate student is contingent each semester upon satisfactory academic performance.

Graduate Students in Probationary Status. Students who failed initially to qualify for admission to advanced degree programs but who aspire to work for advanced degrees may be given a probation period in which to demonstrate the ability to do graduate work, if the departments so recommend. Any student who successfully completes a 12-hour probationary program will be allowed to use for degree credit all course work subject to the approval of the student's Advisory Committee, the Head of the student's major department, and the Dean of the Graduate College (i.e., approval of the degree program).

International Students. A student from another country who seeks admission to the Graduate College must meet the same requirements for admission and candidacy as students from the United States, including the submission of scores on the GRE, or, in the College of Business Administration or for the Master of Public Administration degree program, the GMAT. In addition, prospective students from other countries must demonstrate the ability to speak, write and understand the English language. Prospective students whose native language is not English must take

the **Test of English as a Foreign Language** (TOEFL), which is administered by the Educational Testing Service, Princeton, New Jersey, in over 200 centers around the world. A registration form and a "Bulletin of Information for Candidates" may be obtained by writing to TOEFL, Educational Testing Service, Princeton, New Jersey 08541, USA.

All applicants for admission from non-English-speaking countries must present a score of at least 550 on the TOEFL. Further, to ensure that all applicants are able to take full advantage of the instructional program at Texas A&M University, **all** students from non-English-speaking countries must make a satisfactory score on a rigorous oral and written English proficiency examination after their arrival, regardless of their TOEFL scores or other indications of English language facility. Admission to the University is conditioned upon acceptable TOEFL scores and successful completion of the English proficiency examination.

No student from another country may be admitted to Texas A&M University as a non-degree student, nor register in non-degree status.

More detailed information about Texas A&M University and particularly about enrollment procedures is incorporated in a pamphlet "Information for Prospective International Students," a copy of which may be obtained by writing to the Office of Admissions and Records, Texas A&M University, College Station, Texas 77843, U.S.A.

Each graduate student is responsible for becoming familiar with the rules and regulations pertaining to graduate study and the requirements for advanced degrees.

REGISTRATION

In Residence Registration. Before the first registration, the student should consult the graduate advisor representing the field of his or her major interest. This advisor will assist in planning the student's first registration.

The load for a full-time graduate student or a student holding a fellowship is 12 to 16 hours per semester or six hours per 5½-week summer term. The load for graduate assistants on one-half time employment is 9 to 12 hours per semester or four hours per 5½-week summer term. Recipients of fellowships and assistantships are normally required to register for the course loads specified above.

Graduate students who have completed all course work on their degree programs, but who are still engaged in research for their theses or dissertations, must register for a minimum of four hours of 691 (Research) or 692 (Professional Study) credit each semester and each 11-week summer semester until all requirements for the degree have been completed.

Graduate students whose degree requirements include theses, dissertations or records of study, and who plan to graduate at the end of a summer session (i.e., in August), should always register in the University during the first term of the summer session in which they plan to graduate, even though the completion of their degree requirements may necessitate further registration. This applies to both registration in residence and registration *in absentia*.

***In Absentia* Registration.** 1. Students in Master's Degree Programs Requiring a Thesis — Effective September 1, 1980, students who are enrolled in master's degree programs requiring a thesis and who have completed all course work on their degree programs other than 691 (Research) will register *in absentia* continuously each regular semester for four semester credit hours of 691 credit until all requirements for the degree have been completed. Students who do not comply with this requirement will have their future registrations blocked. They will be allowed to register only after receiving a favorable recommendation from a departmental review committee (not the student's Advisory Committee), the endorsement of the department head, and the approval of the Dean of the Graduate College.

2. Students in Doctoral Degree Programs Requiring a Dissertation or Record of Study — Effective September 1, 1980, students who are enrolled in doctoral degree programs requiring a dissertation or record of study and who have completed all course work on their degree programs other than 691 (Research) or 692 (Professional Study) will register *in absentia* continuously each regular semester for four semester credit hours of 691 or 692 credit (whichever is applicable) until all requirements for the degree have been completed. Students who do not comply with this requirement will have their future registrations blocked. They will be allowed to register only after receiving a favorable recommendation from a departmental review committee (not the student's Advisory Committee), the endorsement of the department head, and the approval of the Dean of the Graduate College.

3. If the chairman of the student's Advisory Committee is unavailable for an extended time in any academic period during which the student is involved in activities relating to a thesis, dissertation, or record of study and is registered for either 691 or 692 courses, the student may request, in writing, that the department head appoint an alternate chairman during the interim period.

4. Under unusual circumstances, a student may petition for a leave of absence. If the petition is granted, the registration requirement will be set aside during the period of leave. Leaves will be granted only under conditions that require the suspension of all activities associated with the thesis, dissertation, or record of study.

Employees Registering as Students. Full details of the conditions under which heads of departments may grant approval of employee requests to enroll as students in Texas A&M University may be found in the *Policy and Procedures Manual* (2.3.1.15). Study opportunities for faculty and staff are also discussed in the *Faculty-Staff Handbook.*

All employees eligible to receive degrees from Texas A&M University must meet degree requirements as set forth in the appropriate catalog.

Limitations for Staff Members. The following limitations have been set by the Academic Council of Texas A&M University upon the conferring of advanced degrees upon members of the resident staff of the University:

1. Members of the faculty of the Texas A&M University System above the rank of assistant professor will not be granted a graduate degree at this institution. They may, however, enroll for graduate work.
2. Members of the faculty of Texas A&M University will not be granted a graduate degree by Texas A&M University after receiving tenure at this institution.

Double Registration. Undergraduates at Texas A&M University who at the beginning of a given semester are within 12 hours of graduation or at the beginning of a summer term are within six hours of graduation may apply for admission to the Graduate College provided they meet the GRE requirements and have a B average or better for the last three semesters of course work. Such students must complete their undergraduate work and obtain the bachelor's degree during the first semester or summer term following their admission to the Graduate College. The maximum total credit hour load for double-registered students is 16 hours in the regular semester or six hours in a 5½-week summer term.

A superior undergraduate student is otherwise eligible to enroll in a graduate course for graduate credit only if he or she files a written petition for approval by the Dean of the Graduate College stating that the student is reserving the graduate course for graduate credit. No graduate course may be listed for credit on an undergraduate degree program. Such petitions must be approved by the head of the student's major (undergraduate) department **and** the student's dean.

VA Benefits. Veteran students should note that in order to receive full VA benefits they must be registered for not less than nine credit hours of course work each full semester or four credit hours per six-week summer term.

Course Load Requirements for International (Non-Immigrant) Students. International (non-immigrant) students who do not initially register for the proper number of semester credit hours required by the Immigration Service or who drop credit hours during the semester or summer term may find themselves in an illegal status and subject to deportation.

The law requires that international (non-immigrant) graduate students be registered for a minimum of nine semester credit hours during a regular semester. The only time that an exception may be made in connection with this requirement is during a student's final semester when he or she needs only to register for the minimum number of hours required to satisfy requirements for the degree or the requirements of the Graduate College. At any time during a semester, if a student drops below the minimum requirements indicated above, the student is in illegal status.

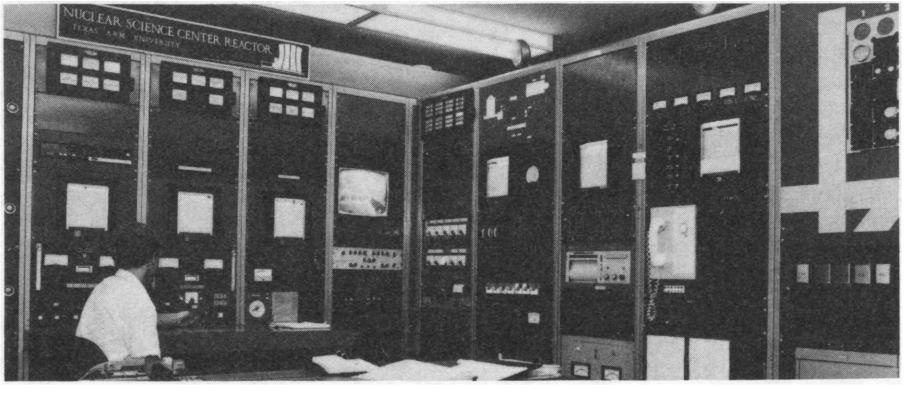
The program in the English Language Institute (ELI) is composed of four increments, each of which is equivalent to three semester credit hours. Accordingly, if a student is required to attend the ELI on a part-time basis, he or she must then also be enrolled in the appropriate number of formal course hours necessary to comply with the Immigration Service requirements stated above.

The law does not require international (non-immigrant) students to enroll during the summer unless their initial entry into the United States is based on admission to an institution for a specified summer term. In other words, if such students gain entry to the United States in late May because they were admitted to Texas A&M University for the summer session, beginning in either late May or early June, they must enroll for the summer term for which they were admitted by the University. In such cases, graduate students at Texas A&M University must enroll for a minimum of four semester credit hours per summer term.

Graduate Credit. Graduate credit will not be allowed normally for any course unless the student has been granted admission to the Graduate College and is registered therein when the course is taken. In case of unusual circumstances a maximum of eight hours taken prior to admission to the Graduate College may be used in the degree program.

Graduate Advisors. A graduate student entering the University for the first time is required to consult with the advisor in his or her particular field of interest regarding courses and various programs of study. Departmental graduate advisors will be available for consultation several days prior to registration. Early in the first semester an advisor will assist each new graduate student in choosing an advisory committee and working out a proposed degree program for consideration by the student's full Advisory Committee.

Texas A&M University is a coeducational university. All counseling services are offered to students based on individual needs or interests without regard to race, color, religion, sex, age, national origin or unrelated physical or mental handicaps.



FEES

The fees set out here for the 1982-83 session are strictly approximations and are subject to change because of economic conditions and/or legislative requirements. The following expenses are for a typical Texas resident enrolled for 15 semester credit hours, including one laboratory, in the fall and spring, and six semester credit hours in a term of the summer session, and who chooses all optional items listed below. All amounts (except Note 9) are due upon receipt of an invoice and are payable in full to the Fiscal Department, Texas A&M University

	Fall	Spring	Summer Term (5½ weeks)
Tuition[1]	$ 60.00	$60.00	$ 25.00
Required Fees			
Student Services Fee[2]	39.50	39.50	19.75
Building Use Fee[3]	90.00	90.00	36.00
Student Center Complex Fee[4]	10.00	10.00	5.00
Health Center Fee[5]	15.00	15.00	7.50
Property Deposit[6] (first semester only)	10.00	—	—
Identification Card[7]	5.00	—	2.00
Additional Fees			
Laboratory Fees[8]	5.00	5.00	5.00
Diploma Fee (graduating students only)	—	15.00	—
Thesis, Dissertation, and Record of Study Fees[9]			
"Degree Only" Service Fee[10]			
Board			
7 day, 20 meals	563.00	563.00	190.00
or			
5 day, 15 meals	503.00	503.00	172.00

OPTIONS

The optional items listed below fall into two categories — essential and secondary expenses. Parking expenses are those considered essential; shuttle bus, yearbook, directory, and sports tickets are secondary. Once a student selects any of these options, full payment is required.

Parking Permit (required for any student operating a vehicle on campus) 1 semester	15.00	15.00	—
or	or		
2 semesters (or summer session)	27.00	—	12.00
or	or		
1 year (2 semesters and summer)	36.00	—	—
Shuttle Bus Pass (per student)	40.00	40.00	—
or	or	or	
(student and spouse)	58.00	58.00	—
Aggieland (yearbook)	15.00	—	—
Picture in *Aggieland*	1.00	—	—
Student Directory	2.50	—	—
Football Tickets (home games)	25.00	—	—
or	or		
All-Sports Tickets (home games)	35.00	—	—

FEE NOTES

1. **Tuition:** Resident students pay $4 per semester credit hour, but the total of such charge shall be not less than $50 per semester, or $25 per summer term. Nonresident and alien students pay $40 per semester credit hour. Students who register (including payment of fees) on the first class day and thereafter pay a late fee of $10.
2. **Student Services Fee:** All students pay this fee at the rate of $3.30 per semester credit hour (not exceeding $39.50 per semester or $19.75 per summer term). This fee covers the services at the Memorial Student Center, medical services and the Intramural Program. It entitles the student to receive *The Battalion* newspaper, reduced admission to many MSC programs, services of a Student Legal Advisor, and services of the Personal Counseling Service.
3. **Building Use Fee:** This fee, at the rate of $6 per semester credit hour, is required of all students to cover bonded indebtedness incurred for the expansion, air conditioning and/or rehabilitation of the Memorial Student Center, G. Rollie White Coliseum, Auditoria, Library, Kyle Field Stadium, University Health Center and other campus facilities.
4. **Student Center Complex Fee:** This fee is required of all students for operating, maintaining, improving, and equipping the University Center Complex.
5. **Health Center Fee:** This fee is required of all students for the purpose of operating, maintaining and equipping the University Health Center and entitles the student to its services. These services do not include surgical operations or charges for consultations with outside physicians.
6. **Property Deposit:** Every student, unless registered *in absentia,* must make a property deposit to protect the University from any loss whatsoever, such as property loss or damages or breakage, failure to return keys furnished by the University, or for damage to or loss of any other University property or United States government property issued for the use of ROTC students. Charges will be billed directly to the student or collected by the department upon re-issue of supplies or property. Failure to promptly pay the charges will cause the student to be barred from readmission and receiving an official transcript from the University. Should the student withdraw without paying the charges, they will be withheld from the deposit before any balance is refunded. Deposits will be held at least 30 days after the close of a semester, or after a student withdraws, so that all charges and fines may be accumulated from the various departments. This deposit, less outstanding charges, will be refunded to the student graduating or withdrawing from school **upon request**.
7. **Identification Card:** All students must have an identification card. This card is used in registration procedures, collection of fees, cashing of checks, laundry service, for dining hall privileges, library privileges, etc. There is only a $2 charge for summer students not enrolled during the fall and spring semesters.
8. **Laboratory Fees:** A laboratory fee ranging in amount from $2 to $8 is charged for each laboratory course each semester.
9. A fee of $22.50 is required to cover the cost of binding three copies of the thesis or dissertation. A collating and editing fee of $10 is required of all students whose degree requirements include a thesis, dissertation, or record of study. Each candidate for the doctorate is required to pay a dissertation or record of study microfilming fee of $32.50. A copy of the Fiscal Department receipt for payment of these fees must be presented to the office of the Dean of the Graduate College and be recorded on the student's records.
10. Any student registering for "Degree Only" will be required to pay a service fee of $15.

Eleven-Week Summer Semester

Students registering for 11-week summer semester courses during first summer term registration will be charged the minimum tuition for a fall or spring semester, $50. The following fees will also be assessed: the maximum Student Services Fee of $39.50, the Student Center Complex Fee of $10 and the Health Center Fee of $15. If students register for additional courses during the second summer term, fees will be automatically adjusted.

Exemptions

Certain students in the following classifications are exempt from paying tuition and some of the required fees by action of the State of Texas and The Texas A&M University Board of Regents. Specific eligibility requirements under these provisions can be obtained from the Office of Admissions and Records.

Dependent children of disabled or killed-on-duty firemen and peace officers and firemen who are enrolled in Fire Science courses are exempt from paying Tuition, Laboratory Fees, Student Services Fee, Building Use Fee, Student Center Complex Fee, and the Health Center Fee.

Blind and deaf students who are eligible for the rehabilitation services of the State Commission for the Blind and/or Division of Vocational Rehabilitation of the Texas Education Agency are exempt from the above fees and also the General Property Deposit.

Exempt students listed above may elect to pay the Health Center Fee and receive the service available.

Certain veterans (and dependents of veterans who died in active service) who are Texas citizens and who were honorably discharged from World War I, World War II, Korean War, or the "Cold War" which began on termination of the Korean War are exempt from paying tuition, laboratory fees, Building Use Fee, and the Student Center Complex Fee. Orphans of members of the Texas National Guard and the Texas Air National Guard killed since January 1, 1946, while on active duty either in the service of their state or the United States may also be eligible under this provision.

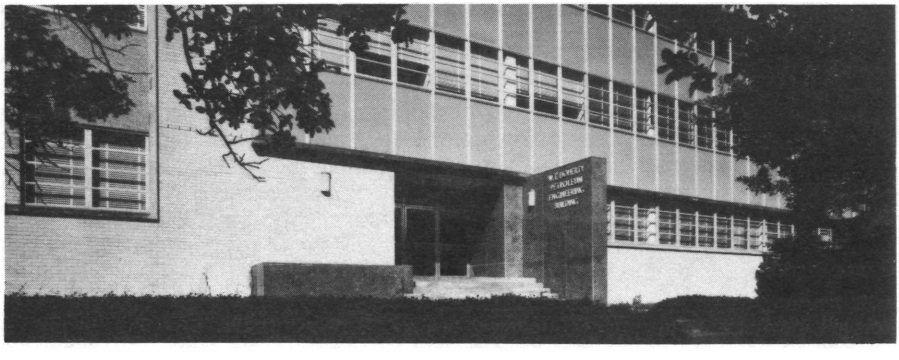
The State Board of Education will certify annually 235 students from other nations in the American Hemisphere to be exempt from paying tuition at institutions of higher learning in the State of Texas.

Full time employees of the Texas A&M University System are exempt from paying all fees except tuition, laboratory fees, I.D. card and property deposit.

Students registered *in absentia* are exempt from all fees except tuition.

Students registered only in courses which have been designated as "off campus" are exempt from paying all fees except tuition, a general fee of $6 per semester credit hour, laboratory fees and I.D. card.

Students taking less than six semester hours during long terms and less than three semester hours during summer terms are exempt from the Health Center Fee.



Withdrawal from the University

Once a fee payment has been accepted by the University, a student is considered officially enrolled. Stopping payment on a check for fees or allowing the check to be returned unpaid by the bank for any reason does not constitute official withdrawal from the University. Failure to follow procedures for withdrawing from the University may result in financial penalties and difficulty with future enrollment in the University.

Refunds

Refund of fees shall be made to students officially withdrawing according to the following withdrawal schedule:

Tuition, Student Services Fee, Building Use Fee, Student Center Complex Fee, Health Center Fee, and Laboratory Fee

Fall, Spring, or 11-week Summer Semester

Prior to the first class day	100 percent
During the first five class days	80 percent
During the second five class days	70 percent
During the third five class days	50 percent
During the fourth five class days	25 percent
After the fourth five class days	None

5½-Week Summer Term

Prior to the first class day	100 percent
During the first, second, or third class day	80 percent
During the fourth, fifth, or sixth class day	50 percent
Seventh day of class and thereafter	None

Identification Card Fee: After the card is issued, none of this fee can be refunded.

Board Fee: The board plan may be terminated at any time through application to the Food Services Department. Board payment will be refunded in full if the request for termination is received prior to the first day of class. Requests for termination initiated on or after the first day of class will be refunded based on a daily proration computation, less an early withdrawal fee equalling ten percent of the semester board rate.

Yearbook Fee: Yearbook fees are refundable in full during the semester in which payment is made. Thereafter, no refunds will be made on cancelled orders. Yearbooks must be picked up during the academic year in which they are published. Students who will not be on campus when the yearbooks are published, usually by September 1, must pay a mailing and handling fee. Yearbooks will not be held, nor will they be mailed without the necessary fees having been paid. Refunds will not be made on books not picked up within one semester of the publication date.

Drop/Add Refunds: A student may **drop** courses with no record during the first 12 class days of a fall or spring semester and during the first 4 class days of a summer term or an 11-week summer semester. A student may **add** courses during the first 5 class days of a fall or spring semester and during the first 3 days of a summer term or an 11-week summer semester. Full refunds or supplemental billings will be made for courses dropped or added during these times. Notices of refunds due or amounts owed will be mailed to the student's local address.

Unpaid Checks

If a check accepted by the Fiscal Department is returned unpaid by the bank on which it is drawn, the person presenting it will be required to pay a penalty of $15. The penalty increases to $25 fifteen days after the date of the first notice, and the student may be dropped from the rolls of the University. In addition. the check will be turned over to the county attorney for prosecution. Students dropped from the rolls of the University for failure to redeem an unpaid check or checks within the prescribed grace period are eligible for reinstatement upon redemption of such check or checks, plus penalties, and the payment of a reinstatement fee of $50.

Duplicate Receipts

Duplicate receipts for fees paid by students will be issued on payment of 55¢.

MARRIED STUDENT APARTMENTS

University-owned apartments, both furnished and unfurnished (in limited numbers), are available to married students. Rentals range from approximately $136.00 to $251 per month, including normal utilities, depending upon the type of apartment assigned. Application for a married student apartment should be made directly to the Student Apartments Office, Box 117, Faculty Mail Service, College Station, Texas 77843.

OFF CAMPUS HOUSING

Off campus students are served by the Off Campus Center, which keeps up-to-date information on apartment listings, rooms for rent, maps, shuttlebus, carpool referrals and other information pertinent to the off campus student. A roommate locator service is available to help students find a person with whom to live. The *Off Campus Living Survival Manual* is updated each spring to introduce students to the community covering such topics as leases, transportation, security deposits, cost estimates, laundry and food arrangements. The Off Campus Center also works with students who are having problems getting along with their roommates or landlords. For information, write Off Campus Center, Department of Student Affairs, Texas A&M University, College Station, Texas 77843.

Off Campus Aggies

The Off Campus Aggies (OCA) is a student organization whose officers are elected by off campus students. OCA officers and representatives aim to provide a voice for all off campus students, and they strive to improve facilities and services both at the University and in the community. OCA volunteers provide the following services: distributing and posting university materials, planning apartment socials, organizing apartment intramural teams and serving as an immediate resource to students in their apartment complexes.

DEGREE PROGRAM

A graduate student's degree program includes those courses which are listed tor degree credit on the official form. All courses on the approved degree program must be completed with a satisfactory grade to meet requirements for the degree. Changes in an approved degree program can be made by petition to the Dean of the Graduate College approved by the student's full Advisory Committee.

Additional course work may be added to the approved degree program by the student's Advisory Committee if such additional course work is deemed necessary to correct deficiencies in the student's academic preparation.

SCHOLARSHIP

A minimum grade point ratio (GPR) of 3.0 (B average based on a 4.0 maximum) in all course work other than in those courses in which grades of Satisfactory (S) or Unsatisfactory (U) are given (681, 684, 690, 691, 692) must be maintained throughout the period of graduate study by every graduate student at Texas A&M University. All grades earned in courses listed for graduate credit on the student's official degree program will be used in computing the grade point ratio.

A course in which the final grade is C or less may be repeated for a higher grade, in which event both or all grades earned and the total number of semester hours represented by the course will be used in the computation of the grade point ratio. Semester credit hours to which grades of WF and F are assigned shall be included; those involving grades of WP and Q shall be excluded. Grades and semester hours of credit transferred to a proposed degree program from another institution shall be used in computing the student's final over-all GPR.

Courses listed for graduate credit on the approved degree program in which the student has received a final grade may not normally be removed from the degree program, although courses acceptable for graduate credit may be added. Exceptions to the regulation set forth in the preceding sentence may be petitioned. Petitions must be approved by all members of the student's advisory committee, the head of the student's major department, and the Dean of the Graduate College.

If a student's cumulative GPR falls below the minimum of 3.0, the student will be considered to be on scholastic probation. If the minimum GPR is not attained in a reasonable time, the student will be dropped from the Graduate College. A grade of C is the lowest grade for which graduate credit will be given. In courses receiving grades of S or U, only the S grade is acceptable toward the completion of a degree program. Courses taken on a "Pass-Fail" basis may not be used for graduate credit.

Every non-degree graduate student must attain a 2.50 GPR on the initial 12 credit hours of course work for which the student enrolls and must maintain a 2.50 GPR thereafter in order to remain eligible to register.

PROFESSIONAL INTERNSHIPS

In those programs in which a professional internship is used*, a student will spend an appropriate period of time under the supervision of a practicing professional in industry, business, an educational institution or a government agency. The objectives of the internship are two-fold: (1) to enable the student to demonstrate the ability to apply both technical training and knowledge by making an identifiable contribution in an area of practical concern to the industry or organization in which the internship is served, and (2) to enable the student to function in a non-academic environment in a position in which he or she will become aware of the organizational approach to problems in addition to those traditional approaches with which the student is familiar. These may include, but are in no way limited to, problems of management, labor relations, public relations, environmental protection, economics, etc.

Internship agreements should be negotiated between the appropriate organization or industry and the appropriate academic department. Copies of such agreements are to be provided to the Graduate College. The organization of the internship, the internship supervisor and the nature of the internship will be determined by mutual consent of the student, the head of the student's major department, the student's Advisory Committee and the supervising organization prior to the commencement of the internship period. The internship experience should be at a level commensurate with the particular degree objective.

An internship report should be prepared by the student in accordance with guidelines established by the student's major department, the student's Advisory Committee or other appropriate body. The report should be submitted to the Advisory Committee and to any other organization which may be specified for specific programs. The internship report must be the original work of the student.

An internship, if utilized as part of a student's degree requirements, should be undertaken near the end of the student's educational program, after the student has had the opportunity to establish a solid theoretical base for the internship experience.

*Master's programs: M.Agr., M.Arch., M.B.A., M.C.S., M.Ed., M.Eng., M.Land., M.P.A., M.U.P. Doctoral programs: Ph.D., Ed.D., D.Eng., D.E.D.

RESIDENCE REQUIREMENTS

A major purpose of the residence requirements for graduate degrees is to insure that the student has an opportunity to benefit from the advantages of a university environment. These advantages include not only the accessibility of library, laboratory, and other physical facilities, but also the opportunity to participate in seminars and a variety of cultural activities. Equally important to the graduate student are the advantages of becoming acquainted with the faculty and other students on both a cultural and a professional basis.

By definition, a student "in residence" is expected to devote most of his or her time and energy to graduate studies **on the main campus under the direction of the major professor and the advisory committee.**

Another major purpose of the residence requirements for graduate degrees is to insure the faculty the opportunity to properly evaluate the student and his or her development in order to guide and direct his or her studies and to determine competency.

The minimum time required to qualify for an advanced degree varies with the ability and preparation of the student. Students may find it necessary to extend their studies beyond the minimum requirements. Specific minimum residence requirements are indicated in connection with the respective degrees.

PETITIONS

Exceptions to published rules may be requested by proper petition to the Dean of the Graduate College. If regarded as fully justifiable on the basis of the facts presented, limited exceptions to some rules may be approved.

Any changes in membership of a student's Advisory Committee, degree program, etc., must be proposed to the Dean of the Graduate College by petition, with endorsements by all members and, when applicable, proposed members of the student's Advisory Committee.

THE DEGREE OF MASTER OF SCIENCE

Residence (See also section entitled "Residence Requirements")

In partial fulfillment of the residence requirement for the degree of Master of Science, the student must complete, on the campus at College Station, nine credit hours during one semester or during two consecutive six-week summer terms. Upon recommendation of the student's advisory committee and the approval of the Dean of the Graduate College, a student may be granted exemption from the requirement of nine credit hours to be taken during one semester or during two consecutive six-week summer terms. However, such a petition must be approved prior to the student's registration for the final nine credit hours of required course work.

Full-time staff members of the University or of closely affiliated organizations stationed at the main campus may fulfill total residence requirements by completion of less-than-full course loads. In this context a full course load is considered to be nine credit hours per semester, or nine credit hours per twelve-week summer session. Specific authorization for such programs must be granted in advance by the employing agency. See also section entitled "Registration."

Student's Advisory Committee

After receiving admission to the Graduate College and enrolling for graduate studies, the student will consult with the head of his or her major or administrative department concerning appointment of the chairman of the Advisory Committee. The student's Advisory Committee for the master's degree will consist of **not fewer than three members of the graduate faculty** representative of the student's fields of study and research; **one of the members must be from a department other than the student's major department.**

The chairman, in consultation with the student, will select the remainder of the Advisory Committee. The chairman will then notify the tentative members of the Advisory Committee, giving the student's name and field of study, and request that they consider serving on the student's Advisory Committee. The student will then personally interview each prospective committee member to determine whether he or she will accept the assignment. No individual located away from the campus of Texas A&M University at College Station may serve as chairman of a student's Advisory Committee but may serve as co-chairman with an individual located on the campus at College Station.

The student's Advisory Committee has the responsibility for guiding and directing the entire academic program of the student and for initiating all academic actions concerning the student. The chairman of the Advisory Committee, who usually has immediate supervision of the student's research and thesis, has the responsibility for calling required meetings of the Advisory Committee, and for calling meetings at any other time considered desirable. The duties of the Advisory Committee include responsibility for the proposed degree program, the research proposal, the thesis, and the final examination. In addition, the Advisory Committee as a group and as individual members are responsible for counseling the student on academic matters, and, in the case of academic deficiency, initiating recommendations to the Dean of the Graduate College.

Degree Program

The student's Advisory Committee, in consultation with the student, will develop the proposed degree program. **This should be completed and filed with the Dean of the Graduate College, whose approval is required, prior to the second semester's registration.**

This proposed degree program must be submitted on the official form with endorsements by the student's Advisory Committee and the head of the student's major department.

Students submitting proposed degree programs for Master of Science degrees should designate at the top of the official proposed degree program form, immediately following the degree designation (line 4), the program option desired (i.e., "Thesis option," or "Non-thesis option").

Additional course work may be added to the approved degree program by the student's Advisory Committee if such additional course work is deemed necessary to correct deficiencies in the student's academic preparation.

Credit Requirement

A minimum of two full semesters of approved courses and research (32 semester hours) is required for the thesis option Master of Science degree.

Ordinarily the student will devote the major portion of his or her time to work in one field or two closely related fields. Other work will be in supporting fields of interest.

Limitations on the Use of Transfer, Extension and Certain Other Courses

If otherwise acceptable, certain courses may be used toward meeting credit-hour requirements for the master's degree under the following limitations:

1. a. Not more than a total of six credit hours of transfer course work. Only course work taken in residence at an accredited institution will be considered for transfer credit. No course in which the grade is below B may be transferred for graduate credit. **(Note also b and d, below).**
   b. Not more than a total of 12 credit hours of course work taken by extension, including 685 (Problems) taken by a student while not in residence on the main campus of Texas A&M University. Credit for course work taken by extension will be granted only for extension courses taken under the direction of Texas A&M University. Extension courses taken at institutions other than those within The Texas A&M University System are not acceptable for transfer credit.
   c. Not more than a total of 12 credit hours of 689 (Special Topics).
   d. Not more than a total of 12 credit hours of **any combination** of (1) transfer credit for course work taken at an accredited institution, (2) credit for course work taken by extension, and (3) 689 (Special Topics).
2. Not more than eight hours each of 691 (Research), or 685 (Problems), nor more than three hours of 690 (Theory of Research) — nor more than 12 hours of any combination of these.
3. Not more than two hours of seminar.
4. Not more than eight hours of advanced undergraduate courses (300 or 400 designation).
5. No credit may be obtained by correspondence study, or for any course of fewer than three weeks duration.
6. No credit hours of 684 (Professional Internship) may be used for the degree of Master of Science.
7. Selected courses offered by the College of Medicine may be used for graduate credit. A maximum of twelve semester credit hours of such course work may be used for credit on a minimal master's degree program. For a listing of approved courses offered by the College of Medicine, the student should see the head of his or her major department, the Dean of the College of Medicine, or the Dean of the Graduate College.

Exceptions will be permitted only in unusual cases and only when recommended by the student's Advisory Committee and approved by the Dean of the Graduate College.

Transfer of Credit

A student who has earned 12 hours of graduate resident credit at Texas A&M University may be authorized, upon the advice of the Advisory Committee and with the advance approval of the Dean of the Graduate College, to transfer from another institution more than six hours of specified courses, **if these courses are not available at Texas A&M University.** Otherwise the limitations stated in the preceding section (see 1) apply. Courses for which transfer credits are sought must have been completed with grades of B or better, and must be approved by the student's Advisory Committee and the Dean of the Graduate College. Credit for thesis or dissertation research is not transferable. Texas A&M University does not normally accept for transfer credit course work taken at colleges and universities of foreign countries nor course work **in which no formal grades are given or in which grades other than letter grades (A, B, C, etc.) are given (for example, CR, P, S, U, H, etc.).**

Foreign Languages

There is no specific language requirement for the Master of Science degree.

Thesis Proposal

For the thesis option Master of Science degree, the student must prepare a thesis proposal for approval by the Advisory Committee and the head of the major department. This proposal must be submitted in quadruplicate for the approval of the Dean of the Graduate College at least 14 weeks prior to the close of the semester or summer session in which the student expects to receive the degree.

Thesis

An acceptable thesis is required for the degrees of Master of Arts (thesis option) and Master of Science (thesis option) and is optional for the degree of Master of Urban Planning. The thesis must be the original work of the candidate. It must be grammatically correct, reflecting the ability of the candidate to express thoughts clearly. In general, the format should be consistent with that used in scholarly journals in the candidate's field. An abstract not exceeding 350 words and a vita page are included in the thesis. **Instructions relating to specific requirements may be obtained from the office of the Dean of the Graduate College.**

Three copies of the thesis in its final form must be filed with the thesis/dissertation clerk of the Graduate College (second floor, University Library), after approval by the student's Advisory Committee and the head of the student's major department, by deadline dates announced each semester or summer session in the "Graduate College Calendar."

A receipt issued by the Fiscal Department showing payment of the required thesis binding fee and the required collating and editing fee must be presented to the thesis/dissertation clerk before the thesis can be accepted.

Credit for Work in Absentia

Upon recommendation of the Advisory Committee and approval of the Dean of the Graduate College, a student may be permitted to carry on work in connection with the thesis *in absentia.* For details concerning *in absentia* registration, see section on "Registration."

Time Limit

No student will be granted a master's degree from Texas A&M University unless all requirements accepted for fulfillment of the degree are completed within a period of seven consecutive calendar years. If within this time period a student does not complete all requirements for the degree sought, he or she cannot receive graduate credit for any course work which is more than seven calendar years old at the time of the final examination.

Application for Degree

Formal application for the degree must be filed in the office of the Dean of the Graduate College not later than 90 days prior to the end of the semester, or 30 days prior to the end of the summer term in which the student expects to complete his or her requirements for graduation. A student must be formally registered in Texas A&M University for the semester in which the degree is to be conferred. Such a student should be registered in the first 5½ week term of the summer session at the end of which the degree is to be conferred.

Final Examination

The candidate must pass a final examination by deadline dates announced each semester or summer session in the "Graduate College Calendar." At the time of the final examination, a student's GPR must be **at least 3.0;** furthermore, there must be no unabsolved grades of D, F, or U (unsatisfactory) for any course listed for degree credit on the student's degree program. Otherwise the student is **not eligible** to take the final examination. The announcement of the final examination should be submitted to the Graduate College at least two weeks in advance of the scheduled date for the examination. A student must have completed all course work on his or her degree program with the exception of any remaining 691 (Research) hours (for which the student must be registered) and must have an approved research proposal on file with the Graduate College before he or she is eligible to take the final examination.

The final examination covers the thesis and all work taken on the degree program and at the option of the committee may be written or oral or both. The examination is conducted by the student's Advisory Committee as finally constituted. Persons other than members of the graduate faculty may, with mutual consent of the candidate and the major professor, attend final examinations for advanced degrees. Upon completion of the questioning of the candidate, all visitors must excuse themselves from the proceedings.

Candidates may exempt the final examination provided their GPR for the course work completed is equal to 3.5 or better and provided the exemption has the approval of the student's advisory committee, the head of the student's major department, and the Dean of the Graduate College.

Students must be registered in the University in the semester or summer session in which the examination is to be given.

A student shall be given only one opportunity to repeat the final examination for the master's degree and that shall be within a time period that does not extend beyond the end of the next regular semester (summer terms are excluded).

Students whose degree requirements include a thesis and who plan to graduate at the end of a summer session (i.e., in August) should always register during the first term of the summer session in which they plan to graduate, even though degree requirements may make it necessary for them to register in the second term also.

Unless otherwise authorized by the Dean of the Graduate College, the final examination for the master's degree must be administered on the campus of Texas A&M University at College Station, Texas.

Non-thesis Option

In departments of the University which wish to do so and which are authorized to offer Master of Science degree programs, the requirements for the degree may be satisfied by completing a minimum of 36 semester hours, of which 18 semester hours must be in the major department, and a minimum of six semester hours in supporting fields.

A thesis is not required. A final comprehensive examination is required. The requirements as to level of courses and examinations are the same as for the thesis option Master of Science degree.

Students who elect to pursue non-thesis option Master of Science degrees are not eligible to include 691 (Research) courses on their degree programs. All requirements for the non-thesis option Master of Science degree other than those specified above are the same as for the thesis option degree.

THE DEGREE OF MASTER OF AGRICULTURE

The program of study leading to the degree of Master of Agriculture is designed to serve those who desire graduate professional training in an agricultural discipline. A student holding a baccalaureate degree or a qualified senior during his or her last semester may apply for admission to the Graduate College to work toward the non-thesis degree of Master of Agriculture. The candidate's Advisory Committee shall specify prerequisite work where necessary.

The degree may be earned in any department of the College of Agriculture and also in the interdisciplinary areas of 1) agricultural chemistry, 2) food science and technology, 3) natural resource development, 4) plant protection and 5) agricultural development.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

Approximately 12 of the minimum of 36 required credit hours will be taken outside of the student's option. Each candidate will normally be required to prepare one or more written reports (not necessarily involving results of research conducted by the candidate) in addition to papers required as a part of regular course work.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Agriculture — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date. The candidate does not qualify to petition for an exemption from the final examination as outlined for the degree of Master of Science.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

Except as noted above, the requirements for the degree of Master of Agriculture are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF ARCHITECTURE

The Department of Architecture in the College of Architecture and Environmental Design offers programs of graduate study as preparation for professional careers in architecture, the construction industry and related environmental design fields. The Master of Architecture is a non-thesis degree and requires the completion of a minimum of 52 hours of course work and a satisfactory comprehensive final examination. For holders of five-year professional degrees in architecture, the minimum number of hours of required course work is 36, none of which may consist of 684 (Professional Internship). Holders of the Bachelor of Environmental Design degree from Texas A&M University and holders of five-year professional degrees in architecture will enter the program directly, subject to admission approval by the department and the Graduate College. Holders of other baccalaureate degrees will normally be required to complete prerequisite course work in the Department of Environmental Design to attain B.E.D. equivalency.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

No more than 8 credit hours each of 684 (Professional Internship), 685 (Problems), or 692 (Professional Study), nor more than 3 credit hours of 690 (Theory of Research) may be used toward the degree of Master of Architecture—nor any combination of 684, 685, 690, and 692 totaling in excess of 16 SCH of these courses in the 52-SCH master's degree program or 11 SCH of these courses in the 36-SCH master's degree program.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.** Departmental requirements and regulations relating to degree plans, professional internships, etc., may be found in the departmental brochure. Students will not normally be permitted to undertake 684 (Professional Internship) as the final course in the sequence of study leading to the master's degree.

Candidates for the degree of Master of Architecture are not eligible for exemption from the final examination as outlined for the degree of Master of Science.

Except as noted above, the requirements for the degree of Master of Architecture are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF ARTS

Thesis Option

The degree of Master of Arts currently is offered to students majoring in anthropology, English, history, modern languages or political science. The residence requirements for this degree are exactly the same as for the Master of Science degree, as is the requirement of a thesis, which must be the original work of the candidate. The thesis is expected to be a competently phrased narrative of the student's original research topic. Of the minimum of 30 semester hours required for the Master of Arts degree, no more than six credit hours for thesis research may be counted toward the degree. The proposed degree program for students seeking the M.A. must include study in more than one area of specialization, but these areas may be contained within the course offerings of a single department.

No credit hours of 684 (Professional Internship) may be used for the degree of Master of Arts.

Foreign Languages: For the degree of Master of Arts a reading knowledge (usually represented by two years of college study) of at least one foreign language is normally required.

Except as noted above, the requirements for the degree of Master of Arts (thesis option) are identical with those for the Master of Science (thesis option).

Students submitting proposed degree programs for Master of Arts degrees should designate at the top of the official degree program form, immediately following the degree designation (line 4), the program option desired (i.e., "thesis option," or "non-thesis option").

Non-Thesis Option

In departments of the University which wish to do so and which are authorized to offer Master of Arts degrees, the requirements for the degree may be satisfied by completing a minimum of 36 semester hours, of which 18 semester hours must be in the major department, and a minimum of six semester hours in supporting fields.

A thesis is not required. A final comprehensive examination is required. The requirements as to level of courses and examinations are the same as for the thesis option Master of Arts degree.

Students who elect to pursue non-thesis option Master of Arts degrees are not eligible to include 691 (Research) courses on their degree programs. All requirements for the non-thesis option Master of Arts degree other than those specified above are the same as for the thesis option degree.

THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION

The College of Business Administration offers a graduate program leading to the degree of Master of Business Administration (M.B.A.). The M.B.A. program includes a curriculum that emphasizes instruction in the basic disciplines and business functions while recognizing the environmental context within which organizational decisions are made. The M.B.A. degree includes 48 semester credit hours of course work. Holders of bachelor's degrees in business administration admitted prior to the Fall semester, 1984, may be allowed to omit some of the required course work at the discretion of the M.B.A. Program Director and a graduate faculty committee. Programs for such students will consist of not less than 36 semester credit hours of course work. All persons must have completed calculus and economics (macro and micro) **prior** to enrollment in the programs. Students admitted for the Fall semester, 1984, and thereafter, will be assigned programs consisting of a minimum of 48 semester credit hours.

The M.B.A. degree program is designed for full time students and includes 36 semester hours of required courses. The 12 semester hours of elective courses may be taken in elective blocks drawn from the professional fields of accounting, business computing science, finance, management or marketing or a student may select an elective block consisting of courses from several professional fields. New students are admitted for fall or spring semesters. Further details concerning the M.B.A. curriculum may be obtained by contacting the M.B.A. Program Office, College of Business Administration. The College of Business Administration is accredited by the American Assembly of Collegiate Schools of Business (AACSB) at both the baccalaureate and master's degree levels.

To satisfy the residence requirement, the student must complete 12 semester credit hours on the campus at College Station.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Business Administration; neither can any combination of 684, 685, and 690 totaling more than 25% of the total credit hour requirement shown on the individual proposed degree program be used.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final oral or written examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

The candidate is not eligible to petition for an exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Except as noted above, the requirements for the degree of Master of Business Administration are identical with those for the degree of Master of Science.

Applications for admission to the M.B.A. program should be submitted for fall semesters by the previous February 15 and for spring semesters by the previous September 15. Applications received after February 15 and September 15 will be considered, but applications submitted before these dates will be given priority.

THE DEGREE OF MASTER OF COMPUTING SCIENCE

The degree of Master of Computing Science is a non-thesis degree, designed to complement the Master of Science degree in computing science. The degree requires the completion of a minimum of 36 hours of course work and a satisfactory comprehensive final examination.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Computing Science — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

The candidate is not eligible to petition for an exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

Except as noted above, the requirements for the degree of Master of Computing Science are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF EDUCATION

Graduate students majoring in adult and extension education, agricultural education, educational administration, educational curriculum and instruction, educational psychology, educational technology, health education, industrial education,

physical education or vocational education may become candidates for the degree of Master of Education. This is a non-thesis degree which requires a minimum of 36 hours of course work and a satisfactory comprehensive final examination.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Education — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

The candidate is not eligible to petition for an exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

Except as noted above, the requirements for the degree of Master of Education are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF ENGINEERING

A student holding a Bachelor of Science degree in engineering or a qualified senior during the last semester may apply for admission to the Graduate College to work toward the non-thesis degree of Master of Engineering, majoring in his or her particular field of engineering. Approximately one-third of the required minimum of 36 credit hours of course work will be taken in fields outside of the major field.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

The work in the major field will include one or two written reports (not necessarily involving results of research conducted by the candidate).

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Engineering — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

The candidate is not eligible to petition for an exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

Except as noted above, the requirements for the degree of Master of Engineering are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF LANDSCAPE ARCHITECTURE

The College of Architecture and Environmental Design offers a non-thesis program leading to the degree of Master of Landscape Architecture. The degree requires the completion of a minimum of 40 hours of course work and a satisfactory comprehensive final examination.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Landscape Architecture — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date. The candidate does not qualify to petition for an exemption from the final examination as outlined for the degree of Master of Science.

Except as noted above, the requirements for the degree of Master of Landscape Architecture are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF PUBLIC ADMINISTRATION

Through its Department of Political Science, the College of Liberal Arts offers an interdisciplinary, non-thesis program leading to the degree of Master of Public Administration. This program of study is under the joint auspices of the College of Liberal Arts and the College of Business Administration, with the cooperation of the College of Engineering, and uses appropriate educational offerings throughout the University.

The minimum requirements for this degree are the completion of 36 hours of course work and a satisfactory final examination. To satisfy the residence requirement, the student must complete 12 credit hours on the campus at College Station.

This professional curriculum is primarily designed to provide broad preparation in public policy and administration for managerial careers in government services, which now comprise nearly one out of five of the employed civilian labor force. In addition, students may avail themselves of traditional University strengths in a wide range of supporting areas and departments in order to prepare themselves for careers in city management; in staff services such as personnel, finance or public relations; or in important governmental or industrial areas of policy and administration such as marine resources, energy, science and technology, agriculture and natural resources, judicial and regulatory processes, and defense and foreign affairs, among others.

Most holders of a bachelor's degree in one of the social sciences, or managerial sciences such as business administration, will normally be prepared to go directly into graduate courses leading to the M.P.A. degree. Others may be required to take preprofessional courses to fulfill prerequisites. For those with no prior administrative experience, an internship may be required.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Public Administration — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

The candidate is not eligible to petition for an exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Except as noted above, the requirements for the degree of Master of Public Administration are identical with those for the degree of Master of Science.

THE DEGREE OF MASTER OF URBAN PLANNING

Students holding the baccalaureate degree may become candidates for the degree of Master of Urban Planning. This two-year interdisciplinary program provides opportunities for individual and collaborative work including the optional thesis. The minimum requirements for this degree are the completion of 48 hours of course work and a satisfactory final examination.

To satisfy the residence requirement the student must complete 12 credit hours on the campus at College Station.

No more than eight credit hours of 684 (Professional Internship), eight credit hours of 685 (Problems), nor more than three credit hours of 690 (Theory of Research) may be used toward the degree of Master of Urban Planning — nor any combination of 684, 685 and 690 totaling in excess of 25% of the total credit hour requirement shown on the individual degree program.

Only those candidates selecting the thesis option may qualify for exemption from the final examination as outlined for the degree of Master of Science. The announcement for the final examination in either case must be submitted to the Graduate College at least two weeks in advance of the scheduled date.

Students who undertake a professional internship in partial fulfillment of master's degree requirements after completing all course requirements for the master's degree **must return to the campus for the final examination.** The final examination **is not to be administered until all other requirements for the degree, including any internship, have been substantially completed.**

Except as noted above, the requirements for the degree of Master of Urban Planning are identical with those for the degree of Master of Science.

SUMMARY OF THE MAJOR STEPS REQUIRED BY THE GRADUATE COLLEGE IN FULFILLING REQUIREMENTS FOR THE MASTER'S DEGREE

Dean — Dean of Graduate College
D. A. & R. — Dean of Admissions and Records
DH — Department Head
GA — Graduate Advisor
ADCom — Advisory Committee

Procedure	Initiate Through / Approved By	Time
1. Apply for admission	D.A. & R. / DH & Dean	At least 6 weeks prior to registration (3-4 months prior to registration for foreign students; use foreign student application)
2. Become familiar with general regulations and appropriate master's degree section of *Catalog*		Before registration
3. Meet with graduate advisor assigned by department head to plan course of study for first semester	DH & GA / GA	Before first semester registration
4. Establish advisory committee; prepare proposed degree program	GA & DH / ADCom, DH & Dean	Before second semester registration
5. If thesis is required, submit thesis proposal	ADCom / DH & Dean	14 weeks prior to graduation
6. Apply for degree	Dean	See deadline in "Graduate College Calendar"
7. Check to be sure degree program and Advisory Committee are up to date and all course work is complete		Well before final examination. Follow regular procedures for changes (see *Catalog*)
8. Submit announcement of the final examination	ADCom Dean	By deadline date in "Graduate College Calendar"
9. Submit 3 approved final copies of thesis	ADCom & DH / Dean	By deadline date in "Graduate College Calendar"
10. File letter-of-intent to continue for doctorate, if the student so plans	DH / Dean & D. A. & R.	Immediately upon completion of all requirements for master's degree
11. Arrange for cap and gown		Texas A&M Book Store in the University Center

THE DEGREE OF DOCTOR OF PHILOSOPHY

Work leading to the degree of Doctor of Philosophy (Ph.D.) is designed to give the candidate a thorough and comprehensive knowledge of his or her professional field and training in methods of research. The final basis for granting the degree shall be the candidate's grasp of the subject matter of a broad field of study and a demonstrated ability to do independent research. In addition, the candidate must have acquired the ability to express thoughts clearly and forcefully in both oral and written languages. The degree is not granted solely for the completion of course work, residence and technical requirements, although these must be met.

Residence (see also section entitled "Residence Requirements")

Students who enter the doctoral degree programs with baccalaureate degrees must spend two academic years in resident study on the campus at College Station. Students who hold master's degrees when they enter doctoral degree programs must spend one academic year in resident study on the campus. In either case, one academic year beyond the first year of graduate study must be in continuous residence on the campus of Texas A&M University at College Station. One academic year may include two adjacent regular semesters or one regular semester and one adjacent twelve-week summer session.

To satisfy the continuous residence requirement, the student must complete a minimum of nine credit hours per semester or twelve-week summer session for the required period. Those students who enter doctoral degree programs with baccalaureate degrees may fulfill residence requirements in excess of one academic year (18 credit hours) on the campus at College Station by attendance during summer sessions or by completion of a less-than-full course load (in this context a full course load is considered nine credit hours per semester). Full-time staff members of the University or of closely affiliated organizations stationed at the campus may fulfill total residence requirements by the completion of less-than-full course loads. See also section entitled "Registration."

A minimum of 96 credit hours beyond the baccalaureate degree or 64 credit hours beyond the master's degree is normally required for the degree of Doctor of Philosophy.

Credit for Work in Absentia

Upon recommendation of the Advisory Committee and approval of the Dean of the Graduate College, a student may be permitted to carry on work in connection with the dissertation *in absentia.* For details concerning *in absentia* registration, see section entitled "Registration."

Time Limit

No student will be granted a doctoral degree from Texas A&M University unless all requirements for that degree are completed within a period of 10 consecutive calendar years. If within this time period a student does not complete all requirements for the degree sought, he or she cannot receive graduate credit for any course work which is more than 10 calendar years old at the time of the final examination.

Student's Advisory Committee

After receiving admission to the Graduate College and enrolling for graduate studies, the student will consult with the head of his or her major or administrative department concerning appointment of the chairman of the Advisory Committee. The student's Advisory Committee will consist of **not fewer than four members of the graduate faculty** representative of the student's several fields of study and research; **one of the members must be from a department other than the student's major department.** A representative of the Graduate Council will be appointed to the student's Advisory Committee by the Dean of the Graduate College at the time of approval of the student's degree program.

The chairman, in consultation with the student, will select the remainder of the Advisory Committee. No individual located away from the campus of Texas A&M University at College Station may serve as chairman of a student's Advisory Committee but may serve as co-chairman with an individual located on the campus at College Station.

The student's Advisory Committee has the responsibility for guiding and directing the entire academic program of the student and for initiating all academic actions concerning the student. The chairman of the Advisory Committee, who usually has immediate supervision of the student's research and dissertation, has the responsibility for calling required meetings of the Advisory Committee, and for calling meetings at any other time considered desirable. The duties of the Advisory Committee include responsibility for the degree program, the research proposal, the preliminary examination (written and oral), the dissertation and the final examination. In addition, the Advisory Committee as a group and as individual members are responsible for counseling the student on academic matters, and, in the case of academic deficiency, initiating recommendations to the Dean of the Graduate College.

Degree Program

The student's Advisory Committee will evaluate the student's previous training and degree objectives. The committee will then outline a proposed degree program and a research problem which when completed, as indicated by the dissertation (or its equivalent for the degree of Doctor of Education, the degree of Doctor of Environmental Design, or the degree of Doctor of Engineering), will constitute the basic requirements for the degree. **The student's proposed degree program must be submitted to the Graduate College prior to the third semester's registration.** The proposed degree program will be submitted on standard forms, with endorsements by the student's Advisory Committee and the head of the major department, for the approval of the Dean of the Graduate College. A field of study may be chiefly in one department or may be in a combination of departments.

Additional course work may be added to the approved degree program by the student's Advisory Committee if such additional course work is deemed necessary to correct deficiencies in the student's academic preparation.

Selected courses offered by the College of Medicine may be used for graduate credit. For a listing of approved courses offered by the College of Medicine, the student should see the head of his or her major department, the Dean of the College of Medicine, or the Dean of the Graduate College.

No credit may be obtained by correspondence study or for any course of fewer than three weeks duration.

Transfer of Credit (See also page 95.)

Courses for which transfer credits are sought must have been completed with a grade of B or better and must be approved by the student's Advisory Committee and

the Dean of the Graduate College. Credit for thesis or dissertation research or the equivalent is not transferable. Credit for "internship" course work in any form is not transferable. Credit for course work taken by extension at any college or university other than those in The Texas A&M University System is not transferable. Texas A&M University does not normally accept for transfer credit course work taken at colleges and universities of foreign countries, nor course work **in which no formal grades are given or in which grades other than letter grades (A, B, C, etc.) are given** (for example, CR, P, S, U, H, etc.). Credit for course work submitted for transfer from any college or university must be shown in semester credit hours, or equated to semester credit hours.

Languages

All students are required to possess a competent command of English. The doctoral (Ph.D.) foreign language requirement at Texas A&M University is a matter of departmental option, to be administered and monitored by the individual departments of academic instruction.

Examinations

The student's major department and his or her Advisory Committee may require qualifying, cumulative or other types of examinations at any time deemed desirable. These examinations are entirely at the discretion of the department and the student's advisory committee.

The preliminary examination is required. No student may be given a preliminary examination or a final examination unless his or her official GPR at the time of the examination is 3.0 or better. This policy applies to any written or oral portions of either of these examinations. The preliminary examination for doctoral students shall be given no later than the end of the first semester after completion of course work and no earlier than a date at which the student is within approximately 6 credit hours of completion of the formal course work on the degree program (i.e., all course work on the degree program except 681, 684, 690, 691 and 692 courses). The examination shall be both oral and written unless otherwise recommended by the student's Advisory Committee (including the Graduate Council representative) and approved by the Dean of the Graduate College. The written part of the examination will cover each field of study included in the student's program. Each of the student's Advisory Committee members will be responsible for administering a written examination in the member's particular field, **unless the member chooses to waive participation in the written examination.** If the member does choose to waive participation in the written examination, this fact must be indicated on the announcement of the examination. Two or more members of the Advisory Committee may give a joint examination. One or more members may require a student to take a departmental examination to either supplement or replace a written examination. Each written examination must be completed and reported as satisfactory to the chairman of the Advisory Committee before the oral portion of the examination may be held. In case any written examination is reported unsatisfactory, the entire Advisory Committee must agree (1) to proceed with the oral portion of the preliminary examination, or (2) to adopt another course of action regarding the unsatisfactory written examination. Either procedure is subject to the approval of the Dean of the Graduate College.

The schedule for the preliminary examination must be approved by the Dean of the Graduate College. Formal announcement of the preliminary examination must be received in the office of the Dean of the Graduate College no less than one week prior to the date of the first scheduled written examination. If departmental preliminary examinations are to be used as part of the written portion of the preliminary examination, the Graduate College should receive prior notification of such examinations,

along with a list of those students who are to participate, no less than one week prior to the date of the first (or only) departmental examination. Both the oral and the written portions of the preliminary examination must be administered on the campus of Texas A&M University at College Station, Texas.

Credit for the preliminary examination is not transferable. Both parts (written and oral) of the preliminary examination must be completed within a length of time approved by the Dean of the Graduate College, usually not to exceed two weeks. If a departmental examination is used as a part of the written portion of the preliminary examination, it must be the last departmental examination offered prior to the date scheduled for the preliminary examination. In the schedule of **written examinations** (the written portion of the preliminary examination), **all members of the student's Advisory Committee are to be included.** If members of the Advisory Committee choose to waive participation in the written examinations, this fact should be indicated by the inclusion of the word "waived" beside the names of the members concerned. The representative of the Graduate Council (GCR) is a member of the student's Advisory Committee, and is to be consulted in establishing examination dates and included among those who receive copies of the announcement of the examination schedule.

Through the preliminary examination, the student's Advisory Committee should satisfy itself that the student has demonstrated the following qualifications:

a. The student has a mastery of the subject matter of all fields in the program.
b. The student has an adequate knowledge of the literature in these fields and has powers of bibliographical criticism.

In case a student is required by his or her Advisory Committee to take, as a part of the written portion of a preliminary examination, an examination administered by a department, the department must:

a. Offer the examination at least once every six months. The departmental examination should be announced at least 30 days prior to the scheduled examination date.
b. Assume the responsibility for marking the examination satisfactory or unsatisfactory, or otherwise graded, and in the case of unsatisfactory, stating specifically the reasons for such a mark.
c. Forward the marked examination to the chairman of the student's Advisory Committee within one week after the examination has been taken.

The chairman of the student's Advisory Committee is responsible for making all written examinations available to the members of the Advisory Committee at or before the oral examination.

The chairman of the student's Advisory Committee will report in writing to the Dean of the Graduate College the results of the preliminary examination. In the report, the Advisory Committee, through the chairman, should also make recommendations regarding the student's admission to candidacy.

After passing the required preliminary oral and written examinations for the doctoral degree, the student must complete all remaining requirements for the degree within three calendar years. Otherwise, the student will be required to repeat the preliminary examination.

By permission of the student's Advisory Committee and the Dean of the Graduate College, a student who has failed the preliminary examination may be given one reexamination, but only after a period of at least six months has elapsed.

A student must be registered in any semester in which he or she asks to appear for either the preliminary or the final examination. Such a student should be registered in the first 5½ week term of the summer session in which he or she asks to appear for either the preliminary or the final examination.

Admission to Candidacy

To be admitted to candicacy for the doctoral degree, a student must have (1) passed the preliminary examination, (2) filed with the Dean of the Graduate College

the dissertation proposal approved by the student's Advisory Committee, and (3) completed the formal course work. The student must be admitted to candidacy well in advance of the date when the degree is to be granted. The final examination will not be authorized for any doctoral student who has not been admitted to candidacy.

Dissertation

The general field of research to be used for the dissertation should be agreed on by the student and the Advisory Committee at their first meeting, as a basis for selecting the proper courses to support the proposed research.

As soon thereafter as the research project can be outlined in reasonable detail, the official forms for proposing the dissertation should be completed. The research proposal should be approved at a meeting of the student's Advisory Committee, at which time the committee should carefully review the proposal as to the feasibility of the proposed research and the adequacy of available facilities. The approved proposal, signed by all members of the student's Advisory Committee, including the Graduate Council representative, and the head of the student's major department, should be submitted (in quadruplicate) to the Dean of the Graduate College for final approval. This should be done before commencement of collection of data.

The ability to perform independent research must be demonstrated by the dissertation. which must be the original work of the candidate. While acceptance of the dissertation is based primarily on its scholarly merit, it must also exhibit creditable literary workmanship. The format of the dissertation must be acceptable to the Graduate College. **Instructions as to format should be obtained from the office of the Graduate College.**

By dates announced each semester or summer session in the "Graduate College Calendar," the candidate must submit to the office of the thesis/dissertation clerk of the Graduate College (second floor, University Library) three copies of the dissertation in final form. The dissertation must be completed with all suggestions and corrections of the members of the student's Advisory Committee incorporated and must bear the signatures of the department head and the student's Advisory Committee, with the exception of the Graduate Council representative.

An abstract not exceeding 350 words and a vita page are included in the dissertation. Two additional copies of the abstract and title page must be submitted with the dissertation for microfilming.

In addition to a dissertation binding fee, all successful candidates for the doctorate are required to pay to the Fiscal Department a dissertation microfilming fee. This fee is used to film doctoral dissertations in cooperation with University Microfilms. A receipt issued by the Fiscal Department showing payment of the required binding, collating and editing fee and the microfilming fee must be presented to the thesis/dissertation clerk before the dissertation or record of study can be accepted.

Application for Degree

Formal application for the degree must be filed in the office of the Graduate College not later than 90 days prior to the end of the semester, or 30 days prior to the end of the summer term in which the student expects to complete requirements for graduation. A student must be formally registered in Texas A&M University for the semester in which the degree is to be conferred. Such a student should be registered in the first 5½-week term of the summer.

Final Examination

The candidate for the doctoral degree must pass a final examination by deadline dates announced in the "Graduate College Calendar" each semester or summer session. No student may be given a final examination unless his or her official GPR at the time of the examination **is 3.0 or better; furthermore, there must be no unabsolved grades of D, F, or U (unsatisfactory) for any course listed for degree credit on the student's degree program.** A student must have completed all course work on his or her degree program with the exception of any remaining 691 (Research) or 692 (Professional Study) hours (for which the student must be registered or must have received permission from the Graduate College to delete from his or her degree program), must have an approved research proposal on file with the Graduate College, and must be advanced to candidacy before he or she is eligible to take the final examination. The announcement of the final examination should be submitted to the Graduate College at least two weeks in advance of the scheduled date for the final examination. The student's Advisory Committee as finally constituted will conduct this examination. The candidate's completed dissertation in substantially final form will be available to this committee. While the final examination may cover the broad field of the candidate's training, it is presumed that the major portion of the time will be devoted to the dissertation and closely allied topics. Persons other than members of the Graduate Faculty may, with mutual consent of the candidate and the major professor, be invited to attend final examinations for advanced degrees. Upon completion of the questioning of the candidate, all visitors must excuse themselves from the proceedings. The Advisory Committee will submit its recommendations to the Dean of the Graduate College regarding acceptability of the candidate for the doctoral degree. Students must be registered in the University in the semester or summer session in which the final examination is taken.

Students whose degree requirements include dissertations or records of study and who plan to graduate at the end of a summer session (i.e., in August) should always register during the first term of the summer session in which they plan to graduate, even though degree requirements may make it necessary for them to register in the second term also.

The final examination for the doctoral degree must be administered on the campus of Texas A&M University at College Station, Texas.

THE DEGREE OF DOCTOR OF EDUCATION

The Doctor of Education (Ed.D.) degree at Texas A&M University is a professional degree designed to prepare candidates for positions of leadership in the full range of educational settings, including public and private schools and colleges, business, government, industry and the military establishment. The program is designed for the practitioner; graduates may be expected to fill instructional, supervisory and administrative positions in which educational services are to be rendered.

Although substantively different from the Ph.D. degree in education, the Ed.D. degree requires equivalent admission qualifications, standards of scholarship, and breadth and depth of study. Since graduates of the program are expected to demonstrate a high level of professional skill and educational statesmanship, only those candidates who show a consistently high level of professional performance in their academic studies, in their role-related studies, in their internship experience, and in the completion of their records of study will be recommended for the degree.

The Ed.D. degree is available in adult and extension education, educational administration, educational curriculum and instruction, educational psychology, health education, industrial education, physical education and vocational education. Details of the degree requirements are presented below.

Admission

Applicants must hold the master's degree, must have completed at least three years of professional experience in an educationally related setting, and must submit Graduate Record Examination scores and an academic record acceptable to the department to which they apply. They must also complete a written instrument which assesses their knowledge of the requirements and duties of the professional roles to which they aspire and demonstrates their ability to write with clarity, organization and correctness.

Degree Program

Each student's proposed degree program will be individually designed on the basis of the student's career objectives and the competencies associated with the professional role to which the student aspires. Every program will contain a minimum of 64 semester hours, including the following components:

1. at least six one-hour proseminars stressing the foundation concepts with which every Ed.D. student should be familiar;
2. a core of courses associated with the field of specialization;
3. a set of courses selected to prepare the candidate for a specific professional role;
4. one or more courses that develop basic understanding of the procedures and applications of research;
5. at least one supporting field of 12 or more semester hours or two supporting fields of nine or more semester hours each;
6. a professional internship of at least six semester hours related to the professional role to which the student aspires;
7. a record of study (described below) involving at least 12 semester hours of credit.

Residence

The residence requirement for the Ed.D. degree is 30 semester hours taken on the campus at College Station, Texas. Of these 30 semester hours, at least 18 must be taken as a full time student. The residence requirement must be fulfilled within five consecutive calendar years. This requirement may be satisfied by a student who presents any combination of full time study during summer sessions of at least six weeks duration and/or work as a full-time student during regular sessions which totals in the aggregate at least 18 semester hours, accomplished within a five-year period beginning with the first course proposed to apply to this requirement.

Internship

Each Ed.D. degree candidate will complete a university-directed internship in a professional employment setting with a minimum duration of 300 clock hours accrued at the rate of 10-40 hours per week. The internship will require of the student full participation and responsibility in experiences directly related to the student's career specialization. Credit for the internship will not be given for a continuation of regular employment activities (e.g., continuing to serve as a junior college teacher or as an elementary school principal), but only for completing an entirely new work experience. The internship may be on a paid or unpaid basis, must be undertaken after the student has a degree plan on file, and must be supported by prior or concurrent course work (usually toward the end of the degree program). Prior to its beginning, the internship must be approved in writing as to details by all members of the students' doctoral committee. At the conclusion of the internship, a formal written summary of its nature and results must be approved by the student's Advisory Committee.

Record of Study

The Ed.D. student will produce a major research document called a record of study. The research project may involve such topics as (1) a field study on a problem of major proportions in time or extent; (2) a curriculum development project validated through pilot and field testing; or (3) action research on a curricular, instructional, supervisory, or administrative problem based on empirical data. The Ed.D. student must have primary responsibility for the design and development of the research, and the record of study must be the sole and original work of the candidate.

Whatever the nature of the research project undertaken by the candidate, he or she will be required to prepare a record of study which explains and supports the activities undertaken in the project and supports its conclusions with adequate investigations, empirical data and a comprehensive bibliography. The record of study will follow the instructions of the Graduate College concerning the preparation of proposals, theses, dissertations and records of study. Procedures used in the student's research will be described in sufficient detail for educators in other locations to apply or extend the procedures. All records of study should be characterized by accuracy of observation and measurements, thoroughness of analysis and synthesis, and accuracy and completeness of presentation.

Examinations

Each Ed.D. degree candidate is required to take a departmentally-prepared written qualifying examination prior to the completion of 30 hours of doctoral work. Although not an absolute requirement, the student is encouraged to take the required six hours of proseminar before taking the qualifying examination. Continuation in the program and/or any additional required study is dependent on the results of this qualifying examination.

In addition, each candidate must successfully complete an oral and written preliminary examination prior to admission to candidacy and a final oral examination upon completion of the record of study. Both of these examinations will conform to the requirements for the Ph.D. preliminary examination and final examination as set forth in the *Graduate Catalog.*

Except as noted in the sections above, the requirements for the Doctor of Education degree are identical with those for the degree of Doctor of Philosophy.

THE DEGREE OF DOCTOR OF ENGINEERING

The Doctor of Engineering program has as its objective the education of men and women to function at the highest levels of the engineering profession, with emphasis on solving problems which arise in the use of technology to benefit mankind. Since these problems frequently have a societal impact which is non-technical in nature and since technological advances are implemented through business and industry, the Doctor of Engineering program seeks to couple understanding of the characteristics of social and business institutions with high competence in solving engineering problems.

The curriculum is a 96 semester-credit-hour professional program beyond the baccalaureate degree. A minimum of 60 credit hours beyond the masters degree will be required. These totals include a maximum of 16 credit hours for a professional internship.

Following entry into the professional program, the student will complete a minimal 36 semester-credit-hour course of study prior to a one calendar year (4 credit hours per semester) internship in which the student will extend his or her education in a practice-oriented environment such as an industrial organization. The professional programs are administered by the departments of the College of Engineering, together with the College of Engineering and the Graduate College.

The final oral/written examination for the Doctor of Engineering degree is administered by the student's Advisory Committee, as approved by the College of Engineering and the Graduate College.

Additional information can be obtained from the Graduate College, the College of Engineering, or any department in the College of Engineering.

Admission

Applicants possessing baccalaureate degrees and a 3.0 Grade Point Ratio (GPR) or graduate degrees may seek admission, provided they meet or exceed academic requirements listed below. These students must be admitted to the program by both the Graduate College and the College of Engineering.

To be admitted to the Doctor of Engineering program by the College of Engineering, applicants must complete the appropriate application form, provide transcripts of all academic work taken beyond the secondary school level, prepare a 300-word essay dealing with the applicants' motivations for seeking admission to the program, complete and provide test scores on the Nelson-Denny Reading Test and on the Minnesota Engineering Analogies tests, be recommended by their respective departments, and be interviewed by the admissions sub-committee of the Doctor of Engineering Program Committee.

Students seeking admission beyond the master's level are required to pass the oral and written examinations associated with the Doctor of Engineering qualifying examination described in "Examinations."

Admission to the Graduate College does not imply admission to the Doctor of Engineering program, nor does admission to the program by the College of Engineering imply admission to the Graduate College.

Residency

Students who enter the D.Eng. program with baccalaureate degrees must spend two academic years in resident study on the campus at College Station. Students who hold master's degrees when they enter the program must spend one academic year in resident study on the campus. In this context, an academic year is defined as two regular semesters, two eleven-week summer semesters, or a regular semester and an eleven-week summer semester. To satisfy the residence requirement, the student must complete a minimum of nine credit hours per semester or eleven-week summer semester for the required period.

Student's Advisory Committee

After receiving admission to the Graduate College and to the Doctor of Engineering program, the student will consult with the head of his or her administrative department concerning appointment of the chairman of the Advisory Committee. The student's Advisory Committee will consist of not fewer than four members of the graduate faculty representative of the student's several fields of study. One member of the committee must be from a department other than the student's administrative department.

The student's internship supervisor, a practicing engineer, is also a member of the Advisory Committee.

The chairman, in consultation with the student will select the remainder of the Advisory Committee. The chairman will then notify the tentative members of the Advisory Committee, giving the student's name and field of study, requesting that they consider serving on the Advisory Committee. The student will then personally interview each prospective committee member to determine whether the prospective member will accept the assignment.

The student's Advisory Committee has the responsibility for guiding and directing the entire academic and internship programs of the student and for initiating all actions concerning the student. The chairman of the Advisory Committee, who usually has immediate supervision of the student's program, has the responsibility for calling required meetings of the Advisory Committee and calling meetings at any other time considered desirable.

The duties of the Advisory Committee include responsibility for the proposed degree program, the Doctor of Engineering qualifying examination (written and oral), the technical adequacy of the internship program, the qualifications of the student to embark on the internship, the internship report, and the final examination. In addition, the Advisory Committee as a group and as individual members are responsible for counseling the student on academic matters, and, in the case of academic deficiency, initiating recommendations to the deans of the Graduate College and the College of Engineering.

Degree Program

The student's Advisory Committee will evaluate the student's previous education and career objectives. The committee will then outline a proposed degree program which will constitute the basic academic requirements for the degree. The student's proposed degree program must be submitted to the Graduate College prior to the third semester's registration. It will be submitted on standard forms, with endorsements by the student's Advisory Committee and the head of the student's administrative department, for the approval of the Dean of the College of Engineering and the Dean of the Graduate College. At the time of approval, the Dean of Engineering will appoint a representative of the College of Engineering to the student's Advisory Committee and the Dean of the Graduate College will appoint a representative of the Graduate Council to the student's Advisory Committee.

The graduate portion of the proposed degree program will include a minimum of 96 semester credit hours. Of these, 80 semester credit hours of course work are required; the Professional Internship (see section on "Internship") will earn 4 semester credit hours/semester.

The 80 semester credit hours of graduate course work shall include a minimum of 20 semester credit hours of required course work, 12 semester credit hours of elective professional development courses, 32 semester credit hours of department-oriented graduate level courses, 12 semester credit hours of engineering design courses, and 4 semester credit hours of professional development seminar.

Additional course work may be added to the approved proposed degree program by the student's Advisory Committee if such additional course work is deemed necessary to correct deficiencies in the student's academic preparation.

Scholarship

In order to remain in good standing, students admitted to the Doctor of Engineering program must maintain a GPR of 3.25 during their graduate studies.

Examinations

All students admitted to the program are required to pass a comprehensive written and oral examination called the Doctor of Engineering Qualifying Examination. It will be administered when semester credit hours equivalent to the number required for a Master of Engineering degree have been accumulated. Individuals holding a master's degree when they enter the Doctor of Engineering program will be expected to take the Doctor of Engineering Qualifying Examination during their first semester of enrollment. The examination determines whether or not the student is prepared to continue study toward the Doctor of Engineering degree. A student who fails the Qualifying Examination may, with the approval of the Advisory Committee and the Dean of the Graduate College, retake the examination once. The second examination will be administered after a suitable period of preparation, normally not less than 6 months, upon the recommendation of the Advisory Committee.

The student's major department and Advisory Committee may require departmental, cumulative, or other types of examinations at any time deemed desirable. These examinations are entirely at the discretion of the department and the student's Advisory Committee. For instance, these examinations may be used for determining the technical depth and breadth required for the internship project. The candidate for the degree of Doctor of Engineering must pass an oral examination not less than two weeks before the date on which the degree is to be conferred. The student's Advisory Committee, as finally constituted, will conduct this examination, which will include the internship experience and closely allied topics as well as the broad field of the candidate's training. Persons other than members of the graduate faculty may, with mutual consent of the candidate and the major professor, attend final examinations for advanced degrees. Upon completion of the questioning of the candidate, all visitors must excuse themselves from the proceedings. The Advisory Committee will submit its recommendations through the Dean of Engineering to the Dean of the Graduate College regarding the acceptability of the candidate for the doctoral degree.

Internship

As part of the degree requirements, each student will spend a minimum of one calendar year working under the supervision of a practicing engineer in industry, business or government. The objectives of the internship are two-fold: (1) to enable the student to demonstrate the ability to apply both knowledge and technical training by making an identifiable contribution in an area of practical concern to the organization or industry in which the internship is served, and (2) to enable the student to function in a non-academic environment in a position in which he or she will become aware of the organizational approach to problems, in addition to those of traditional engineering design or analysis. During the internship phase of the program, the student must be continually enrolled in the University.

The nature of the internship experience will be determined by mutual consent among the student, the Advisory Committee, and the supervising organization prior to commencement of the internship period. It is expected that the internship experience will be at a level in the organization which will enable the student to deal with broadly based problems affecting more than one facet of the organization, rather than a single narrow or specific technical problem. Specific arrangements for the internship will be made through the student's major department, and an internship agreement must be negotiated between the student and the Advisory Committee, and the internship supervisor and appropriate representatives of the industrial organization. Copies of all agreements must be approved by the College of Engineering and the Graduate College.

An internship report must be prepared in accordance with guidelines issued by the Doctor of Engineering Program Committee. By dates announced each semester, the candidate must submit to the office of the Dean of Engineering three copies of the internship report in final form. The suggestions and corrections of the members of the Advisory Committee must be incorporated and the report must bear the signature of the department head and the members of the student's Advisory Committee, with the exception of the representative of the Graduate Council. The internship report must be the original work of the candidate.

Except as noted in the sections above, the requirements for the Doctor of Engineering degree are identical with those for the degree of Doctor of Philosophy.

THE DEGREE OF DOCTOR OF ENVIRONMENTAL DESIGN

The Doctor of Environmental Design (D.E.D.) program is intended to provide the candidate with academic and research competence of the highest order in the professions of architecture and landscape architecture.

Each student is expected to enter the program with mature objectives, a clear choice of a professional discipline and a strong interest in a specific aspect of the profession. The student will essentially be responsible, in consultation with his or her Advisory Committee, for developing a proposed degree program.

Admission

In addition to the normal admission requirements of the Graduate College, each applicant for admission to the D.E.D. programs of the Departments of Architecture and Landscape Architecture must submit the following materials to the department:

A. An illustrated brochure, or portfolio, which has been designed to exhibit the individual's professional experience and competence. Preferred format size is 8½ " x 11 ".
B. A comprehensive paper describing in detail the individual's goals, objectives, and the proposed program of study.

Program Requirements

Students entering the D.E.D. program must complete 96 semester hours of approved graduate study beyond the baccalaureate degree. In addition, the candidate must complete one of the three following assignments to demonstrate professional competence:

A. A written dissertation, which must be the original work of the candidate, on a subject approved by the candidate's advisory committee.
B. A comprehensive professional report resulting from research and a related period of professional internship approved by the candidate's advisory committee.
C. A major design and/or planning research project approved by the candidate's advisory committee.

Options B and C require the filing of a record of study by deadline dates announced each semester or summer session in the "Graduate College Calendar." The requirements and procedures for this record of study are similar to those for theses or dissertations.

Except as noted above, the requirements for the degree of Doctor of Environmental Design are identical with those for the degree of Doctor of Philosophy.

SUMMARY OF THE MAJOR STEPS REQUIRED BY THE GRADUATE COLLEGE IN FULFILLING REQUIREMENTS FOR THE DOCTORAL DEGREE

DH—Department Head
GA—Graduate Advisor
ADCom—Advisory Committee
GCR—Graduate Council Representative
Dean—Dean of Graduate College
D. A. & R.—Dean of Admissions and Records

Procedure	Initiate Through / Approved By	Time
1. Apply for admission	D. A. & R. / DH & Dean	At least 6 weeks prior to registration (3-4 months prior to registration for foreign students; use foreign student application)
2. Familiarize yourself with general regulations and appropriate doctoral degree section of *Catalog*		Before registration
3. Meet with graduate advisor assigned by department head to plan course of study for first semester	GA & DH / GA	Before first semester registration
4. Establish Advisory Committee; prepare degree program	GA & DH / ADCom, DH & Dean	Before third semester registration
5. Complete course work detailed on proposed degree program		Prior to preliminary examination (See *Catalog* for specific details)
6. Arrange preliminary examination	ADCom / Dean	
7. Submit proposal for dissertation or record of study	ADCom, DH & GCR / Dean	Well in advance of expected graduation date
8. Request ADCom to recommend admission to candidacy; completion of 5, 6, and 7 above required	ADCom / Dean	Well in advance of the date on which the degree is to be conferred
9. Prepare rough draft of dissertation	ADCom	
10. Apply for degree	Dean	During final semester; see "Graduate College Calendar" for deadline
11. Submit announcement for final examination	ADCom / Dean	See "Graduate College Calendar" for deadline
12. Submit 3 approved final copies of dissertation or record of study	ADCom & DH / Dean	See "Graduate College Calendar" for deadline
13. Arrange for cap, gown, and hood		Texas A&M Book Store in the University Center

GRADUATION

Graduate degrees are conferred at the close of each regular semester or summer session. During the semester or summer session in which the degree is conferred, a student must be officially registered in the University.

Candidates for advanced degrees who expect to complete their work at the end of a given semester must give written notice to the Dean of the Graduate College to that effect not later than 90 days prior to the end of the semester or 30 days prior to the end of the summer term in which the student expects to have the degree conferred.

PUBLICATION OF THESIS OR DISSERTATION MATERIAL

Graduate students pursuing work leading to an advanced degree may publish in scholarly journals materials that may subsequently be used as a part of the thesis, dissertation, or record of study provided the Dean of the Graduate College is notified of this intention **by the student** at the time the paper is submitted for publication. The complete title, the names of authors as they appear on the paper, and the name of the journal must be furnished the Dean of the Graduate College.

FINANCIAL ASSISTANCE

Graduate assistantships, both teaching and nonteaching, which require one-half time service, may be applied for by qualified students. An appointment to the latter is normally for nine months, whereas the appointment to a teaching assistantship may vary from nine to 12 months. Graduate assistantships – research are usually 12 month appointments, although vacancies may be filled for shorter periods.

A course load of nine to 12 credit hours of academic work per semester and four hours per summer term is normally required of graduate assistants.

A limited number of fellowships are available for students with outstanding records. Ordinarily such fellowships require no service except satisfactory academic performance. However, at the discretion of the head of the student's major department, a fellow may be required to spend up to one-fourth time on relevant teaching activities during one semester only (or during one twelve-week summer session) during a twelve-month period. Since fellowships normally permit full-time study and research, the holder of such a grant will be expected to register for 12 to 16 credit hours per semester and six hours per six-week summer term.

Student Financial Aid Office

Graduate students who desire to apply for financial assistance for the fall semester or for the entire academic year must submit the Financial Aid Form (FAF) with supplement to the College Scholarship Service by April 15. Those who wish consideration only for the spring semester must submit the FAF by September 15. Award/offer letters will be sent out during June or November, provided that the results of the FAF are on file and that the student has been granted nonconditional acceptance for enrollment and maintains a minimum 3.0 cumulative GPR on all graduate course work at the University.

Applications for Federally Insured Student Loans (Guaranteed State Loans) should be submitted to the Student Financial Aid Office at least 90 days or more prior to the required "need" date. Applications are available upon request.

Employment leads for campus and off-campus jobs are available at the Student Financial Aid Office, third floor, YMCA Building.

Inquiries and requests for forms, brochures, or other information should be sent to the Student Financial Aid Office, Texas A&M University, College Station, Texas 77843.

LIBRARY FACILITIES

Sterling C. Evans Library

The University's principal research collections, numbering over 1,300,000 physical volumes and the microtext equivalent of more than 248,000 volumes, are housed in a centrally located facility which provides seating for 4,470 readers.

Construction on a new multi-million dollar library addition was completed in February 1979, and renovation on the older part of the library was completed in August 1979. Since completion of the renovation process, 572 lockers on the third through sixth floors are available for assignment to graduate students. There are, in addition, 385 closed studies for use by faculty members and doctoral students engaged in research requiring extensive and constant use of library materials.

Centralized reference service is available on the first floor. The Documents Division, located on the second floor, offers assistance in using the large collection of government documents and technical reports.

More than 16,000 current periodicals are received, as well as state, national and foreign newspapers. The library is also a depository for selected federal documents. The Technical Reports Department includes university, government and corporation reports. Its emphasis is on three major subject collections — oceanography and sea grant, transportation and water. It also houses over 430,000 reports (primarily, but not exclusively, in the engineering disciplines) on microfiche.

Most materials may be checked out for a period of four weeks. Exceptions are periodicals, reference materials and materials temporarily reserved by instructors for required reading; these must be used in the library.

As a member of the Center for Research Libraries, the library can provide access to the Center's more than three million volumes of research materials. Information about the Center for Research Libraries is available from Interlibrary Services Division on the second floor of the Sterling C. Evans Library.

Another special service is offered in bibliographic instruction. Tours of the library can be arranged to cover areas from general orientation to in-depth bibliographic instruction in specific fields of study. Classroom instruction is also available. Contact the instructional services librarian for further information.

The library's Automated Information Retrieval Service (AIRS) offers a wide range of on-line bibliographic and statistical data bases. All major fields of inquiry are represented in the data bases. Types of materials retrieved by the system range from technical reports and patent information to published articles and project descriptions for current research activities. Costs vary with the data base searched.

The Special Collections Division, housed on the second floor of the Evans Library, includes several collections which support research in specific subject areas. These are the Jeff Dykes Range Livestock Collection (including a sub-collection of J. Frank Dobie items), a Western Illustrators Collection, the Science Fiction Research Collection, the Texas Collection, the Ku Klux Klan Collection, the Dyksterhuis Collection of the Earliest Scientific Literature of the Forests and Ranges of North America, the Bodenstein Reprint Collection on Developmental Biology, and a collection of early architectural works. Additionally, there is a small collection of approximately 1,000 rare books on a wide variety of topics.

Medical Sciences Library

This special library located in the Veterinary Medicine Administration Building serves the Colleges of Medicine and Veterinary Medicine, as well as other students and faculty of Texas A&M University. The Library serves as the administrative component of a five-unit consortium of libraries for the College of Medicine. The Texas A&M University Consortium of Medical Libraries also includes the Learning Resource Unit, College of Medicine, in College Station and the Media Center, the Scott and White Memorial Hospital library and the Olin E. Teague Veterans Administration Center library, all in Temple, Texas.

The Medical Sciences Library's collection numbers in excess of 46,000 volumes of bound journals and books, and the library currently subscribes to approximately 1400 American and foreign periodicals.

Reference service is extended to students, faculty, and medical and veterinary practitioners in the region. These services provide information available in books and journals and from on-line data bases. The information services of data bases accessible from the National Library of Medicine, Lockheed, SDC and BRS are in much demand. Available for use at the Medical Sciences Library is an in-house search/edit program, the first of a scheduled series of microcomputer applications. The Medical Sciences Library presents a nationwide symposium on medical library applications every two years.

The Library is open 88 hours each week, and an open stack arrangement provides easy access to books and journals. Books circulate for two weeks unless temporarily reserved for required reading. Periodicals do not circulate. Coin-operated copy machines are available.

DIVISION OF STUDENT SERVICES

The Division of Student Services is a cluster of administrative departments under the supervision of the Vice President for Student Services. It is designed to serve students at Texas A&M University and includes:

Department of Security and Traffic, which coordinates and implements university functions relating to security and traffic, including traffic control, vehicle registration, building and property security, and enforcement of all state and university laws and regulations (located at the corner of Jersey and Houston streets).

Memorial Student Center, which is a combination of a beautiful facility and a wide variety of services and programs intended to meet the cultural, social and recreational needs of the university community. This facility includes meeting rooms, lounges, a cafeteria and snack bar, bookstore, a music listening room, bowling lanes and an art gallery. The MSC Council and Directorate (located in room 216) is responsible for producing a wide variety of programs, ranging from ballet to backpacking, as well as for providing a laboratory for individual growth and development. All students are invited to become involved in MSC programs and to use the facilities and services of the MSC.

Students' Legal Department, which offers legal advice and counseling to all students on a variety of problems including landlord/tenant relations, consumer protection complaints and domestic relations problems (located in Room 306, YMCA Building).

Office of the Commandant, which plans, coordinates and implements programs of the Corps of Cadets. Army, Navy/Marine and Air Force ROTC programs are offered (located in the Military Science Building).

Personal Counseling Service, which provides limited duration personal-social, crisis/emergency, marriage/couples, human sexuality, career and group counseling; a career, educational and personal growth information library; test interpretation; and referral to other services. Confidentiality, to the limits provided by law and judicial decisions, is respected (located in Room 017, YMCA Building).

Student Activities, which assists approximately 400 student organizations with organizational development, funding and activities. This office also publishes calendars, handbooks and other publications of an informational nature for the university community and handles Quonset Hut facilities (located in Room 221, Memorial Student Center).

Student Affairs, which is responsible for university housing, off-campus programs, withdrawals, student life orientation, discipline, and other areas of student concern (main office in Room 103, YMCA Building).

University Health Service, which provides a modern clinic for out-patient services and beds for 44 in-patients. The facilities of the clinic include a modern laboratory, and X-ray, physical therapy and diagnostic departments. The medical staff includes not only general practitioners, but also consulting specialists in general practice, surgery, orthopedics, urology, gynecology and psychiatry.

The University Health Center is closed only during official University holidays; otherwise it operates 24 hours per day. The out-patient clinic is open from 8 a.m. to 4 p.m., Monday through Friday, and 8 a.m. to 12 noon on Saturdays. The Health Center fee entitles the student to clinic visits as needed, most diagnostic examinations, care of illnesses or accidents, ten days of treatment(s) per semester for cases requiring hospitalization at the University, medications according to pharmacy policy (medications unavailable at the hospital must be purchased by the student), and X-rays and laboratory tests as indicated.

The University Health Center does not perform or provide care for major surgery. In these cases, the student selects the hospital and surgeon and assumes financial responsibility for surgical or medical procedures.

Veterans Advisor and Advisor to the Handicapped, which offers assistance to students entitled to Veterans Administration educational benefits and to handicapped students and other university personnel. The office is located on the first floor of Ramp B, Hart Hall. While not a part of the Division of Student Services or of Texas A&M University, the Texas Rehabilitation Commission maintains an office on campus in room 146 of the MSC with a full-time counselor to assist eligible handicapped students.

GRADUATE COURSES

All graduate courses offered in the University are described on the following pages and are listed by departments, arranged alphabetically.

Figures in parentheses following the number of the courses indicate the clock hours per week devoted to theory and practice, respectively. Theory includes recitations and lectures; practice includes work done in the laboratory, shop, drawing room, or field. The unit of credit is the semester hour, which involves one hour of theory, or from two to four hours of practice per week for one semester of sixteen weeks.

Roman numerals to the right of the credit value of some courses indicate the semester in which it is regularly offered. The letter "S" denotes summer offerings.

Any course may be withdrawn from the session offerings in case the number of registrations is too small to justify offering the course.

DEPARTMENT OF ACCOUNTING

W. T. Andrews, Jr., J. J. Benjamin*, E. D. Bennett, L. L. Bravenec, D. L. Crumbley, G. A. Giroux, S. D. Grossman, S. H. Kratchman**, C. J. Nixon, C. W. Plum, L. G. Pointer, K. B. Putnam, R. G. Schroeder, G. Schugart (Head), W. T. Shearon, Jr., C. D. Stolle, R. H. Strawser, M. Tummins

*Doctoral Student Advisor
**Master's Student Advisor

The Department of Accounting offers graduate studies leading to the M.S. and Ph.D. degrees, and course work supporting the College of Business Administration's M.B.A. degree. The M.S. degree provides the necessary course work for students who wish to enter public accounting, private industry or government service. The Ph.D. program is designed to prepare students for careers in teaching and research.

Additional information, including specific departmental requirements, may be obtained by contacting the master's Student Advisor or the doctoral Student Advisor in the Department of Accounting.

(Acct.)

602. Business Combinations and Accounting Measurements. (3-0). Credit 3. Accounting treatments for business combinations; reporting practices followed by conglomerate companies. Security and Exchange Commission decisions, corporation annual reports, and stock exchange listing statements. Case studies. Prerequisite: Acct. 642 or equivalent.

607. Seminar in Auditing. (3-0). Credit 3. Current issues and research in auditing, attestation, and financial disclosures. Prerequisite: Acct. 407 or equivalent.

611. Management of Taxation. (3-0). Credit 3. Various income taxes on taxable entities. For business and other majors. Prerequisite: For non-accounting majors.

612. Partnership and Real Estate Taxation. (3-0). Credit 3. Concepts and principles of partnerships and real estate taxation; the use of partnerships and real estate for tax planning. Prerequisite: Acct. 405 or 611.

613. Estate Planning. (3-0). Credit 3. Taxation of decedent's estates and lifetime gifts; valuation of property subject to estate and gift taxes; concepts and principles of estate and trust taxation; estate planning. Prerequisite: Acct. 405 or 611.

614. Current Topics in Taxation. (3-0). Credit 3. Selected topics may include oil, gas, and mineral taxation, compensation techniques, consolidated returns, and foreign taxation. Prerequisite: Acct. 405 or 611.

616. Institutional Accounting. (3-0). Credit 3. Accounting principles and practices of schools, hospitals, governmental agencies, and other not-for-profit organizations. Prerequisite: Graduate classification.

640. Accounting Concepts and Procedures I. (3-0). Credit 3. Accounting concepts and relationships essential to administrative decisions; use of accounting statements and reports as policymaking and policy execution tools. Prerequisite: Graduate classification.

641. Accounting Concepts and Procedures II. (3-0). Credit 3. Financial accounting; conceptual aspects obtained through the problem approach. Prerequisites: Graduate classification; Acct. 640 or equivalent.

642. Accounting Concepts and Procedures III. (3-0). Credit 3. Advanced financial accounting topics. Theoretical and problematical treatment of accounting in the corporate structure, debt and equity funding, and preparation and analysis of financial statements under conditions of changing economic environment. Prerequisites: Graduate classification; Acct. 641 or equivalent.

649. Managerial Accounting. (3-0). Credit 3. Cost accounting concepts and use of accounting data in planning and control of operations. Prerequisite: Acct. 640 or equivalent.

651. Development of Accounting Thought. (3-0). Credit 3. Criteria for choices among income-determination and asset-valuation rules in context of public reporting. Prerequisite: Acct. 642 or approval of instructor.

661. Interdisciplinary Interface of Accounting Thought. (3-0). Credit 3. Implications for accountants of new developments in other disciplines and of changes in the technology and financing of particular industries.

671. Contemporary Accounting Topics. (3-0). Credit 3. Current issues and research in topical areas: financial data audit and control; international accounting; accounting for natural resources; tax planning, theory and structure of taxation. Students select three of the topics available. Prerequisites: Graduate classification; approval of instructor.

679. Managerial Accounting Analysis. (3-0). Credit 3. Primary aspects of managerial accounting needs; planning, internal control, cash and inventory management, data systems and analysis, and mergers and acquisitions. Prerequisite: Acct. 649 or equivalent.

680. Tax Research and Policy. (3-0). Credit 3. Methodology and sources of tax research; tax analysis research, policy implications, behavioral aspects, and use of quantitative analysis. Prerequisite: Acct. 405 or 611.

681. Seminar. (1-0). Credit 1 each semester. Critical examination of subject matter presented in current periodicals, recent monographs, and bulletins in field of accounting.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems using recent developments in business research methods. Prerequisites: Graduate classification; approval of instructor.

688. Doctoral Seminar. (3-0). Credit 3. Historical development of the conceptual framework of accounting theory and practices; analysis of current research and controversial issues in the field. For doctoral students only. Prerequisite: M.B.A. or equivalent.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of accounting. May be repeated for credit.

690. Theory of Research in Accounting. (3-0). Credit 3. The design of research in the various subfields of accounting and the evaluation of research results using examples from the current research literature. May be repeated for credit. Prerequisites: Graduate classification in accounting.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF AEROSPACE ENGINEERING

D. H. Allen, L. A. Carlson, H. L. Chevalier, E. J. Cross, Jr. (Head), W. E. Haisler, W. J. Horn, S. H. Lowy, S. J. Miley, D. J. Norton*, C. A. Rodenberger, C. H. Samson, Jr., R. A. Schapery, R. E. Thomas, R. S. Wick

*Graduate Advisor

The Department of Aerospace Engineering offers graduate work to provide training in preparation for the practice of aeronautical/aerospace engineering and careers in pertinent areas of research. Programs leading to the degree of M.Eng., M.S. and Ph.D. are offered. The department also offers courses and faculty supervision for students pursuing the doctor of engineering degree. There are no foreign language requirements in any of these programs. Major areas of interest are aerodynamics, structural analysis, propulsion and environmental aerodynamics.

Wind tunnels provide equipment for aerodynamic research in fundamental fluid flow problems, for atmospheric boundary layer flow about buildings, vehicles and other common structures, and for three-dimensional testing of complete airplane models. Investigations of structural dynamics problems are undertaken in well instrumented laboratories. Finite element solutions and computational fluid mechanics are efficiently developed with the Amdahl 470V/6 digital computer and supporting departmental computational facilities.

Courses relating to structural mechanics and materials are contained within the "Interdisciplinary Engineering" listing. The mechanics and materials courses are administered by the Department of Aerospace Engineering and are taught by faculty from the Departments of Aerospace, Civil and Mechanical Engineering.

(Aero.)

601. Principles of Fluid Motion. (4-0). Credit 4. Formulation of equations of motion for subsonic, transonic, and supersonic flow. Classical and numerical solution methods for aerodynamic flow fields. Applications to slender body theory, method of characteristics and drag minimization. Prerequisite: Approval of instructor.

602. The Theory of Fluid Mechanics. (3-3). Credit 4. Entry-level graduate course on the theory of fluid mechanics, employing a wide-range unified approach; concepts of compressibility, turbulence, and boundary layer theory. Laboratory includes elements of measurement techniques, numerical methods, and physical modeling. Prerequisite: Math. 601 or registration therein.

608. Aircraft Flutter Analysis. (4-0). Credit 4. Theoretical development of the structural and aerodynamic equations for two and three-dimensional flutter. Numerical solutions in practical problems to determine flutter velocities. Methods of testing to determine vibration characteristics of aircraft. Prerequisite: Aero. 420 or M.E. 459 or 617.

620. Unsteady Aerodynamics. (3-0). Credit 3. Theoretical formulation of unsteady airfoil theory and techniques used for determining airloads on oscillating lift surfaces. Exact solutions and various approximations presented and evaluated. Application to problems of unsteady incompressible, subsonic and transonic flows about airfoils and wings. Prerequisite: Approval of instructor.

630. Aerodynamics of the Helicopter. (3-0). Credit 3. General aerodynamic theory of rotating-wing aircraft. Development of the theory in its elemental form emphasizing basic concepts. Hovering and vertical flight performance analyses. Aerodynamics and performance of forward flight. Prediction and effects of rotor blade stalls. Prerequisite: Aero. 301 or 601.

650. Atmospheric Engineering. (2-3). Credit 3. Natural aerodynamics applied to practical problems. Effects of the Earth's boundary layer on transport processes in urban and rural environments. Wind loads on structures, separated flow regions, and interaction between buildings. Laboratory simulation methods. Prerequisite: Undergraduate fluid mechanics.

675. Aerodynamic Heating. (3-0). Credit 3. Analysis of compressible laminar and turbulent boundary layers in high-speed flows; convective aerodynamic heating. Prerequisite: Aero. 475 or approval of instructor.

681. Seminar. (1-0). Credit 1. Selected research topics will be presented by the faculty, students, and outside speakers. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 4 each semester. Special topics not within scope of thesis research and not covered by other formal courses. Prerequisite: Graduate classification in aerospace engineering.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of aerospace engineering. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Technical research projects approved by department head.

The following M.M. courses (Mechanics and Materials found in the Interdisciplinary Engineering section) are part of the curriculum in aerospace engineering and are taught by the faculty of the Department of Aerospace Engineering.

601. Theory of Elasticity. (3-0). Credit 3.
605. Energy Methods. (3-0). Credit 3.
632. Structural Stability. (3-0). Credit 3.
633. Theory of Plates and Shells. (3-0). Credit 3.
641. Plasticity Theory. (3-0). Credit 3.
647. Theory of Finite Element Analysis. (3-0). Credit 3.
648. Nonlinear Finite Element Methods in Structural Mechanics. (3-0). Credit 3.
689. Special Topics in . . . Credit 1 to 4.

The following M.M. courses are part of the curriculum in aerospace engineering but are normally taught by faculty of other engineering departments.

603. Foundations of Solid Mechanics. (3-0). Credit 3.
607. Flow and Fracture of Solids. (3-0). Credit 3.
608. Elasticity of Structural Elements. (3-0). Credit 3.
609. Materials Science. (3-0). Credit 3.
610. Applied Polymer Science. (3-0). Credit 3.
613. Principles of Composite Materials. (3-0). Credit 3.
618. Designing with Composites. (2-3). Credit 3.
620. Processing and Testing of Composite Materials. (2-3). Credit 3.
636. Theory of Thermal Stresses. (3-0). Credit 3.
640. Theory of Shells. (3-0). Credit 3.
650. Dynamic Fluid-Solid Interactions. (3-0). Credit 3.
651. Viscoelasticity of Solids and Structures I. (3-0). Credit 3.
652. Viscoelasticity of Solids and Structures II. (3-0). Credit 3.

DEPARTMENT OF AGRICULTURAL ECONOMICS

W. E. Black, R. E. Branson, J.-P. Chavas, J. R. Conner, E. E. Davis, R. A. Dietrich, D. E. Farris, S. W. Fuller, W. R. Grant, W. L. Griffin, C. R. Harston, W. A. Hayenga, J. A. Hopkin (Head), L. L. Jones, R. D. Kay, D. A. Klinefelter, R. D. Knutson, R. D. Lacewell, C. F. Lard, J. T. Long, J. M. McGrann, J. R. Martin, J. P. Nichols, J. B. Penson, Jr., R. D. Pope, J. W. Richardson, I. W. Schmedemann, V. E. Schneider, C. E. Shafer*, C. R. Shumway, T. L. Sporleder, J. R. Stoll, H. Talpaz, E. Uvacek, Jr., A. L. Wright

*Graduate Advisor

The objective of the Department of Agricultural Economics is to train scientific and professional workers. Increasing attention of public agencies and private organizations to rural, economic and social problems points to enlarged opportunities for well-qualified graduates for teaching, research, public administration, management and private employment.

In planning a student's program, the need for broad training, rather than narrow specialization, is recognized. The student, regardless of his or her primary interest, is expected to take not only advanced courses covering various fields within the department but also essential supporting courses in other departments. In all cases the student is expected to acquire a knowledge of economic theory, its application to contemporary agricultural problems, and the ability to employ statistical techniques and other methodology in making social and economic studies.

The teaching and research activities are grouped broadly as follows: (1) farm management and production economics, (2) marketing and market development, (3) resource and real estate economics, (4) agricultural finance, (5) rural development and agricultural policy. The present and expanding program of research in the department affords the student a wide choice and capable guidance in thesis or dissertation research.

The M.S. degree in agricultural economics may or may not require a thesis and is oriented to the basic professional requirements. Graduates holding the master of agriculture degree have been employed in the following areas: (1) agribusiness management, (2) agribanking, (3) commodity analysis, (4) real estate economics, (5) international agricultural development. A professional internship rather than a thesis is required. The Ph.D. program concentrates on the theory, quantitative tools and methodology required of the professional agricultural economist.

No foreign language requirement is stipulated for students pursuing a Ph.D. program in agricultural economics.

(Ag.Ec.)

602. Agricultural Market Organization and Structure. (3-0). Credit 3. Framework within which farm products are marketed. Implications of horizontal and vertical integration and governmental activities. Influence on market structure of producers, the food and fiber industries, and consumers. Prerequisite: Econ. 607 and Math. 230 or equivalent.

603. Land Economics. (3-0). Credit 3. Selected problems of allocation and use of natural resources with special reference to government organizations, quasi-governmental bodies and other interest groups. Prerequisite: Ag.Ec. 422 or equivalent.

604. Economics of Natural Resources Development. (3-0). Credit 3. Critical evaluation of policies and procedures in natural resource development and use. Identification of problems in resource development, the political-economic decision-making processes, and analytical tools which can contribute to economic decisions.

605. Rural Real Estate Appraisal and Organization. (3-0). Credit 3. Concepts of property rights and their valuation; factors affecting the value of these rights are related to general economic theory to explain real estate market process. Specific applications of appraisal techniques in valuing urban and rural real properties.

607. Research Methodology. (3-0). Credit 3. Scientific method in economic research: problem identification and selection, hypothesis testing, assumptions, model selection, data communication. Evaluation of research studies and development of thesis prospectus or equivalent.

609. Applied Welfare Economics. (3-0). Credit 3. Social benefits and costs of policy alternatives for commercial agriculture, natural resource development and public investment in agricultural research; general equilibrium and welfare economics including consumers' and producers' surplus; benefit-cost analysis; applications from contemporary agricultural economics literature. Prerequisite: Econ. 629.

610. Economics of Environmental Issues Relating to Agriculture. (3-0). Credit 3. Current and emerging problems in environmental economics relating to agriculture; factors contributing to environmental quality decline. Environmental quality in relation to current agricultural technology, economic problems, legal and political constraints, and institutions. Prerequisite: Math. 130 or equivalent.

611. Production Economics. (3-0). Credit 3. Economic principles for analyzing agricultural production and resource use; problems are treated regarding the technical unit, the firm and society; conditions for efficiency. Prerequisites: Econ. 607 and Math. 230 or equivalent.

612. Economic Development of Rural Areas. (3-0). Credit 3. Economic problems of rural areas in the U.S. Review of fundamental causes of economic decline in rural areas. Application of economic principles and theory to problems of rural areas. Evaluation of current methods and public programs for development. Application of analytical methods to development problems.

614. Agricultural Policy. (3-0). Credit 3. Public policies and programs affecting agriculture. Development of policies and programs, identifying relevant issues, alternative means to attain desired goals and review of criteria for evaluating action programs.

615. Agricultural and Food Policy Analysis. (3-0). Credit 3. Advanced analytical base for understanding, evaluating and formulating farm and food policy. Economic analyses developed and applied to selected contemporary policy issues. Prerequisite: Approval of instructor.

617. Market Development Research Theory. (3-0). Credit 3. Emergence of market development concepts, practices and strategies for food and fiber products. Causes, effects and relationship to business and consumer economics and psychological behavior theories. Market development technical research methods and operations.

619. Agricultural Business Analysis. (3-0). Credit 3. For master of agriculture students. Practical application of modern decision-making tools to agribusiness. Management process, basic functions of managing, and important managerial and economic skills and understanding needed to carry out these functions.

620. Capital Market in Agriculture. (3-0). Credit 3. Selected micro and macro economic issues in agricultural finance. Application of economic and finance theory with appropriate quantitative methods to financial management in agriculture and financial markets serving agriculture. Prerequisites: Ag.Ec. 630, 611, 641, Stat. 608 or equivalent.

627. Agricultural Market and Price Analysis. (3-0). Credit 3. Application of economic theory and statistical methods to the analysis of agricultural commodity price behavior; price forecasting; relationships among farm prices, marketing costs and retail prices. Prerequisites: Ag.Ec. 447 and Stat. 608 or equivalent.

629. Public Administration in Agriculture. (3-0). Credit 3. Basic theories in public administration in agriculture; techniques for accomplishing public goals; legal basis for public agriculture programs; economic, social, political and organizational considerations in agriculture programs.

630. Financial Planning of the Farm Firm. (3-0). Credit 3. Application of financial planning principles to farm business firms: capital budgeting and selection of farm investments; the role of debt structure and liquidity in firm growth and stability; how to build, merchandize and manage a firm's "credit;" alternatives for gaining control over resources and maintaining business efficiency over time.

632. Resource Allocation in Agriculture. (3-0). Credit 3. Production economics. Theory of the firm applied to problems of product supply, factor demand and resource allocation; major estimating methods. Prerequisites: Ag.Ec. 611 or Econ. 630, Ecmt. 669 or equivalent and Ecmt. 663 or Stat. 608.

633. Economics of Underdeveloped Agricultural Areas. (3-0). Credit 3. Function of agriculture in economic growth. Agricultural productivity as influenced by an economy's physical, cultural and institutional attributes. Economic problems of underdeveloped areas.

634. Economics of Agricultural Production. (3-0). Credit 3. Application of economic principles to crop and livestock units, stressing amounts and combinations of inputs required for most profitable production. Design of experiments in the physical sciences to permit economic evaluation of results. For non-agricultural economics students in the College of Agriculture.

641. Operations Research Methods in Agricultural Economics. (2-2). Credit 3. Quantitative methods applying operations research tools appropriate to problem-solving and decision-making. Current operations research techniques in various areas of economic research. Model application and electronic data processing techniques. Prerequisites: Stat. 651, Math. 230 or equivalents.

642. Systems Analysis and Programming in Agricultural Economics. (3-0). Credit 3. Modeling of systems analysis applied to agricultural economics systems. Modeling and simulating of agricultural production and market systems under dynamic deterministic, and stochastic conditions. Simulation carried out using CSMP computer language (Continuous System Modeling Program). Prerequisite: Ag.Ec. 641.

644. Law and Agriculture. (3-0). Credit 3. Laws affecting agricultural firms and individuals in day-to-day farm and ranch decision-making; legal arrangements and issues in intensive livestock operations; agronomic marketing practices; agricultural use of herbicides, insecticides and pesticides; other current legal issues. Prerequisite: Graduate classification. Cross-listed with Mgmt. 644.

645. Agricultural Consumption Analysis. (3-0). Credit 3. Specification, estimation and interpretation of models of consumer behavior with emphasis related to farm economy and food commodities. Building and evaluating food consumption models. Prerequisites: Econ. 629, Stat. 608, Ecmt. 663.

655. Agricultural Marketing Operations. (3-0). Credit 3. Commodity system: structure and performance; forces of change affecting responses of marketeers to change within. Practical management: analysis, planning, organization and control. Prerequisites: Ag.Ec. 314, Econ. 203, or equivalent.

681. Seminar. (1-0). Credit 1 each semester. Review of current literature, preparation of papers on selected topics, discussions with visiting agricultural economists. Prerequisite: Graduate classification.

684. Professional Internship. Credit 1 to 4. A work-study course for master of agriculture program in agricultural economics.

685. Problems. Credit 1 to 4 each semester. Directed individual study of a selected problem in the field of agricultural economics.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of agricultural economics. May be repeated for credit.

691. Research. Credit 1 or more each semester. Initiation and completion of a research project of approved scope for an advanced degree.

DEPARTMENT OF AGRICULTURAL EDUCATION

G. E. Briers, H. D. Brown*, J. E. Christiansen*, K. L. Denmark, D. R. Herring*, E. H. Knebel* (Head), R. A. Lewis

*Graduate Advisor

Advanced study in agricultural education or agricultural development is designed to help agricultural professionals to work with people. Teachers of agriculture at secondary and postsecondary institutions, agricultural extension personnel, international development representatives, and a wide array of private and public sector professionals who are responsible for the introduction of change may improve their capabilities through a program of selected courses described here. Program planning and program implementation receive emphasis. Course content and teaching procedures used in graduate courses are selected to assist in the development of skills in recognizing and analyzing professional problems and initiating plans of action for the solution of these problems.

Candidates for advanced degrees in agricultural education or in agricultural development should have at least one year of successful professional experience or should plan for an internship in a specific career in professional agriculture or education. Evidence of maturity, purposefulness and scholastic ability may be considered in lieu of experience upon approval of the faculty and the head of the department.

The staff of the department maintains continuous contact with agricultural professionals in the field. These contacts enable faculty members to conduct graduate programs with understanding and appreciation of important and complex problems encountered by professional agricultural workers.

(Ag.Ed.)

601. Advanced Methods in Agricultural Education. (3-0). Credit 3. Learning theories; techniques and procedures to enhance the teaching-learning process; methods to evaluate learning. Prerequisite: Approval of department head.

602. Problem Analysis in Teaching Vocational Agriculture. (3-0). Credit 3. Designed for teachers of vocational agriculture and for those returning to the profession. Problems encountered by teachers identified, analyzed and resolved. Prerequisites: Graduate classification and employment as a teacher.

605. Supervision of Occupational Experience Programs in Agriculture. (3-0). Credit 3. Occupational experience programs — their nature and scope in relation to supervised farming, part-time agricultural cooperative experiences, and pre-employment laboratories. Prerequisite: Professional experience or approval of department head.

607. Youth Leadership Programs. (3-0). Credit 3. Methods and procedures of organizing and conducting youth programs. Prerequisite: Professional experience or approval of department head.

610. Principles of Adult Education. (3-0). Credit 3. Identification of basic principles motivating adults to learn. Procedures to implement these principles in bringing about changes in adult behavior. Prerequisite: Professional experience or approval of department head.

615. Philosophy of Agricultural Education. (3-0). Credit 3. Historical and philosophical developments in education that brought about education in agriculture; ideas of individuals that culminated in agricultural education institutions and organizations. Prerequisite: Approval of department head.

619. Workshop in Agricultural Education. Credit 1 to 3. Offered for three or six weeks or full semester to study selected problems in agricultural or extension education. Consultants are used in specialized areas. Prerequisite: Professional experience or approval of department head.

630. Guidance and Counseling for Rural Youth. (3-0). Credit 3. Problems of youth with special attention given to rural youth. Theories of vocational development reviewed and techniques and procedures developed to help youth make career choices. Prerequisite: Approval of department head.

640. Methods of Technological Change. (3-0). Credit 3. Dynamics of cultural change as theoretical framework for planned technological change; methods of planning and implementing change, its effects and how it can be predicted. Prerequisite: Approval of department head.

641. The Transfer of Technology by Institutions. (3-0). Credit 3. Role and organization of institutions for effective transfer of technology; institutional models, assignment of priorities, institutional linkages, communications, special program design, program strategies and program evaluation. Prerequisite: Professional experience or approval of department head.

680. Proseminar. (1-0). Credit 1. Structured seminar in agricultural education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Designed for Ed.D. students with non-agricultural education backgrounds. May be repeated for credit. Prerequisite: Approval of department head.

681. Seminar. (1-0). Credit 1 each semester. Group study and discussion of current developments in agricultural education. Research and legislation as they affect programs in teacher education, vocational agriculture and related areas of education. Prerequisite: Graduate classification.

684. Professional Internship. Credit 1 to 6 each semester. An on-the-job supervised experience program conducted in the area of the student's specialization. Prerequisites: Graduate classification; approval of department head.

685. Problems. Credit 1 to 4 each semester. Studies related to classroom, laboratory, supervised farming, work experience, extension education, adult educational activities in agricultural programs. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of agricultural education. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Initiation and completion of research for advanced degree. Prerequisite: Approval of department head.

DEPARTMENT OF AGRICULTURAL ENGINEERING

J. M. Aguilera, W. H. Aldred, G. F. Arkin, C. G. Coble, G. L. Curry, K. C. Diehl, C. R. Engler, E. A. Hiler* (Head), O. R. Kunze*, W. A. LePori*, W. M. Lyle, W. E. McCune, A. R. McFarland, M. J. McFarland, J. L. Nieber, C. B. Parnell, D. L. Reddell, B. R. Stewart, B. A. Stout, D. A. Suter, V. E. Sweat, J. M. Sweeten, L. H. Wilkes, W. L. Zingery

*Graduate Advisor

The Department of Agricultural Engineering offers graduate studies leading to the degrees of master of science, master of engineering and doctor of philosophy. In addition, the department offers the master of agriculture degree in mechanized agriculture and courses and faculty supervision for students pursuing the doctor of engineering degree. The department has no Ph.D. foreign language requirement. Faculty expertise exists for study in fields such as machinery, product processing, structures, soil and water, food engineering, animal environment, agricultural waste management and pollution abatement, and forest engineering (in cooperation with the Departments of Forest Science and Civil Engineering). Supporting advanced courses are available in a wide variety of disciplines as well as within the department.

Minimum preparation for entry into advanced study would include a baccalaureate degree in engineering. Students with baccalaureate degrees in non-engineering disciplines will be accepted but must take some basic engineering courses in addition to their graduate courses.

Excellent facilities for research are available, including modern laboratories, testing equipment, technical support and field plots.

(Ag.En.)

601. Research Methods and Control Systems Theory. (3-0). Credit 3. Theory of control systems analysis with applications to living systems. Research and modeling in thermoregulation and other biological control areas. Prerequisite: Approval of department head.

602. Irrigation and Drainage. (3-0). Credit 3. Theory and practice in irrigation and drainage. Soil moisture, moisture flow, hydraulics of wells, erosion and sedimentation of structures, and theory of water application methods. Salinity and sodicity and their control. Drainage methods and theory, steady state and non-steady state. Prerequisites: Math. 308, Agro. 445 or approval of department head.

603. Agricultural Machinery. (3-0). Credit 3. Functional farm machinery design. Analysis of problem need, functional requirements, common materials used, design, testing, and production of efficient operational units. Prerequisite: Approval of department head.

606. Agricultural Process Engineering. (3-0). Credit 3. Engineering principles involved in mechanical handling, conditioning, and storage of agricultural products. Application of refrigeration, electric energy and physical properties of agricultural products. Prerequisite: Approval of department head.

611. Hydraulic and Power Transmission Systems for Tractors. (2-2). Credit 3. Theory and application of hydraulic and power transmission systems used in agricultural tractors. Laboratory practice includes study of application and use of hydraulic and power transmission systems related to the functional requirement of tractors. For non-engineering graduate students. Prerequisite: Ag.En. 330 or approval of department head.

612. Planning and Management of Irrigation Systems. (2-2). Credit 3. Planning and management of irrigation systems; surface, sprinkler, trickle and subsurface irrigation systems. The total system: sources of water, water rights, economics, water requirements, distribution systems, water measurement, system efficiencies, drainage, pollution and water conservation. For non-engineering graduate students. Prerequisite: Ag.En. 335 or approval of department head.

613. Small Watershed Hydrology. (3-0). Credit 3. Hydrology of agricultural watersheds; soil and water conservation, precipitation frequency analysis, infiltration, groundwater, runoff, erosion theory, sediment transport theory, evapotranspiration, reduction of water losses and experimental techniques. Prerequisite: Math. 308 or approval of department head.

614. Advanced Metals and Welding Processes. (2-4). Credit 4. Metals, welding metallurgy and welding processes. Practice includes certification requirements and techniques in tube welding, template construction, material preparation and inert gas welding. For non-engineering graduate students. Prerequisite: Ag.En. 222 or approval of department head.

615. Measurement Techniques in Agricultural Engineering. (2-3). Credit 3. Agricultural measurement systems; soil, water and humidity devices and instruments for quality evaluation and control of agricultural products; measurement of product maturity and ripeness, inspection of grains and seeds, animal carcass quality and milk fat analysis. Prerequisite: Ag. En. 430 or approval of department head.

616. Remote Sensing Applications in Water Resources. (3-0). Credit 3. Available sensors, capability and limitations of sensors, developing technology and sensor-platform combinations. Water resources models studied to determine variables that can be remotely measured. Current data processing and interpretation techniques demonstrate applications in water resources problems. Prerequisite: Approval of instructor.

619. Workshop in Mechanized Agriculture. (2-2). Credit 3. Offered three or six weeks for technical study and practice of selected subject areas in the field of mechanized agriculture. If offered in three weeks, 12 hours of theory and 12 hours of practice are required per week; or if offered in six weeks, six hours of theory and six hours of practice per week are required. Prerequisite: Professional experience or approval of department head.

651. Biochemical Engineering. (3-0). Credit 3. Integration of principles of engineering, biochemistry and microbiology; application to the design, development and improvement of industrial processes that employ biological materials. Engineering discipline directed toward creative application of interdisciplinary information to the economic processing of biological and related materials. Prerequisite: Approval of instructors. Offered jointly by Agricultural Engineering, Bioengineering, and Chemical Engineering and cross-listed with B.E. 651 and Ch.E. 651.

652. Enzyme Engineering. (3-0). Credit 3. Application of basic principles of life science and engineering technology; large scale unit operations involved in production, isolation, immobilization, economical use of enzymes, and optimization of enzyme reactor systems. Application of enzymes in pharmaceutical, food and fine chemicals industries as well as medical and clinical application. Prerequisite: Approval of instructors. Offered jointly by Agricultural Engineering and Chemical Engineering and cross-listed with Ch.E. 652.

661. Systems Engineering Applications in Agriculture. (3-0). Credit 3. Engineering applications of operations research methodology to agricultural production systems; optimal crop harvesting schedules, irrigation scheduling, irrigation system design optimization, machinery selection and machinery dynamics. Prerequisite: Approval of department head.

681. Seminar. (1-0). Credit 1 each semester. Reviews, reports and discussion of ideas, recent advances and current topics.

684. Professional Internship. Credit 1 to 4. An on-the-job supervised experience program, conducted on an individual basis in the area of the student's specialization in mechanized agriculture. Prerequisite: Graduate classification or approval of instructor.

685. Problems. Credit 1 to 4 each semester. Advanced laboratory or field problems not related to student's thesis. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of agricultural engineering. May be repeated for credit.

690. Theory of Research. (1-0). Credit 1. Development of research inquiry and discussion of applicable experimental design, theoretical techniques and methodological principles of conducting original research. Evaluation of current research of faculty and students and in engineering and scientific literature. Communication of research proposals and results. May be repeated for credit. Prerequisites: Graduate classification and approval of department head.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

AGRONOMY

(See Soil and Crop Sciences)

DEPARTMENT OF ANIMAL SCIENCE

J. W. Bassett, R. W. Blake, O. D. Butler, Jr., F. M. Byers, J. Caldwell, M. C. Calhoun, L. M. Canfield, Z. L. Carpenter* (Head), T. C. Cartwright, B. E. Conrad, C. E. Coppock, C. W. Dill, T. R. Dutson, R. L. Edwards, W. C. Ellis, G. Finne, J. L. Fleeger, D. W. Forrest, T. H. Friend, T. R. Greathouse, P. G. Harms, D. B. Herd, J. H. Hesby, N. M. Kieffer, G. T. King*, D. A. Knabe, D. C. Kraemer, J. L. Kreider, H. O. Kunkel, W. A. Landmann, A. L. Lawrence, H. Lippke, C. R. Long, C. S. Menzies, R. Nickelson, F. A. Orts, G. D. Potter, R. D. Randel, K. S. Rhee, R. L. Richter, J. O. Sanders, J. W. Savell, L. M. Schake, G. T. Schelling, J. M. Shelton, G. C. Smith, D. M. Stiffler, T. D. Tanksley, Jr., R. N. Terrell, W. B. Thomas, G. B. Thompson, M. Tomaszewski, C. Vanderzant, D. F. Weseli

*Graduate Advisor

Advanced study in animal science offers preparation for a future in teaching, research, extension, livestock and dairy production, and in industries involving food technology, and livestock products and supplies. Majors offered are:

Animal breeding	M.S. and Ph.D.
Animal science	M.S., M.Agr., and Ph.D.
Dairy science	M.S., M.Agr., and Ph.D.
Food science and technology	M.S., M.Agr., and Ph.D.
Nutrition	M.S. and Ph.D.
Physiology of reproduction	M.S. and Ph.D.

The animal science subject matter fields are strongly supported by course work in agricultural economics, biochemistry, biophysics, biology, genetics, statistics, and in veterinary anatomy, microbiology, parasitology, pathology, physiology, pharmacology and public health.

Laboratories available for graduate research include cytogenetics, dairy manufacturing, food technology, immunogenetics, meats, meat chemistry, nutrition and reproductive physiology. The Robert Justus Kleberg, Jr. Animal Science Center provides 39 laboratories for research and graduate training. Special equipment available in these laboratories or in readily available facilities, such as at the large Data Processing Center, offers a wide array of opportunities for study and research.

Dairy, beef, horse and swine herds and sheep and goat flocks at the main station or at research centers afford opportunities to study various problems in artificial insemination, breeding, management, nutrition and production. A dairy processing plant equipped to manufacture all dairy foods on a semi-commercial scale, and a meat processing plant equipped to fabricate and process all meat foods on a semi-commercial scale, are in operation and are available for research problems. Experiment Station projects in all subject matter fields offer opportunities for graduate students to participate in current research activity.

Support areas such as biochemistry and biophysics, economics, genetics and statistics may be readily arranged. Food science and technology courses are jointly listed.

There is no specific foreign language requirement for the doctor of philosophy degree. A student's advisory committee may require a foreign language or additional course work in an unrelated area.

ANIMAL SCIENCE

(An.Sc.)

601. General Animal Nutrition. (3-0). Credit 3. Nutrients required by whole animals based on continuing physiological and metabolic functions to the whole animal. Prerequisites: An.Sc. 303 and 309 or equivalent or approval of department head.

602. Protein and Energy Nutrition. (3-0). Credit 3. II Current fundamental concepts in protein and energy matabolism relating to nutrients required for maintenance, growth and development of animals. Prerequisite: Bich. 410 or approval of department head.

603. Experimental Nutrition. (1-6). Credit 3. II Laboratory and animal procedures applicable to nutrition research, with emphasis on the principles and techniques of sample collection and analysis. Prerequisite: Bich. 410 or approval of department head.

604. Ruminant Nutrition. (3-0). Credit 3. I Current knowledge and concepts in anatomy, physiology and microbiology of digestion in herbivorous animals and how such relates to current and future nutrition practice and research with emphasis on ruminants. Prerequisites: An.Sc. 601 or 602, Bich. 411 or 603 and/or approval of department head.

605. Advancements in Beef Cattle Production. (3-0). Credit 3. I, S 1983 Current knowledge and concepts in production of lean beef; review of research in beef cattle production, breeding, nutrition, reproduction and economics. Prerequisites: An.Sc. 305, 306, 309 and 406 or approval of department head.

606. Advancements in Beef Cattle Production. (3-0). Credit 3. II, S 1983 Continuation of An.Sc. 605 with emphasis on efficiency of growth and development of diverse types of cattle through computer simulation of beef production systems. Prerequisites: An.Sc. 307, 309 and 406, or 408 or approval of department head.

607. Physiology and Biochemistry of Muscle as a Food. (3-0). Credit 3. I Biochemical, histological, anatomical and physical factors associated with transformation of muscle cell into meat. Prerequisite: Bich. 410 or approval of department head. Cross-listed with F.S.T. 607.

608. Feedlot Management. (3-0). Credit 3. S Current knowledge of commercial beef production systems. Disciplines of nutrition, management, breeding, meats, herd health, pollution and sanitation control emphasized through computer-simulated gaming and industry contact. Prerequisite: An.Sc. 406 or 408.

610. Behavior and Training of Domestic Animals. (2-2). Credit 3. I Review and evaluation of current research, points of controversy, importance of behavior in experimentation, and management of species important to agriculture. Behavior principles are integrated with applied aspects. Research projects on behavior are developed and conducted by students in area of interest. Guest lecturers prominent in ethology lead several discussions.

616. Quantitative Genetics II. (3-0). Credit 3. II Theories and methods useful in quantitative genetics research; estimation of genetic parameters and their precision; genetic discriminant functions; and experimental design and interpretation. Prerequisites: Gen. 613; Stat. 608, 619.

617. Experimental Techniques in Meat Science. (1-6). Credit 3. II Methods used in separating and identifying muscle proteins and fats. Techniques for determining postmortem changes of muscle tissue as a result of antemortem treatments. Prerequisites: Bich. 604 or 411 and An.Sc. 607. Cross-listed with F.S.T. 617.

619. Advancements in Sheep and Angora Goat Production. (3-0). Credit 3. Review of research relating to sheep and goat production; specifically, genetics and animal breeding, physiology of reproduction and meats. Evaluation of potential application for research to improve efficiency of production and economic return. Consideration of research methodology, techniques and analyses. Prerequisites: An.Sc. 305, 306, 414; or approval of department head.

620. Advancements in Sheep and Angora Goat Production. (3-0). Credit 3. Continuation of An.Sc. 619 with consideration of nutrition, fiber production and marketing, diseases, parasites, physical facilities and management.

621. Advancements in Swine Production. (3-0). Credit 3. II Review of research relating to various phases of pork production. Evaluation of research and application of basic principles to efficient management. Economic requirements and current production problems. Prerequisites: An.Sc. 305, 306, 412; or approval of department head.

625. Least-Cost Feed Formulation. (1-2). Credit 2. Cross-listed with P. S. 625.

628. Animal Breeding. (2-2). Credit 3. II Concepts from Mendelian, population and quantitative genetics; heritability, selection response, selection criteria, selection index, genetic relationship, inbreeding, mating systems, hybrid vigor and genetic-environmental interaction applied to livestock breeding and to production systems. Interactions between genetics and nutrition, reproduction, production and management for both established concepts and recent trends are emphasized according to special interests of students. Prerequisites: An.Sc. 305 and 306 or P.S. 414.

631. Physiology of Reproduction. (2-2). Credit 3. I Basic biochemical, physiological and endocrine mechanisms involved in reproductive function. Current research principles and techniques useful in studying physiology of reproduction. Prerequisites: An.Sc. 433, Bich. 410, V.P.P. 601 and 603, or approval of department head.

633. Concepts in Reproduction. (3-0). Credit 3. II Concepts from current research in physiology of reproduction will be evaluated and applied for enhancement of livestock production efficiency. Ovulation control, embryo transfer, multiple births and control of parturition. Prerequisite: An.Sc. 433 or equivalent or approval of department head.

647. Technology of Meat Processing and Distribution. (3-0). Credit 3. II Quantitative and qualitative characteristics of meat and meat products as related to food technology processing operations; manufacturing, preservation, packaging and merchandising. Cross-listed with F.S.T. 647.

650. Issues in Animal Agriculture. (3-0). Credit 3. Nonmarket factors related to food production and consumption. National and global nutritional, environmental, ethical, social, and political issues faced by agricultural systems. Animal agriculture is used as a model. Prerequisite: Approval of instructor.

657. Food Additives, Ingredients and Regulatory Compliance. (3-0). Credit 3. Identification nomenclature, purpose and function of additives used in meat and non-meat food products. Governmental regulatory agencies, their organization and control over food ingredient labeling; commercial supplies and basic manufacturing operations used in food ingredients. Cross-listed with F.S.T. 657. Prerequisite: Approval of instructor.

667. Industrial Processed Meat Operations. (2-2). Credit 3. Application of scientific principles and business practices to manufactured meat products. Interrelationship between marketing, manufacturing, product development, regulatory compliance and quality assurance in commercial processed meat operations. Cross-listed with F.S.T. 667. Prerequisite: Approval of instructor.

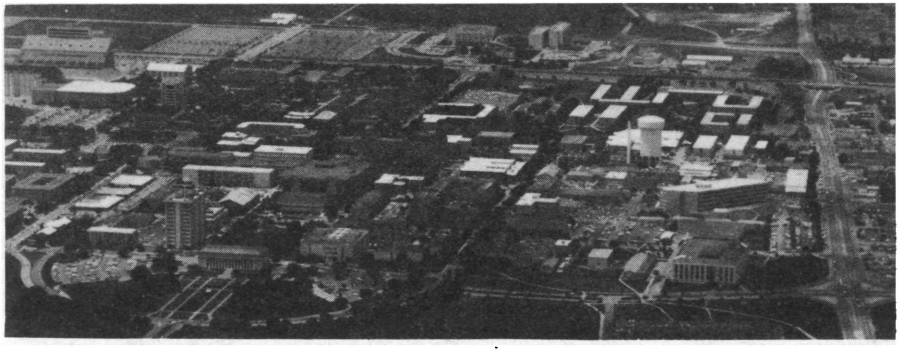
681. Seminar (1-0). Credit 1 each semester. I, II Important current developments in field of animal science. Review of current literature and presentation of papers on selected animal science topics. Prerequisites: Graduate classification in animal science.

684. Professional Internship. Credit 1 to 4. I, II, S Experience in the application of formal training to a commercial operation under supervision of the operations manager and a designated faculty member. The student will investigate a matter of mutual interest to the enterprise manager and to Texas A&M University; will collect, analyze and interpret the data and report the results in a professional paper approved by his or her graduate committee.

685. Problems. Credit 1 to 4 each semester. I, II, S Advanced studies in animal science problems and procedures. Problems assigned according to experience, interest and needs of individual student. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. I, II, S Special topics in an identified area of animal science. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. I, II, S Investigations leading to student's thesis or dissertation in fields of animal production, meats, wool and mohair, nutrition, inheritance of farm animals and physiology of reproduction.



DAIRY SCIENCE

(D.S.)

601. Dairy Production. (2-6). Credit 4 each semester. I Dairy production problems; research literature. Several principles are studied in search of a bio-economic model to improve production efficiency. Prerequisites: D.S. 418 or equivalent; Stat. 651.

602. Dairy Production. (2-6). Credit 4 each semester. II Continuation of D.S. 601. Research techniques and methodologies, data procurement and analysis, and reporting of results. Prerequisites: D.S. 601, Stat. 651, and Stat. 652 recommended.

606. Microbiology of Foods. (3-0). Credit 3. II Nature and function of beneficial and defect-producing bacteria in foods. Food-borne illness, effects of processing, storage, and distribution. Techniques for isolation and identification from foods. Cross-listed with F.S.T. 606.

684. Professional Internship. Credit 1 to 4. I, II, S Application of formal training in a commercial operation under the supervision of a manager and a designated faculty member. Data will be collected on a study of mutual interest to the enterprise manager and Texas A&M University. The student will collect, analyze and report the data, as well as experience. Prerequisite: Minimum of 20 hours of master's credit or approval of department head.

685. Problems. Credit 1 to 4 each semester. I, II, S Research methods and review of scientific literature dealing with individually selected problems in production or manufacturing and not pertaining to thesis or dissertation.

689. Special Topics in . . . Credit 1 to 4. I, II, S. Special topics in an identified area of dairy science. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. I, II, S Research leading to thesis or dissertation in respective fields of dairy production and dairy manufactures.

ANTHROPOLOGY

(See Sociology and Anthropology)

DEPARTMENT OF ARCHITECTURE

L. O. Degelman, J. deJong, D. C. Ekroth, C. E. Estes (Head), W. W. Harper, C. M. Hix, Jr., G. J. Mann, J. H. Marsh III, R. D. Reed, E. J. Romieniec, F. J. Trost, W. V. Wells, D. G. Woodcock*

*Graduate Advisor

The Department of Architecture offers programs of advanced study as preparation for professional careers in architecture, the construction industry and related environmental design fields. Candidates for the non-thesis degree of master of architecture select an area of emphasis approved by the department. Current areas include architectural design, architectural history and preservation, construction management, health facilities planning and design, interior space design and urban design. The department also provides course work and advisory support for those students seeking the degree of doctor of environmental design (with descriptive emphasis in architecture).

(Arch.)

605. Architectural Design I. (2-12). Credit 6. Design processes using architectural projects as case studies. Assigned projects. Design experience includes schematic design: program development, concept formulation, design methodologies, graphic and verbal communication skills. Core design studio for professional degree candidates. Prerequisite: Graduate classification in architecture.

606. Architectural Design II. (2-12). Credit 6. Continuation of Arch. 605. Design experience; schematic design and design development: selection and design of structural systems, building services, materials, connections and equipment. Core design studio required for professional degree candidates. Prerequisite: Arch. 605 or equivalent.

607. Architectural Design III. (2-12). Credit 6. Individually directed design studios; elected and assigned projects. Advanced analysis, synthesis and appraisal techniques responding to contemporary architectural issues. Prerequisite: Arch. 606 or equivalent.

608. Architectural Design IV. (2-12). Credit 6. Individually selected design project of major architectural significance and complexity. Professional documentation required. Project requires approval of instructor. Prerequisite: Arch. 607 or equivalent.

613. Urban Design I. (2-4). Credit 3. State of the art of urban design, the theory and application of the design process to problems of urban context, complexity and scale. Visual, physical and social components of urban design and implementation techniques. Prerequisite: Graduate classification. Cross-listed with Land. 613.

614. Urban Design II. (2-4). Credit 3. Theories and processes which define urban growth and form. Interdisciplinary studies and analysis techniques necessary for designing in modern urban environments. Prerequisites: Arch. 613 or approval of instructor.

621. Energy Optimization in Building Design. (3-0). Credit 3. Optimum energy use strategies for buildings, energy audit methods, life-cycle cost analysis of building energy systems, solar system applications, building system optimization by computer simulation techniques, case studies in passive energy and solar applications. Prerequisites: Arch. 633 and C.S. 203 or equivalent.

623. Design Methods I. (3-0). Credit 3. Importance of intuitive methods in design; meaning, symbolism and creativity in art and architecture; techniques to develop creative approaches to problem-solving.

624. Design Methods II. (3-0). Credit 3. Design as innovative problem-solving. Focus on rational approaches to problem-solving in architecture and related fields.

625. Design for Life Safety. (3-0). Credit 3. Principles of life safety in building design to reduce potential for loss of life under fire, earthquake, hurricane or windstorm conditions. Life safety in conjunction with building codes and standards and other legal contexts and professional liability. Prerequisites: Arch. 631 and 633 or approval of instructor.

628. Contemporary and Creative Structures. (2-2). Credit 3. Contemporary and creative structures as related to architectural design. Form finding processes. Synthesis of form, structural behavior, and use of material. Model techniques of close packing and polyhedral structures, space frames, goedesics and domes, tensegrities and lightweight structures. Prerequisite: Graduate classification.

631. Structural Systems. (3-0). Credit 3. Structural analysis of building structural systems: components, frames, shapes. Selection and economics of structural systems. Survey of current structural design codes. Supervision practices in structural construction. Prerequisite: 9 hours of structures.

633. Environmental Control Systems. (3-0). Credit 3. Building energy consumption patterns and conservation strategies. Natural and mechanical subsystems for environmental control. Subsystem design criteria, economic considerations and selection methods. Prerequisite: B.C. 336.

639. Contemporary Architecture. (3-0). Credit 3. Twentieth century architecture; development of style, structure, materials, social and economic factors influencing architecture. Discussion and criticism of work and writings of architects and architectural theorists. Prerequisite: Arch. 449 or approval of instructor.

640. Morphology of Architectural Form. (3-0). Credit 3. Forces influencing structure and form of architecture: climate, culture, site, economics, construction methods. Prerequisite: Graduate classification.

641. History of the Urban Environment. (3-0). Credit 3. Evolution of town planning and urban design from prehistory to present. Cultural and industrial conditions affecting development; the American city. Prerequisite: Graduate classification.

642. Data Processing in Environmental Design. (2-3). Credit 3. Application of the computer to architectural problems. The computer as a mapping device for graphical display of spatially related data; simple and multiple linear regression on sets of data; correlation analyses and practice at running the computer for these applications.

645. Alternative Futures and Architecture. (3-0). Credit 3. Theory and form-giving in architecture as affected by alternative futures, changing technology and environmental issues. Prerequisite: Approval of instructor.

646. Historic Building Preservation. (3-0). Credit 3. History of the preservation movement in the U.S. Architectural and regulatory techniques employed in building preservation. Case study of selected examples. Prerequisite: Graduate classification.

647. Recording Historic Buildings. (1-5). Credit 3. Techniques for recording historic buildings; measuring and drawing to Historic American Building Survey Standards. Field experience in photography, field notes and record drawing preparation. Prerequisite: Graduate classification and appropriate background in architectural drawing.

650. Industrialized Building Systems. (3-0). Credit 3. Social, economic and technological forces determining building systems in both industrially developed and industrially underdeveloped countries. Detailed examination of selected examples.

651. Construction Management. (3-0). Credit 3. Organization of construction activities and resources; interrelationship of time, sequence, material delivery and personnel availability. Methods of construction, project planning, management, cost and time accounting. Prerequisite: Graduate classification.

657. Professional Practice. (3-0). Credit 3. Business and legal environment; design and construction industry; legal forms of practice; office organization, personnel practices, policies and management; basic and expanded professional services; economics of practice, profit planning, and accounting; client selection; standard forms of agreement between design professionals, consultants, and clients; professional ethics; relationships and forms of construction, bidding and contract documents; standard conditions of construction contracts; selection of contracts; project procedures and administration; professional liability. Prerequisites: Mgmt. 212; graduate classification.

661. Interior Component Selection and Design. (2-4). Credit 3. Standard lines of furniture and accessories; methods of selection; theory and application in designing components; furniture, accessories and architectural graphics. Prerequisite: Approval of instructor.

663. Interior Space Design I. (2-4). Credit 3. Theory and application of interior architectural programming and design processes using small scale interior architectural projects as case studies. Design as a synthesis of human perception, user's background of behavior, sociological makeup, design tools and systematic predictions. Prerequisite: Approval of instructor.

665. Interior Space Design II. (2-12). Credit 6. Professional solutions to interior architectural problems on a broad scale; feasibility studies, cost estimating, design execution, specifications and construction documents. Prerequisite: Arch. 663 or equivalent.

666. Interior Space Design III. (2-12). Credit 6. Interior architect's role as consultant. Projects require collaboration in team projects and with other design professionals, to simulate professional practice situation. Prerequisite: Arch. 665 or equivalent.

667. Development Feasibility and Design. (3-4). Credit 5. Selected residential and nonresidential development projects of varying size analyzed by student teams with respect to economic feasibility and cash flow; site analysis; and design concept. Interdisciplinary faculty team. Prerequisite: Approval of department head. Cross-listed with Land. 667 and Plan. 667

670. Architecture for Health Care Facilities. (3-0). Credit 3. The health care facility as related to medical care organization and the health care delivery system. Prerequisite: Approval of instructor.

671. Health Facility Programming and Design. (3-0). Credit 3. Designed to give architects and planners the insight, background, and technical knowledge for rational decision-making in health facilities programming and design. Emerging concepts and developmental systems in problem solution and review of research findings. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. Discussion and review of current practice in architecture and environmental design.

684. Professional Internship. Credit 1 to 8. Professional practice under approved arrangement with public or private agencies or in residence to complement academic course work and to provide the basis for, and allow the preparation of, an appropriate report. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 6. Individual problems involving application of theory and practice in design and construction of buildings and groups of buildings. Prerequisite: Approval of instructor and department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in architecture and environmental design. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for and preparation of dissertation for Option A of the D.E.D. degree in architecture.

692. Professional Study. Credit 1 or more each semester. Approved professional study or project undertaken as the terminal requirement for the master of architecture or doctor of environmental design degrees. Preparation of a record of study (required for D.E.D. degree only) summarizing the rationale, procedure and results of the complete project. Prerequisite: Approval of committee chairman.

DEPARTMENT OF BIOCHEMISTRY AND BIOPHYSICS

E. Ashworth-Tsutsui, T. O. Baldwin, G. W. Bates, N. R. Bottino, C. R. Creger, J. M. Gunn*, A. R. Hanks, E. D. Harris, G. M. Ihler, H. O. Kunkel, W. A. Landmann, R. W. Lewis, J. M. Magill, E. F. Meyer, J. Nagyvary, R. D. Neff, J. L. Nordstrom, G. A. O'Donovan, C. N. Pace, J. M. Prescott, H. A. Röller, E. G. Sander (Head), J. R. Wild, R. D. Wood

*Graduate Advisor

The Department of Biochemistry and Biophysics offers programs of study and research leading to the M.S. and Ph.D. degrees in biochemistry and the M.S. degree in biophysics. These programs are designed to provide the background for a career in independent research; in addition, graduate students gain some experience in teaching, inasmuch as each is required to serve as a teaching assistant at some time during his or her graduate work. A non-thesis option for the M.S. degree is available to students not intending to enter a research career.

The department is well-equipped for conducting research at the forefront of biochemistry. Specialized items of equipment include an X-ray diffractometer and an interactive computer graphics display; a variety of spectrophotometers for study in the UV, visible and IR, including stop-flow spectrophotometers, an atomic absorption spectrophotometer, a fluorescence spectrophotometer and a spectropolarimeter; two high-resolution mass spectrometers, one equipped with Cf-plasma desorption; various liquid scintillation and gamma-ray counters; analytical and preparative ultracentrifuges; a variety of electrophetic instruments; modern high pressure liquid chromatography equipment; and fully equipped tissue culture laboratories with laminarflow hoods, CO_2-incubators, etc.

Research interests and activities, supported by modern equipment, span the broad fields of proteins, lipids, nucleic acids, intermediary metabolism, biochemical nutrition, biochemical genetics and molecular biology. More specifically, current research interests include enzymology and enzyme mechanisms, conformational stability of proteins; structure-function relationships in proteins; analysis of active sites by computer graphics; mechanisms of protein turnover and regulation of intracellular protein degradation; lipid chemistry and metabolism; structural analysis of membrane lipids; effect of normal and abnormal dietary fatty acids on composition and biosynthesis of lipids; control of serum cholesterol; biochemistry of polypeptide hormones, their physical, chemical and biological properties, and mechanism of action; the absorption, deposition, mobilization and regulation of trace mineral metabolism; evaluation of novel protein food sources; normal biochemical control mechanisms regulating intermediary metabolism, and the effects of derangements producing cancer and other metabolic disorders; and nucleotide chemistry, RNA processing, DNA sequencing and gene cloning.

Students entering graduate work in biochemistry or biophysics are required to have adequate preparation in chemistry, mathematics, physics and modern biology. The program leading to the Ph.D. degree is designed so that the student experiences extensive involvement in research. The resulting dissertation must demonstrate a superior knowledge and understanding of the subject area. In addition, the student must demonstrate a broad and commanding knowledge of general biochemistry. There is no language requirement at the M.S. level. The Ph.D. language requirement is determined by the student's Advisory Committee in order to meet individual needs related to the research program. There is, however, an English requirement for all students, including those seeking the M.S. degree, who are found to be deficient in writing skills. The department encourages interdisciplinary research projects with other departments. Detailed information about the graduate program may be obtained from the Graduate Coordinator.

BIOCHEMISTRY
(Bich.)

603. General Biochemistry I. (3-0). Credit 3. The biochemical properties of substances found in living matter. Proteins, enzymes, carbohydrates and carbohydrate metabolism. Prerequisites: Chem. 228, 316.

604. General Biochemistry II. (3-0). Credit 3. Continuation of Bich. 603. Cell respiration. Photosynthesis. The biochemical properties of lipids and nucleic acids. Lipid and nitrogen metabolism. Principles of gene action. Prerequisite: Bich. 603.

605. Biochemical Calculations and Their Applications. (1-2). Credit 2. Development of data handling skills. Laboratory exercises, demonstrations and calculation exercises. Interpretation of biochemical data. Prerequisite: Graduate classification.

607. Methods of Biochemical Analyses. (1-6). Credit 3. Laboratory investigation of proteins and the relationships between their structures and functions. Prerequisites: Bich. 410 and 411 or equivalent.

618. Chemistry and Metabolism of Lipids. (3-0). Credit 3. Lipids of biological membranes and lipoproteins. Intermediary metabolism of glycerolipids, glycolipids and steroids and its regulation. Lipidoses. Prerequisite: Bich. 604.

624. Proteins and Enzymes. (3-0). Credit 3. Chemical and physical properties of proteins and enzymes. Thermodynamics, kinetics and mechanisms of enzyme catalyzed reactions. Prerequisites: Bich. 603; Chem. 324.

630. Current Topics in Metabolism I. (2-0). Credit 2. Selected topics in metabolism and biochemical pathways. May be repeated once for credit. Prerequisites: Bich. 604 and classification of 8.

636. Metals in Biological Systems. (3-0). Credit 3. Roles of metals in life processes. Exact molecular structure and function; metals as integral part of many biomolecules and subcellular organelles and the metabolic processes mediated. Medical aspects. Prerequisite: Bich. 411 or 603.

641. Nutritional Mechanisms and Metabolic Regulation in Man. (3-0). Credit 3. Mechanisms of nutrient digestion, absorption, transport, degradation and intracellular metabolic regulation at the molecular level. Mechanisms in normal and the diseased state of the human. Prerequisites: Bich. 411 or 604.

642. The Biochemistry of Metabolic Disorders. (2-3). Credit 3. Advanced level metabolism course; perturbation of normal regulatory processes in disease states; hormone action, second messengers, carbohydrate metabolism, protein turnover, interrelationship of fat, protein and carbohydrate metabolism, cancer, atherosclerosis, diabetes, cirrhosis. Prerequisite: Bich. 604.

650. Chemistry and Metabolism of Nucleic Acids. (3-0). Credit 3. Chemical, physical and biological characteristics of nucleic acids. Prerequisite: Bich. 604.

681. Seminar. (1-0). Credit 1 each semester. Original articles in biochemistry and related fields designed to broaden understanding of problems in the field and to stimulate research.

685. Problems. Credit 1 or more each semester. Biochemical laboratory procedures; preparations and instrumentation. Problems assigned according to experience, interests and needs of individual student. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of biochemistry. May be repeated for credit. Prerequisite: Bich. 604.

690. Theory of Biochemical Research. (2-0). Credit 2. State-of-the-art examination of modern trends in various subfields of modern biochemistry concentrating on the design of experiments, evaluation of research results and discussion of the current literature. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Laboratory facilities available for original investigations in various phases of biochemistry. Prerequisite: Approval of major advisor.

See Gen. 631 for full description of related course.

BIOPHYSICS
(Biph.)

621. Interpretation of Organic Mass Spectra. (3-0). Credit 3. Mass spectra of organic compounds; biologically related structures. Basic instrumentation for low- and high-resolution mass spectrometers. Fragmentation mechanisms described for common classes of compounds. Prerequisite: Chem. 228.

622. Thermodynamics of Biochemical Equilibria. (3-0). Credit 3. Calculation of equilibrium constants for biochemical reactions. Methods of evaluating standard free energy changes for chemical reactions, standard free energies of formation of compounds, and activities of substances in solution. Prerequisite: Chem. 323.

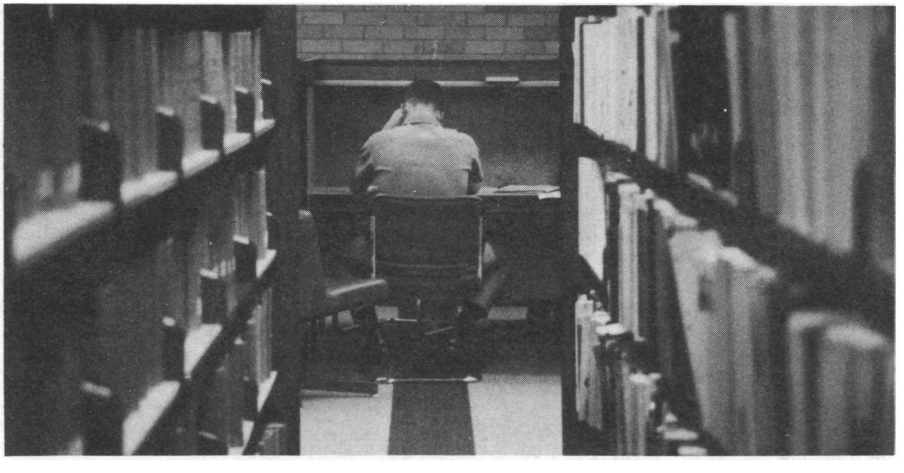
626. Radioisotopes Techniques. (2-3). Credit 3. Nature and use of radioisotopes in chemical and biophysical studies. History, general properties of nuclei, nuclear reactions, radiation, health physics and instrumentation. Prerequisites: Math. 122; Phys. 201, 202.

685. Problems. Credit 1 or more each semester. Individual problems or research not pertaining to thesis or dissertation. Prerequisites: Approval of instructor prior to registration; graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of biophysics. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis.

BIOENGINEERING
(See Industrial Engineering)



DEPARTMENT OF BIOLOGY

K. J. Aufderheide, G. Bhaskaran, V. M. Bryant, Jr., R. C. Burghardt, E. R. Cox, K. H. Dahm, N. O. Dronen, W. P. Fife, B. G. Foster, I. F. Greenbaum, D. E. Harper, J. R. Johnson, J. E. Kanz, W. M. Kemp, R. Kosinski, G. M. Krise*, D. R. Lueking, D. M. Mueller, J. M. Neff, C. L. Nessler, D. W. Owens, E. T. Park, S. M. Ray, P. J. Rizzo, H. A. Röller, H. W. Sauer (Head), G. L. Schroeter, J. R. Seed, M. H. Sweet, W. A. Taber, E. L. Thurston, C. Vanderzant, U. G. Whitehouse, H. D. Wilson

*Graduate Advisor

The Department of Biology offers graduate studies leading to the M.S. and Ph.D. degrees in biology, botany, microbiology and zoology.

Other areas of study are aquatic and marine biology; biology of algae; various phases of ecology; plant, invertebrate, and mammalian physiology; cell and molecular regulatory biology; electron microscopy; vertebrate and invertebrate endocrinology. The objective of the graduate training is to produce leaders in biological teaching and research. Biology has major applications in education, medicine, veterinary medicine, agriculture, fisheries, and environmental and wildlife management. The Department recognizes that students are individuals and strives to develop their talents through individual programs.

The Biology Department also offers cooperative research programs with other departments on campus. Graduate students in biology may do cooperative research in the areas of animal parasitology and physiology, agricultural plant sciences, wildlife management, fisheries biology, entomology, environmental engineering, oceanography, genetics, education and philosophy.

The Biology Department requires no foreign language proficiency for either the M.S. or Ph.D. degree.

(Biol.)

602. Transmission Electron Microscopy. (3-6). Credit 5. Methods of studying biological material with the transmission electron microscope; fixation; ultra-microtomy; cytochemistry; replica and shadowing; and other biological related procedures. Prerequisite: Approval of instructor received one month prior to registration.

604. Neurobiology of Psychoactive Agents. (3-0). Credit 3. Biological approach to the study of drugs that act on behavior, as well as on cognitive and emotional functions. Neuronal and biochemical bases of action. Psychopharmocological agents; ethanol, narcotics, barbiturates, psychotomimetics. Prerequisite: Approval of instructor.

605. Principles and Methods of Systematic Biology. (3-3). Credit 4. Evolutionary theory, subspecific variation, speciation, and phylogeny; evolutionary, cladistical and numerical taxonomy; methods and rules used in viral, bacteriological, botanical and zoological classification.

606. Terrestrial Ecosystems. (3-3). Credit 4. Population and community structure and function in organization of terrestrial ecosystems; the world-wide pattern of major terrestrial ecosystems. Representative ecosystems studied in the field. Prerequisite: Biol. 357 or equivalent.

607. Ethnobotany. (3-3). Credit 4. Interrelationship between plants and humans from prehistoric times to present; theoretical and methodological use of botany as a research tool for the understanding of cultural systems.

608. Phycology. (3-3). Credit 4. Morphology, systematics, ecology and physiology of fresh water and marine algae. Discussion of current literature. Laboratory stresses systematics and physiology. Three day collecting trip to the Texas coast required. Prerequisite: Biol. 408 or approval of instructor.

609. Invertebrate Pathology. (3-3). Credit 4. Cross-listed with Ento. 609. Prerequisite: One course in microbiology and Ento. 313 or equivalent; or approval of instructor.

610. Immunology. (3-4). Credit 4. Immunological reactions as related to the diagnosis of human disease. Both basic immune phenomena and practical laboratory experience. Prerequisite: Biol. 351 or equivalent.

611. Molecular Biology of the Cancer Cell. (3-0). Credit 3. Biochemical, physiological and immunological aspects of the cancer cell during neoplastic growth; mechanisms of neoplastic induction and inhibition. Prerequisite: Nine graduate credits in biological or chemical sciences.

612. Biology of Estuarine Organisms. (3-3). Credit 4. Experimental study of biological adaptations and ecological interrelationships of estuarine organisms. Prerequisite: Course in physiology or approval of instructor.

613. The Sensory Physiology of Fish Behavior. (3-0). Credit 3. Role of sensory processes and perception in animal behavior; orientation mechanisms in marine and freshwater fish and other aquatic organisms. Prerequisite: Major in biology, wildlife and fisheries sciences, or psychology or approval of instructor.

614. Palynology. (3-3). Credit 4. Principles and techniques used in palynology; pollen morphology, ontogeny, biochemistry, dispersion and preservation. Role of palynology as a research tool in plant taxonomy, agriculture, medicine, paleobotany and anthropology. Prerequisite: Graduate classification in a biological or related science.

615. Cytology. (3-3). Credit 4. Structure and ultrastructure of cells; relationship between structure and function at cellular and sub-cellular levels; structural and ultrastructural aspects of cell division. Prerequisite: Graduate classification in biology or related science.

617. Ultrastructure of Microorganisms. (3-0). Credit 3. Structure and function in prokaryotic and eukaryotic microorganisms discussed on a comparative basis to seek out origins and possible evolutionary histories of complex cells and their parts. Prerequisite: Graduate classification in a biological or related science.

619. Plant Biosystematics. (3-3). Credit 4. Experimental and analytical approaches to plant variation and evolution; breeding systems, cytogenetics, hybridization and phylogeny. Prerequisite: Biol. 201 or equivalent or approval of instructor.

620. Field Systematic Botany. (2-6). Credit 4. Basic principles and concepts of seed plant systematics; procedures of identification, family recognition, terminology, nomenclature, herbarium techniques, systems of classification and the taxonomic literature. Prerequisite: Biol. 201 or equivalent or approval of instructor.

623. Plant Morphology. (2-6). Credit 4. Anatomical, reproductive, ontogenetic and phylogenetic features of vascular plants representing major plant taxa. Prerequisite: Biol. 327 or equivalent.

625. Bryology. (3-3). Credit 4. Morphology, systematics and ecology; field studies of mosses, liverworts and hornworts. Offered in alternate years. Prerequisite: Approval of instructor.

626. Lichenology. (3-3). Credit 4. Taxonomy, morphology, and ecology of lichenized fungi with laboratory emphasis on identification of the local species. Symbiosis, air pollution and lichens, chemosystematics, and modern herbarium techniques for lichens and other cryptogams. Prerequisite: Approval of instructor.

627. Helminthology. (3-3). Credit 4. Parasitic worms, especially Trematoda, Cestoda, Nematoda and Acanthocephala. Prerequisite: Biol. 436 or approval of instructor.

628. Scanning Electron Microscopy. (3-6). Credit 5. Principles and techniques of scanning electron microscopy. Prerequisite: Approval of instructor one month prior to registration.

630. Protozoology. (3-3). Credit 4. Morphology, taxonomy, physiology, reproduction, phylogeny, ecology and life history of protozoa. Prerequisite: Six hours of biology or approval of instructor.

635. Physiology of Microorganisms. (3-0). Credit 3. Physiological activities of bacteria; metabolism, regulatory mechanisms, cell composition and use of 14C-substrates in physiology. Prerequisite: Bich. 410 or 412.

637. Marine Botany. (2-6). Credit 4. Systematics, morphology, ecology and economics of marine macroalgae, microalgae and sea grasses. Gulf of Mexico and especially the Texas coast. Both laboratory and field work required. Prerequisite: Graduate classification in biology or related science.

640. Neurobiology. (3-3). Credit 4. Neurobiological information ranging from single cell function to the physiology of behavior. Experiments include use of common electrophysiological instruments. Prerequisite: Biol. 434 or approval of instructor.

647. Methods in Industrial Microbiology. (2-6). Credit 4. Bioassays of antibiotics, amino acids and vitamins; statistical design and analyses of dose-response assays. Fermentative production of overflow and secondary metabolites using stirred fermentors, and isolation of products. Screening oil isolates for capacity to degrade radioactively-labeled molecules and to produce antibiotics. BOD and bacterial analyses of wastewaters. Prerequisite: Bich. 410 or 412.

649. Comparative Endocrinology. (3-3). Credit 4. Function of endocrine glands and hormonal regulatory systems in different animal groups, vertebrates and invertebrates. Mechanisms of action of hormones at the cellular, subcellular and molecular level. Recent experimental advances in endocrinological research. Isolation, purification and assay of certain hormones and of enzymes involved in hormone metabolism. Prerequisites: Course in physiology, Bich. 410 or equivalent; approval of instructor.

651. Mycology. (2-6). Credit 4. Fungi; life cycles of representative forms; genetics and cytology; taxonomy; ecology. Prerequisite: Biol. 353 or approval of instructor.

652. Human Physiological Response. (3-0). Credit 3. Function of human body in response to physical exertion and environmental stress. Systems of the body which are most affected by heavy exercise or man-made environment. Classroom demonstrations. Prerequisite: Biol. 220 or 388 or 470 or approval of instructor.

653. Zoogeography. (3-0). Credit 3. Evolutionary, geological and ecological interpretations of the present and past distributions of terrestrial, freshwater and marine organisms.

657. Ecology of Host-Parasite Populations. (3-3). Credit 4. Host-parasite population dynamics; impact of environmental factors on parasite populations, and the parasite's impact on the ecosystem. Prerequisite: Approval of instructor.

660. Aquatic Ecology. (3-3). Credit 4. Primary and secondary productivity in lakes and streams; controlling factors, sampling and data analysis methodology. Introduction to the construction and interpretation of computer models of aquatic systems. Previous modeling experience is unnecessary.

662. Biology of the Mollusca. (3-3). Credit 4. Survey of the phylum mollusca. Prerequisite: Graduate classification in biology or related fields or approval of instructor.

663. Biology of the Crustacea. (3-3). Credit 4. Classification, life history, morphology, physiology, ecology, diseases, parasites and predators of crustaceans. Economic aspects of crustaceans. Original literature emphasized. Prerequisites: Biol. 435 or equivalent; graduate classification or approval of instructor.

665. Biology of Invertebrates. (3-3). Credit 4. Morphology, biology and phylogeny of invertebrates. Topics may be either detailed discussions of specific organisms or comparative information on a process. Prerequisite: Biol. 435 or equivalent.

666. Aerospace-Hydrospace Physiology. (3-0). Credit 3. Physiological systems most affected by changes experienced by the body both in aerospace and underwater existence. Overcoming physical hazards such as decompression, heat loss, fire, explosion. Methods of overcoming physiological limitation and requirements of life support systems. Prerequisite: Approval of instructor.

667. Physiology of Host-Parasite Systems. (3-0). Credit 3. Physiology and biochemistry of parasites, environmental conditions under which parasites are living and integration of the host into functional host-parasite complex. Prerequisite: Courses in physiology or biochemistry and immunology or approval of instructor.

668. Biology of Animal Symbioses. (3-0). Credit 3. Physiology, ecological relations and populations significance of various types of symbiotic associations; parasitism and mutualism. Prerequisite: Biol. 667 or approval of instructor.

681. Seminar. (1-0). Credit 1. Detailed reports on specific topics in field chosen. Prerequisite: Graduate classification in appropriate field.

685. Problems. Credit 1 to 6 each semester. Limited investigations in fields other than those chosen for thesis or dissertation.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of biology. May be repeated once for credit.

690. Theory of Biological Research. (3-0). Credit 3. Design of research experiments in various subfields of biology and the evaluation of research results with the aid of examples taken from the current scientific literature. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Prerequisite: Approval of ranking professor in field chosen.

DEPARTMENT OF BUILDING CONSTRUCTION

W. L. Buckingham, C. D. Claycamp (Head), J. W. Craig, Jr., C. M. Hix, Jr., R. P. Maher, J. H. Marsh III, A. Pedulla*, F. J. Trost

*Graduate Advisor

The Department of Building Construction offers graduate studies leading to the master of science degree and provides support for students enrolled in any of the emphasis areas in the master of architecture program as well as elective support for students in many other advanced degree programs.

(B.C.)

617. Building Construction Practices I. (3-0). Credit 3. Innovative building construction methods.

618. Building Construction Practices II. (3-0). Credit 3. Construction problems relating to building foundations and concrete structural frames. Prerequisite: B.C. 427 or equivalent.

619. Building Construction Practices III. (3-0). Credit 3. Cost estimating process (conceptual and definitive); cost analysis methods; bidding and construction contract procedures; case studies of subcontractor bidding practices; computer applications in estimating and cost analysis; compiling bidding data based on past labor productivity rates.

620. Building Construction Practices IV. (3-0). Credit 3. Theory and case studies relative to management of construction operations with special reference to business practices employed by construction firms.

621. Construction Scheduling. (3-0). Credit 3. Types of construction schedules; case studies of critical path schedules and allocation of resource needs for multi-story and multi-building commercial projects. Prerequisites: B. C. 619 and C. E. 641 or approval of instructor.

628. Applications of Construction Law. (3-0). Credit 3. Analysis of construction law and the construction process; legal problems in the bidding process and in the performance of the contract. Prerequisite: B. C. 479 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. Discussion and review of current practice in building construction.

685. Problems. Credit 1 to 6. Individual problems in the area of building construction involving the application of theory and practice. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified field of construction management. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis.

BUSINESS ADMINISTRATION

(B.A.)

620. Business Communication. (1-0). Credit 1. Techniques for effective use of oral and written communication in business. Written elements and applications; purposes, preparation sequences and delivery skills of oral presentations. Cross-listed with Engl. 620. Prerequisite: Approval of instructor.

DEPARTMENT OF BUSINESS ANALYSIS AND RESEARCH

T. F. Anthony*, F. P. Buffa**, J. J. Dinkel (Head), W. Ferguson, G. C. Fowler, W. L. Fuerst, N. Gaither, L. W. Glorfeld, R. G. McLeod, Jr., W. Rose, M. J. Tretter

*Doctoral Student Advisor
**Master's Student Advisor

The Department of Business Analysis and Research offers graduate studies leading to M.S. and Ph.D. degrees and course work supporting the College of Business Administration's M.B.A. degree. These programs provide training for students interested in business computing science, operations and logistics management, and quantitative analysis.

The M.B.A. degree program consists of 48 credit hours of which 12 credit hours may be concentrated in the department. Areas of course work include business computing science, operations and logistics management and management science.

The M.S. degree program is designed to provide specialization in business computing science. The Ph.D. program emphasizes course work in management information systems, operations and logistics management and management science.

Additional information, including specific departmental requirements, may be obtained by contacting the department or the office of the dean, College of Business Administration.

(B.Ana.)

617. Automated Business Systems. (2-0). Credit 2. Business data processing; concepts of why and how the business community uses computing techniques. Selected business applications.

618. Assembly and COBOL Languages for Business Systems. (3-0). Credit 3. Internal functions and internal data representations of a digital computer presented through the medium of assembly language. Functions and representations used to illustrate the interaction of major software components and several advanced features of the COBOL programming language. Prerequisite: B.Ana. 337 or equivalent or approval of instructor.

620. Systems Analysis for Business Data Processing. (3-0). Credit 3. Concepts of planning, developing, implementing and operating major business data processing systems. Prerequisite: B.Ana. 617 or equivalent.

622. Corporate Information Planning. (3-0). Credit 3. Design and use of computer-based management information and decision support systems. Combinations of computing equipment and design concepts evaluated to meet managers' information needs. Prerequisite: B.Ana. 617 or equivalent.

646. Business Trends, Fluctuation, and Measurements. (2-0). Credit 2. Business trends and economic fluctuations; theory, causes and control of cyclical behavior; analytical forecasting. Basic business statistical techniques and applications. Prerequisite: Math. 230 or equivalent or approval of instructor.

656. Operations Management. (2-0). Credit 2. Theory and applications of designing, analyzing, and controlling productive systems in the allocation and use of productive resources to produce goods and services. Prerequisites: B.Ana. 646 and 666 or equivalents; graduate classification in business administration.

666. Quantitative Analysis for Business Decisions. (2-0). Credit 2. Formulation and structuring of business problems using selected quantitative techniques. Investigation of prior research and formulation of specific problems. Prerequisite: B.Ana. 646 or equivalent or approval of instructor.

668. Business Computer Models and Simulation. (3-0). Credit 3. Design and implementation of computerized decision models in the business organizational setting. Prerequisites: A computer language; B.Ana. 666.

670. Distribution Management (3-0). Credit 3. Management of physical distribution systems, the activities of planning, implementing and controlling flows of materials from supplier through production or operations to consumer. Economic trade-offs involved in decisions regarding the transportation and storage of materials and the counterflow of information. Prerequisite: Approval of instructor.

671. Distribution Analysis. (3-0). Credit 3. Integration of physical distribution decisions to facilitate product and information flows. Development of analytical skills and the application of quantitative techniques for planning and controlling physical distribution operations. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. Critical examination of subject matter presented in current periodicals, recent monographs and bulletins in field of quantitative methods applied to business.

684. Professional Internship. Credit 1 to 6. A directed internship in an organization to provide students with on-the-job training with professionals in organizational settings appropriate to the student's professional objectives. Prerequisite: Approval of committee chairman and department head.

685. Problems. Credit 1 to 3 each semester. Directed study on selected problems using recent developments in business research methods. Prerequisite: Approval of instructor.

688. Doctoral Seminar. (3-0). Credit 3. Historical development of the conceptual framework of business analysis; evaluation of current research and controversial issues in quantitative methods, business data processing and physical distribution management. For doctoral students only. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in identified area of business analysis. May be repeated for credit.

690. Theory of Research in Business Analysis. (3-0). Credit 3. Design of research in various subfields of business analysis and the evaluation of research results using examples from the current research literature. Prerequisite: Graduate classification in business analysis.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF CHEMICAL ENGINEERING

A. Akgerman, R. G. Anthony, J. A. Bullin, R. Darby, R. R. Davison, L. D. Durbin, P. T. Eubank, K. R. Hall, D. T. Hanson, W. B. Harris, C. D. Holland (Head), J. C. Holste*, A. D. Messina*, G. B. Tatterson, A. T. Watson, R. E. White

*Graduate Advisor

The Department of Chemical Engineering offers three graduate degrees: master of science, master of engineering (non-research) and doctor of philosophy. Also, the department offers courses and faculty supervision for students pursuing the doctor of engineering degree. A special program for B.S. degree holders in science seeking a master's degree in chemical engineering is available.

The graduate program in chemical engineering provides students with well-rounded training in the fundamentals and research methods of the field. Core courses are Ch.E. 606, 608, 612, 623, 624, 629, 631 and 640. A minimum of four core courses form a partial requirement for the M.S. degree, five for the M.Eng. degree and all eight for the Ph.D. degree. A three-hour course in technical writing is required for the Ph.D. degree as a language option.

Research is an integral part of the work leading to an advanced degree. Some areas of specialization are rheology, thermodynamics, cryogenics, polymer kinetics, distillation, electrochemistry, phase equilibria, extraction, process control, transport phenomena, economics, environmental research, tertiary oil recovery, heat transfer, lignite liquefaction and gasification, catalysis, mixing phenomena, mathematical models, methanol fuel, and solar energy. Modern equipment is available in numerous

laboratories designed for one of the above specialties. Digital and analog computers of medium size are also available within the department in addition to the major facilities of the Data Processing Center.

Further details about programs, faculty, facilities and financial aid are contained in an annual poster and descriptive brochure available by writing to the graduate advisor in the department.

(Ch.E.)

606. Unit Operations. (3-0). Credit 3. Applications of chemical engineering fundamentals in manufacture of chemicals, refining petroleum and other allied industries. Prerequisite: Ch.E. 424.

608. Heat Transmission. (3-0). Credit 3. Theoretical principles of conduction, radiation and forced convection; steady and unsteady state conduction problems with chemical reactions and phase changes. Boundary layer theory is stressed in connection with forced convection problems. Prerequisite: Ch.E. 323.

612. Distillation. (3-0). Credit 3. Process design calculations involving distillation of multicomponent and complex systems. Extractive and azeotropic distillation. Prerequisites: Ch.E. 409, 424.

613. Unsteady State Processes. (3-0). Credit 3. Formulation of exact models for, and solution of, corresponding equations for problems involving process equipment such as distillation columns, packed columns, evaporators and adsorption columns at unsteady state operation. Prerequisites: Ch.E. 606, 612.

619. Corrosion and Materials of Construction. (3-0). Credit 3. Fundamentals of corrosion and corrosion control. Electrochemical theory of corrosion processes, mixed potentials and corrosion rates. Corrosion resistance of metals and alloys, measurement of corrosion rates, anodic and cathodic control, and coatings. Prerequisites: Chem. 324; Ch.E. 354.

623. Applications of Thermodynamics to Chemical Engineering. (3-0). Credit 3. Application of thermodynamics to chemical engineering operations and processes. Prerequisite: Ch.E. 354.

624. Chemical Engineering Kinetics I. (3-0). Credit 3. Rates and mechanisms of chemical reactions. Thermal and catalytic reactions both homogeneous and heterogeneous. Prerequisite: Ch.E. 464.

629. Transport Phenomena. (3-0). Credit 3. Principles of transfer of momentum, energy and mass studied by application to advanced chemical engineering problems. Theoretical analogy of these three modes of transfer. Prerequisite: Ch.E. 424 or approval of instructor.

631. Process Dynamics I. (3-0). Credit 3. Dynamics, simulation and control of linear models of fluid, thermal and mass transfer processes for chemical industries by means of transient and frequency response analysis and design methods. Prerequisites: Ch.E. 461; Math. 601; or registration therein.

633. Theory of Mixtures. (3-0). Credit 3. Basic relations of statistical thermodynamics, intermolecular forces, liquid state, theory of mixtures, critical state, theory of conformal solutions, orientational effects, theorem of corresponding states, and applications to distillation and extraction. Prerequisite: Ch.E. 623 or Chem. 611.

640. Rheology. (3-0). Credit 3. Principles of stress, deformation and flow; vector and tensor equations of fluid mechanics. Behavior of Newtonian, non-Newtonian and viscoelastic fluids. Prerequisite: Math. 601.

650. Electrochemical Processes. (3-0). Credit 3. Fundamentals of reversible and irreversible electrode processes; energy conversion and electrochemical reactor design. Interaction between mass transport and kinetic mechanisms, industrial applications and corrosion. Prerequisite: Ch.E. 424 or approval of instructor.

651. Biochemical Engineering. (3-0). Credit 3. Integration of principles of engineering, biochemistry and microbiology; application to the design, development and improvement of industrial processes that employ biological materials. Engineering discipline directed toward creative application of interdisciplinary information to the economic processing of biological and related materials. Prerequisite: Approval of instructors. Cross-listed with Ag.En. 651 and B.E. 651.

652. Enzyme Engineering. (3-0). Credit 3. Application of basic principles of life science and engineering technology; large scale unit operations involved in production, isolation, immobilization and economical use of enzymes, and optimization of enzyme reactor systems. Application of enzymes in pharmaceutical, food and fine chemicals industries as well as medical and clinical application. Prerequisite: Approval of instructors. Cross-listed with Ag.En. 652.

681. Seminar. (1-0). Credit 1. Graduate students will be required to attend discussions covering problems of current importance in chemical engineering research.

685. Problems. Credit 1 to 6. One or more of numerous problems in chemical engineering processes and operations. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified areas of chemical engineering. May be repeated for credit. Prerequisites: Approval of department head and instructor.

691. Research. Credit 1 or more each semester. Problems of unit operations and unit processes. For maximum credit, comprehensive thesis must be prepared of sufficiently high calibre to permit publication in scientific and technical journals. Prerequisite: Approval of department head.

(The chemical engineering courses in mechanics and materials such as continuum mechanics, mechanics and rheology of non-Newtonian and viscoelastic fluids, materials science, etc. are listed under Mechanics and Materials within the section entitled Interdisciplinary Engineering.)

DEPARTMENT OF CHEMISTRY

E. T. Adams, G. J. Bastiaans, D. E. Bergbreiter, J. W. Bevan, J. O'M. Bockris, S. K. Chung, A. Clearfield, D. M. Collins, D. C. Conway, F. A. Cotton, G. M. Crippen, K. H. Dahm, D. J. Darensbourg, M. Y. Darensbourg, C. S. Giam, K. A. Gingerich, M. B. Hall, K. E. Harding, E. E. Hazen*, R. M. Hedges, C. A. Hoeve, J. L Hogg, K. J. Irgolic, J. Laane, S. L. Lee, J. H. Lunsford, R. D. Macfarlane, A. E. Martell, E. A. Meyers, J. B. Natowitz (Interim Head), M. E. Newcomb, D. H. O'Brien, M. L. Peck, F. M. Raushel, A. S. Rodgers, M. P. Rosynek, M. W. Rowe, D. H. Russell, R. P. Schmitt, E. A. Schweikert, A. I. Scott, B. L. Shapiro, F. Sicilio, Y. N. Tang, I. M. Warner, R. L. Watson, D. L. Yeager, V. Y. Young, R. A. Zingaro, B. J. Zwolinski

*Graduate Advisor

Graduate work in chemistry is offered at both the master's and doctoral levels. The program leading to the master's degree is designed to provide the student with a strong fundamental knowledge and understanding in the major areas of chemistry. In addition, a thesis is required which affords the student an opportunity to actively participate in experimental or theoretical research.

The program leading to the Ph.D. degree is designed so that the student experiences extensive involvement in research. The dissertation which results from this research must satisfactorily demonstrate that the student is capable of independent and creative research in a specialized area of chemistry and has a superior knowledge and understanding of the area in which research activities were performed. In addition, the student must demonstrate that he or she has a broad and commanding knowledge of the subject matter in the general field of chemistry. The Department of Chemistry requires that each student participate in the teaching program of the department for either two or four semesters as part of the M.S. or Ph.D. degree requirement. There is no language requirement at the M.S. level; the Ph.D. language requirement is determined by the student's advisory committee in order to meet individual needs related to research.

Opportunities for research are available to graduate students in the basic subfields of chemistry and in a variety of significant and relevant specialized areas. Faculty members are conducting continuing research programs and provide students with opportunities to make significant research contributions in modern physical, organic, inorganic, analytical and biological chemistry. There is also considerable departmental research activity in various interdisciplinary areas such as nuclear chemistry, theoretical chemistry, x-ray crystallography, electrochemistry, biophysical, bioorganic and bioinorganic chemistry. Six nuclear-related faculty, including three members of the Cyclotron Institute, provide one of the best graduate nuclear chemistry research programs available in this country. The department also offers strong research programs in heterogeneous and homogeneous catalysis, analytical instrumentation, coordination chemistry, high temperature chemistry, organic and physical photochemistry and organometallic chemistry. Highly relevant research problems are available in pollution control and environmental chemistry.

Major scientific equipment required for modern chemical research is available in the department for the use of graduate students, including x-ray diffractometers; nmr, epr and photoelectron spectrometers; mass spectrometers; and infrared, ultraviolet, optical rotatory and circular dichroism spectrophotometers. Two new buildings bring the total space available for the work of the department to over 200,000 sq. ft. For further details about programs, faculty, facilities and financial aid, write to J. B. Natowitz, head of the Department of Chemistry, for a descriptive brochure.

(Chem.)

601. Analytical Chemistry I. (3-0). Credit 3. Classical analytical chemistry: complex chemical equilibria, wet chemical methods of analysis, and an introduction to electrochemical methods. Prerequisite: Chem. 317 or 620 or approval of instructor.

602. Analytical Chemistry II. (3-0). Credit 3. Modern analytical techniques: electrochemical, spectroscopic, chromatographic, thermal and trace methods of analysis. Prerequisite: Chem. 601.

606. Principles of Organic Chemistry. (3-0). Credit 3. General principles of organic chemistry and selected applications to other disciplines. Prerequisite: Chem. 228 or equivalent.

609. Theory of Organic Chemistry. (3-0). Credit 3. Detailed and advanced coverage of the basic principles of physical organic chemistry; applications of molecular orbital theory, solution kinetics, and determination of reaction mechanism. Prerequisite: Chem. 646.

610. Organic Reactions. (3-0). Credit 3. Continuation of Chem. 646. Introduction to mechanisms and scope of the basic organic reaction types as applied to major functional groups. Prerequisite: Chem. 646.

611. Principles of Physical Chemistry. (3-0). Credit 3. General principles of chemistry from quantitative standpoint; thermodynamics and kinetics. Prerequisite: Graduate classification.

615. Organic Synthesis. (3-0). Credit 3. Application of organic reactions to synthesis of complex organic molecules. Synthesis design and methodology, scope and limitations of reactions, and experimental design. Prerequisite: Chem. 610.

617. Applications of Instrumental Methods of Analysis. (0-3). Credit 1. Advanced laboratory problems in instrumental methods of analysis. Prerequisite: Chem. 602 or registration therein or approval of instructor.

619. Analytical Spectroscopy. (3-0). Credit 3. Modern analytical spectroscopic techniques. U.V., visible spectroscopy, atomic absorption, emission spectrometry, flame emission, fluorometry, x-ray methods and other new developments in analytical spectroscopy. Prerequisite: Chem. 620 or approval of instructor.

620. Principles of Chemical Analysis. (3-0). Credit 3. Equilibria, including non-aqueous equilibria; the theoretical and practical aspects of modern instrumental methods of analyses. Prerequisite: Graduate classification in chemistry or approval of instructor.

621. Chemical Kinetics. (3-0). Credit 3. Present theories about chemical reaction rates and mechanisms. Prerequisite: Chem. 324.

622. Adsorption Phenomena and Heterogeneous Catalysis. (3-0). Credit 3. Chemistry of the gas-solid interface; energetics, isotherms and rates of gas adsorption on solid surfaces; experimental methods of studying solid surfaces and adsorption phenomena; kinetics and mechanisms of selected heterogeneous catalytic reactions.

624. Physical-Organic Chemistry. (3-0). Credit 3. Mathematical and quantitative investigation of organic chemical phenomena. Prerequisite: Chem. 609 or approval of instructor.

626. Thermodynamics. (3-0). Credit 3. Theory and applications of classical thermodynamic functions. Prerequisite: Chem. 324.

627. Diffraction Methods. (3-0). Credit 3. Diffraction methods for determination of molecular structure. Results of diffraction of X-rays by crystals and other related methods. Prerequisites: Chem. 324; Math. 601 or equivalent; approval of instructor.

629. Chemistry of the Regular Elements. (3-0). Credit 3. Chemistry of the elements of subgroup A of the periodic table and the noble gases. Prerequisite: Chem. 641.

631. Statistical Thermodynamics. (3-0). Credit 3. Methods of statistical mechanics based primarily on Boltzmann statistics. Approach to thermodynamics through partition function. Statistical concept of entropy. Prerequisite: Chem. 626.

633. Principles of Inorganic Chemistry. (3-0). Credit 3. General principles of inorganic chemistry treated with a view to applications in other sub-fields of chemistry. Prerequisite: Graduate classification in chemistry or approval of instructor.

634. Physical Methods in Inorganic Chemistry. (3-0). Credit 3. Determination of the molecular structure of inorganic and organometallic species; modern aspects of diffraction, magnetic resonance and vibrational methods. Prerequisite: Chem. 641 or 673.

635. Heterocyclic Compounds. (3-0). Credit 3. Structure, preparation and properties of heterocyclic compounds with special emphasis on those with biological activity. Prerequisite: Chem. 228.

637. Electroanalytical Chemistry. (3-0). Credit 3. Modern electroanalytical methods including potentiostatic, galvanostatic, sweep and periodic techniques. Prerequisite: Chem. 620 or approval of instructor.

638. Chemical Instrumentation. (2-3). Credit 3. The measurement process in chemical experimentation, review of analog and digital electronics, detector mechanisms, signal transfer and enhancement, automated control and computer interfacing techniques. Laboratory work emphasizes electronics and instrument design. Prerequisite: Approval of instructor.

640. Transition Metal Chemistry. (3-0). Credit 3. Chemistry of the subgroup B elements of the periodic table; lanthanides and actinides. Coordination compounds. Prerequisite: Chem 641.

641. Structural Inorganic Chemistry. (3-0). Credit 3. Introduction to chemical bonding; inonic, covalent, coordinate and hydrogen bonding; relationship of molecular orbital and ligand field theories to experimental studies of the electronic structure of inorganic molecules. Prerequisites: Chem. 633, 673.

642. Homogeneous Catalysis. (3-0). Credit 3. Chemistry of metal complexes pertaining to catalysis; homogeneous active sites including chemical kinetics and energetic aspects; elementary processes for general and radical interactions; mechanisms of electron transfer and oxidation-reduction reactions, group transfer reactions, hydrogenations, carbonylation, polymerizations, etc. Prerequisites: Chem. 640, 641, 645.

645. Organometallic Chemistry of Transition Metals. (3-0). Credit 3. Nomenclature, classification, nature of the bond, implications of the significant physical properties, structure, structure determination, reactions and catalysis of organotransition metal compounds. Prerequisites: Chem. 641, 646.

646. Organic Chemistry. (3-0). Credit 3. A detailed introduction to the theory and principles of organic chemistry; bonding and structure in organic chemistry, stereochemistry, reactive intermediates in organic chemistry, and transition state theory; kinetics and thermodynamic approaches. Prerequisite: Approval of instructor.

647. Spectra of Organic Compounds. (3-0). Credit 3. Correlations of molecular structure with spectroscopic and other physical properties. Applications to modern problems in organic chemistry. Prerequisite: Chem. 646 or approval of instructor.

648. Principles of Quantum Mechanics. (3-0). Credit 3. Classical mechanics and development of wave mechanics. Application of wave mechanics to special chemical problems. Prerequisite: Approval of instructor.

649. Molecular Quantum Mechanics. (3-0). Credit 3. Continuation of Chem. 648. Introduction to group theoretical methods and applications in molecular quantum mechanics and elements of ligand field theory. Prerequisite: Chem. 648.

650. Molecular Spectra and Structure. (3-0). Credit 3. Introduction to molecular spectroscopy and its relations to structure, theoretical treatments, quantum and wave mechanics, vibrations and normal coordinates, molecular symmetry and group theory. Prerequisite: Qualifying graduate students in chemistry and physics or approval of instructor.

651. Recent Topics in Physical Chemistry. (2-0). Credit 2. Recent advances in such areas as surface chemistry and catalysis, properties of high molecular weight polymers and their solutions, photochemistry and theories of liquids and solutions. Prerequisites: Chem. 324 or equivalent; approval of instructor. The course may be taken for credit twice.

652. Recent Topics in Analytical Chemistry. (2-0). Credit 2. Recent advances and special methods in field of analytical chemistry. Methods discussed in terms of basic theory, particular advantages, limitations and required instrumentation. Prerequisite: Chem. 620. The course may be taken for credit twice.

653. Recent Topics in Organic Chemistry. (2-0). Credit 2. Special topics of current interest in organic chemistry which are not normally covered in sufficient depth in other courses. Most subjects will be taken from recent or current chemical literature. Prerequisite: Chem. 646 or approval of instructor. The course may be taken for credit twice.

654. Recent Topics in Inorganic Chemistry. (2-0). Credit 2. Topics such as boron hydrides, crystal field theory, inorganic reaction mechanisms, organometallic chemistry and nuclear chemistry. Prerequisite: Chem. 641. The course may be taken for credit twice.

655. Polymer Science I. (3-0). Credit 3. Synthesis of polymers by condensation, addition and other types of polymerization. Solution methods of characterization. Solid state properties and their structural basis.

656. Polymer Science II. (3-0). Credit 3. Selected topics in polymer synthesis, solution and solid state properties. Prerequisite: Chem. 655.

657. Magnetic Resonance Spectroscopy. (3-0). Credit 3. Magnetic resonance and electron paramagnetic, nuclear magnetic, and nuclear quadrupole magnetic resonance spectroscopies. Application to elucidation of molecular structure. Prerequisites: Chem. 648 and/or approval of instructor.

658. Theoretical Nuclear Chemistry. (3-0). Credit 3. Phenomenology and theory of selected topics in current literature of nuclear chemistry; e.g., collective model, compound nuclear reactions and fission. Prerequisite: Chem. 648 or approval of instructor.

660. Nuclear Chemistry. (3-3). Credit 4. Radioactive decay, nuclear models, nuclear spectroscopy, nuclear reactions, fission and other topics of current interest in nuclear chemical research. Laboratory work to emphasize modern nuclear chemical instrumentation. Prerequisite: Chem. 464 or approval of instructor.

663. X-Ray Absorption and Emission in Analysis. (3-0). Credit 3. Fundamental knowledge of x-rays as applied to chemistry. Use of x-ray absorption, emission and diffraction in chemical analysis and control. Prerequisite: Approval of instructor.

664. Organometallic Chemistry of the Main Group Elements. (3-0). Credit 3. Synthesis, reactivities, structures and applications of organometallic compounds of the main group elements. Correlation between physical and chemical properties of organometallic compounds and position of the central metal atom in the periodic system. Prerequisites: Chem. 641, 646.

665. Biophysical Chemistry. (3-0). Credit 3. The physical chemistry of macromolecules of biological importance. Methods applicable to solids and solutions, such as x-ray diffraction and scattering, osmometry, sedimentation equilibrium, electrophoresis and other thermodynamic and transport methods. Prerequisite: Chem. 324.

666. Nuclear Geochemistry. (3-0). Credit 3. Application of nuclear, chemical and physical principles for a better understanding of the origin of the solar system and the conditions acting upon it. Prerequisite: Bachelor's degree in science (chemistry, physics, geology, engineering, oceanography, etc.).

670. Chemistry of Proteins. (3-0). Credit 3. Chemical synthesis and degradation of proteins, chemical modification of proteins, primarily specific reactions with affinity labeling reagents. Applications of chemical modification. Prerequisites: Bich. 603, Chem. 646 or approval of instructor.

672. Bioorganic Reaction Mechanisms. (3-0). Credit 3. Proposed mechanisms of action of various enzymes and coenzymes from the "model systems" approach. New developments, theory and established mechanisms. Prerequisites: Bich. 624 or Chem. 670; Chem. 646.

673. Symmetry and Group Theory in Chemistry. (2-0). Credit 2. Applications of symmetry and group theory to various types of chemical systems. Classification of molecules into symmetry point groups and use of character tables. Prerequisite: B.S. or B.A. in chemistry.

677. Nuclear and Radiochemical Methods of Analysis. (3-0). Credit 3. Theory and application of nuclear interactions; radioactivity and radiation in chemical analysis. Prerequisite: Approval of instructor.

680. Frontiers in Chemical Research. (3-0). Credit 3. Present status of research in a variety of significant chemical fields. Content will depend on the availability of visiting lecturers who will be selected because of distinguished international recognition in their fields of research. May be taken twice. Prerequisite: Graduate classification.

681. Seminar. (1-0). Credit 1 each semester. Oral presentations and discussions of recent advances in chemistry.

685. Problems. Credit 1 to 6. Special topics to suit small group requirements. More recent problems and results in various branches of chemistry. Laboratory work or conference and discussion. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of chemistry. May be repeated for credit. Prerequisites: Graduate classification and approval of instructor.

690. Theory of Chemical Research. (3-0). Credit 3. The design of research experiments in various subfields of chemistry, and the evaluation of research results with the aid of examples taken from the current scientific literature. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF CIVIL ENGINEERING

CIVIL ENGINEERING: D. R. Basco, B. Batchelor, A. R. Benton, Jr., M. Biswas, J.-L. Briaud, C. E. Buth, H. M. Coyle, C. L. Dudek, W. A. Dunlap, J. A. Epps, J. E. Flipse, B. M. Gallaway, E. G. Garrison, R. W. Hann, Jr., J. B. Herbich, T. J. Hirsch, C. M. Hix, Jr., D. L. Ivey, M. E. James, Jr., W. P. James, J. K. Jeyapalan, H. L. Jones, C. J. Keese, A. H. Layman, W. B. Ledbetter, D. N. Little, Jr., Y. K. Lou, L. L. Lowery, Jr., R. L. Lytton, D. McDonald (Head), A. R. McFarland, E. L. Marquis, J. E. Martinez, D. A. Maxwell, C. J. Messer, J. M. Niedzwecki, J. S. Noel, R. M. Olson, R. E. Randall, R. O. Reid, T. D. Reynolds, E. J. Rhomberg, H. E. Ross, Jr., N. J. Rowan, C. H. Samson, Jr., D. Saylak, R. A. Schapery, R. E. Schiller, Jr., J. F. Slowey, V. G. Stover, T. C. Su, L. J. Thompson, J. T. Tielking, R. D. Turpin*, G. Venezian, Y. Weitsman, H. W. Wolf, C. E. Woods, D. L. Woods

OCEAN ENGINEERING: D. R. Basco, J. E. Flipse, J. B. Herbich (Program Head), W. P. James, Y. K. Lou, J. M. Niedzwecki, R. E. Randall, R. O. Reid, R. E. Schiller, Jr.*, T. C. Su, G. Venezian

*Graduate Advisor

CIVIL ENGINEERING
(C.E.)

A variety of courses is offered in civil engineering to permit a student to specialize in a given branch. The department is especially well equipped to offer, with support from other departments, areas of specialization in civil engineering systems; coastal and ocean engineering; construction engineering; environmental engineering; forest engineering (in cooperation with the Departments of Agricultural Engineering and Forest Science); geodesy, photogrammetry and surveying; geotechnical engineering;

hydraulic engineering and fluid mechanics; materials engineering; public works engineering; structural engineering and structural mechanics; transportation engineering; urban management; and urban planning.

No foreign language is required for the Ph.D. in civil engineering.

601. City Management. (3-0). Credit 3. Development of European and American cities, forms of city government, functions of city manager, administration of municipal affairs, organization of city departments, city finances, public utilities, fire prevention and protection, police administration, parks and playgrounds.

603. Water Quality in Lakes, Streams and Estuaries. (3-0). Credit 3. Physical, chemical, radiological and biological properties of streams, impoundments, reservoirs and estuaries, and the interrelationships of these properties; local, state, regional and federal water quality standards, legal aspects of water pollution control; quality criteria for beneficial uses of water; evaluation of critical problems. Prerequisite: Graduate classification in engineering or approval of instructor.

604. Introduction to Unit Operation Theory. (3-0). Credit 3. Introduction to the theory of various unit operations for water supply and waste water treatment; development of theoretical approaches to the design of various unit operations and criteria behind the development of the theoretical approach; fundamental principles of unit operations which are common to many systems; the evaluation of proto-type unit operations from laboratory data. Prerequisite: C.E. 402 or approval of instructor.

605. Experimental Analysis in Environmental Engineering. (1-6). Credit 3. Theory and practice of analytical methods used in the environmental engineering field. Instrumental and wet chemical techniques used in measurement of environmental quality parameters and pollutants. Prerequisite: Graduate classification in engineering or approval of instructor.

606. Design of Waste Water Treatment Systems. (1-6). Credit 3. Application of the theories of unit operations and unit processes to design waste water treatment systems for domestic and industrial wastes. Prerequisites: C.E. 603, 604 or approval of instructor.

607. Engineering Aspects of Air Quality. (3-0). Credit 3. Characterization of air contaminants. Health effects and legal aspects. Dispersion of pollutants in the atmosphere. Technology for the control of gaseous and particulate emissions. Prerequisite: C.E. 311.

608. Solid Waste Engineering. (1-6). Credit 3. Design and operation of solid waste collection and disposal systems. Review of appropriate state and federal regulations. Prerequisite: Approval of instructor.

610. Industrial Wastes. (2-3). Credit 3. Theory of industrial processes which create industrial wastes. Effect of industrial wastes on treatment processes. Process recovery units to prevent pollution and effluent waste treatment practices. Prerequisites: C.E. 603, 605, or approval of instructor.

611. Design of Potable and Industrial Water Systems. (1-6). Credit 3. Application of theories of unit operations and unit processes to the design of systems for treatment of water for domestic and industrial uses. Prerequisites: C.E. 603, 604, or approval of instructor.

612. Transportation in City Planning. (2-3). Credit 3. Influence of transportation in shaping urban form; relationships between land use and transportation; and conceptual layout of street systems. Trends in urban development; site development; circulation and relationships to the street system. Guidelines for the redevelopment of existing streets and the adjacent land. Cross-listed with Plan. 612.

613. Urban Engineering. (3-0). Credit 3. Service course for nonengineers on influence and relative importance of engineering aspects of urban development; engineering factors important in consideration of utilities, land allocation, waste disposal, drainage, public health and recreation.

614. Stabilization of Soil-Aggregate Systems. (2-0). Credit 2. Theory of mechanical and chemical stabilization of soils and soil-aggregate systems.

615. Structural Design of Pavements. (3-0). Credit 3. Characteristics of pavement loads, stress analysis in pavements, design practices, construction, rehabilitation and maintenance. Prerequisite: C.E. 307.

616. Systems Design of Pavements. (2-3). Credit 3. Optimization of the design of rigid and flexible pavement systems. Empirical and mechanistic stochastic structural subsystems. Utility theory, serviceability concept, cost studies, traffic delay, environmental deterioration, rehabilitation and maintenance optimization systems. Prerequisite: C.E. 307.

617. Traffic Engineering: Characteristics. (2-3). Credit 3. Human, vehicular and traffic characteristics as they relate to driver-vehicle-roadway operational systems. Traffic studies and methods of analysis and evaluation. Prerequisite: C.E. 457 or equivalent.

618. Traffic Engineering: Operations. (2-3). Credit 3. Advanced theory and application of traffic control. Signalization and freeway operations. Prerequisite: C.E. 457 or equivalent.

621. Advanced Reinforced Concrete Design. (3-0). Credit 3. Reinforced concrete principles; analysis of rigid building frames, design of building frames, slabs, biaxially loaded columns, rectangular and circular tanks, and deep beams. Prerequisite: C.E. 344 or equivalent.

623. Properties of Concrete. (3-0). Credit 3. Engineering properties of aggregate, cements, and concrete. Special cements, mix design, construction practices, pumping, quality control, lightweight concrete strength, curing, volume change and ready-mixed concrete. Prerequisite: Approval of instructor.

624. Environmental Effects of Transportation Systems. (2-0). Credit 2. Interaction of traffic facilities with the adjacent land uses considering fundamental driver needs as well as aesthetic values in location and design of streets and highways. Noise, air pollution, energy in transportation, roadway lighting and roadside beautification considerations.

626. Roadside Safety Design. (3-0). Credit 3. Fundamental concepts of designing safety into roadways. Safety improvement programs, accident data analysis, safety methodology, safety in cross section design, and the design of safety devices. Safety improvement programs, sideslopes and ditches, breakaway devices, crash cushions and roadside barriers.

627. Hydrology. (3-0). Credit 3. Weather and hydrology, precipitation, streamflow analysis, evaporation and transpiration, subsurface water, streamflow hydrographs, precipitation-runoff relations, streamflow routing, computer simulation of streamflow, probability studies, stochastic hydrology, sedimentation, morphology of river basins. Prerequisite: Approval of instructor.

628. Hydraulic Engineering. (2-3). Credit 3. Project course in which student teams analyze and solve hydraulic problems. Pipelines, pipe networks, storm-water collection systems, open channel flow, river modification, flood plain delineation, spillway, outlet works, energy dissipators, and water hammer. Prerequisite: Approval of instructor.

629. Hydraulics of Open Channels. (3-0). Credit 3. Application of momentum and energy principles to advanced topics in uniform, nonuniform, gradually varied and rapidly varied flow problems. Backwater flow profile computation in steady flow. The method of characteristics applied to unsteady flows. Jeffreys-Vedernikov criteria. Flood routing calculations by advanced computer methods. Prerequisite: Approval of instructor.

631. Industrial Construction. (3-0). Credit 3. Planning, project management and construction management of large industrial construction projects; planning procedures of clients for new construction; functions of project management and construction management teams; construction operations associated with power plant, process plant or other industrial construction. Prerequisite: Graduate classification in engineering or building construction.

632. Street and Highway Systems Management. (2-0). Credit 2. Street classification and function; obtaining the maximum potential from the surface street system and basic design criteria for city streets; transportation systems management of the urban system. Prerequisite: Graduation classification in engineering or urban and regional planning or approval of instructor.

633. Advanced Mechanics of Materials. (4-0). Credit 4. Stresses and strains at a point, torsion of noncircular cross sections, beams with combined axial and lateral loads, energy methods, thick walled pressure vessels, theories of failure, introduction to the theory of elasticity, theory of plates, theory of elastic stability and solution to elementary problems. Prerequisites: Aero. 306 or C.E. 306; Math. 308 or approval of instructor.

634. Airport Planning and Design. (2-2). Credit 3. Planning and design of the airfield; functional terminal configurations and adjacent area land use problems. Airport location, runway orientation, runway capacity, surface drainage, runway pavement design, terminal orientation, and ground access considerations.

635. Street and Highway Design. (3-0). Credit 3. Advanced concepts of the design of streets and highways, design criteria, controls and standards for design alignment, cross section, intersections and interchanges for urban streets and highways. Prerequisite: C.E. 456 or equivalent.

640. Heavy and Civil Works Construction. (3-0). Credit 3. Application of geotechnics, engineering design and the construction arts to the design and evaluation of systems for construction of heavy and civil works. Prerequisites: C.E. 348, 473, 488 or equivalent.

641. Construction Engineering Systems. (3-2). Credit 4. Application of systems theory to project planning and control; probabilistic network diagramming, resource allocation, statistical bidding analysis, activity planning, financial management of construction projects and project control. Prerequisites: C.E. 348, 473, 490 or approval of instructor.

642. Construction Engineering Management. (3-0). Credit 3. Construction planning, organization, coordination and direction, feasibility, contract specifications, risk, liability, quality; role of the owner, engineer and contractor; contract performance problems. Prerequisites: C.E. 348, 473, 490 or approval of instructor.

643. Plastic Analysis and Design in Steel. (3-0). Credit 3. Principles and methods that are basis for plastic analysis and design. Static and mechanism methods of analysis of structures. Influence of shear and axial forces on plastic design. Effect of lateral buckling. Design of connections to provide plastic action. Prerequisite: Graduate classification in civil engineering or approval of instructor.

644. Rock Mechanics. (3-0). Credit 3. Deformation, strength and fluid-flow properties of intact rock and rock masses with applications to underground openings, rock slopes and dam foundations and abutments. Methods of rock-mass exploration and characterization; techniques of laboratory and *in situ* field measurements in rock; theoretical analysis and model studies; design considerations and excavation methods; selected case histories. Prerequisite: Approval of instructor.

645. Scientific Methods in Urban Engineering and Management. (2-3). Credit 3. Mathematical models for managerial decision-making in the urban situation; mathematical programming and simulation and their application to a wide variety of organizational settings; techniques for solving optimization problems encountered in public works organizations. Prerequisites: C.E. 384 or equivalent; Math. 308.

646. Foundations on Expansive Soils. (3-0). Credit 3. Properties of partially saturated soils, analysis of beams and plates on foundations, slab-subgrade friction, design of slabs and drilled piers, soil improvement techniques, risk analysis and foundation rehabilitation operations. Prerequisites: C. E. 365, Math. 308 or approval of instructor.

647. Numerical Methods in Geotechnical Engineering. (2-2). Credit 3. Formulation and application of finite element and discrete element methods in solving geotechnical engineering problems related to seepage, diffusion, elasticity, plasticity, fracture and dynamic motion of soil masses, stability and convergence problems and use of existing computer programs in working applied problems. Prerequisite: Degree in engineering or approval of instructor.

648. Design and Analysis of Earth Structures. (2-0). Credit 2. Principles of design and stability analysis applied to earth and rock-filled dams, embankments, natural slopes and cuts. Types of dam cross sections and selection criteria. Prediction of pore pressures during and after construction. Stability calculations. Total and effective stress methods. Initial and long-term stability. Prerequisites: Aero. 320 or equivalent; C.E. 650 or registration therein.

649. Soil Mechanics. (3-3). Credit 4. Introduction to physico-chemical properties of soils; soil structure; soil classification; permeability; principle of effective stress; stress-deformation and strength characteristics; partly saturated soils; testing procedures. Prerequisites: C.E. 365, 435 or approval of instructor.

650. Soil Mechanics. (3-3). Credit 4. Site investigation; fundamentals of groundwater flow; Dupuit theory; principles of flow nets; numerical methods and conformal mapping; flow under and through earth structures; advanced theory of consolidation; secondary consolidation; numerical methods in consolidation; design of sand drains; field instrumentation. Prerequisite: C.E. 649.

651. Advanced Theory and Application of Soil Mechanics. (3-3). Credit 4. Fundamentals of mechanics of deformable bodies. Application of theoretical continuum mechanics and approximate rheological equation for soils to slope stability, arching, bearing capacity and earth pressure problems. Prerequisite: Approval of instructor.

652. Soil Dynamics. (3-0). Credit 3. Behavior of soils during high rates of loading. Introduction to wave propagation through soils, cratering by explosives, penetration of earth by projectiles, dynamic loads on foundations, and slope stability during earthquakes. Prerequisite: Math. 601 or registration therein.

653. Bituminous Materials. (2-3). Credit 3. Production, specifications, and tests of bituminous materials; design and evaluation of asphaltic concrete for construction and maintenance; inspection control of street, parking and highway paving surfaces. Prerequisite: Graduate classification in engineering.

657. Dynamic Loads and Structural Behavior. (3-0). Credit 3. Forces resulting from wind, other moving fluids, earthquake, blasts, impact, moving loads and machinery. Dynamic behavior of various structures and structural elements under action of such loads. Self-induced vibration. Prerequisites: Math. 308; M.M. 467, or approval of instructor.

660. Photogrammetry. (3-0). Credit 3. Photographic processes related to measuring, interior and exterior orientation of photographs, analysis of geometry and measurements relating photographic image and object, applications of photogrammetry to science and engineering. Prerequisites: Math. 152; approval of instructor.

661. Photo Interpretation. (2-2). Credit 3. Photographic processes related to interpretation; principles, methods, and techniques of photo interpretation; applications in soils, engineering materials, geology, geomorphology, water resources, transportation and urban planning. Prerequisite: Approval of instructor. Cross-listed with F.S. 661.

664. Water Resources Development. (3-0). Credit 3. Planning and measurement concepts for control, conservation and use for water resources by emphasizing interdisciplinary approaches; alternatives to minimize flood damages; Texas water rights and water districts, multipurpose projects, environmental impacts, policies for the future and systems approach to planning. Prerequisite: Approval of instructor.

666. Foundation Structures. (3-0). Credit 3. Geological and soil mechanics principles: load bearing capacity, soil pressure and settlement. Design of shallow foundation sub-structures: pedestals, spread footings, combined footings, mats and underream footings. Design of deep foundations: piles and drilled piers. Retaining walls, cofferdams and sheet piles.

670. Urban Public Transportation Planning. (2-3). Credit 3. Cross-listed with Plan. 670.

671. Comprehensive Transportation Planning and Urban Development. (3-9). Credit 6. Cross-listed with Plan. 673.

672. Urban Transportation Study. (3-3). Credit 4. Procedures and techniques of traditional urban transportation studies. Study design, data collection and processing, trip generation, trip distribution, traffic assignment and mode choice. Data reliability; sketch planning and abbreviated study techniques. Cross-listed with Plan. 672.

673. Urban Transportation. (2-2). Credit 3. Transportation system planning and evaluation; characteristics, cost and application of all modes of transportation. Behavior patterns of transportation users. Alternative analysis of passenger transportation systems.

674. Groundwater Hydrology and Hydraulics. (3-0). Credit 3. Groundwater hydrology, theory of groundwater movement, steady state flow, potential flow, flow nets, mechanics of well flow, multiple-phase flow, salt water intrusion, artificial recharge, legal aspects and models. Prerequisite: C.E. 311 or approval of instructor.

678. Hydromechanics. (3-0). Credit 3. General conservation laws, Euler's equation, forms of the Bernoulli's equation. Potential flow of an incompressible fluid; flow past a body of any shape; source and vortex distribution; lift for a slender body. Linear and nonlinear water waves. Small amplitude oscillations in a compressible ideal fluid or viscous flow theory. Prerequisite: C.E. 462 or approval of instructor.

679. Theory of Fluid Mechanics Models. (3-0). Credit 3. Dimensional analysis; model laws; mathematical techniques; applications to fluid mechanics and coastal engineering models; fixed-bed; movable-bed, geometric and distorted models for flows with free surface; sediment transport; waves, tides and estuary models. Prerequisite: Approval of instructor.

681. Seminar. (0-2). Credit 1. Reports and discussion of current research and of selected published technical articles. May not be taken for credit more than once in master's degree program and twice in Ph.D. program.

685. Problems. Credit 1 to 6 each semester. Enables majors in civil engineering to undertake and complete with credit in their particular fields of specialization limited investigations not within their thesis research and not covered by other courses in established curriculum.

686. Offshore and Coastal Structures. (3-0). Credit 3. Fundamental design and analysis techniques; offshore platform analysis by computer (STRUDL, STRAN), pile driving analysis of large offshore piles by the wave equation, finite element analysis of underwater shells of revolution. Solutions to problems submitted by industry to the class during the semester. Prerequisite: Approval of instructor. Cross-listed with O.E. 686.

687. Marine Foundation Engineering. (2-2). Credit 3. Foundation engineering problems associated with a marine environment. Settlement and bearing capacity analysis of nearshore and offshore foundations. Computer programs used to analyze axially-loaded piles, laterally-loaded piles and sheet-pile walls. Prerequisites: C.E. 365; approval of instructor. Cross-listed with O.E. 687.

688. Computational Fluid Dynamics. (3-0). Credit 3. Finite-difference and finite-element methods and basic numerical concepts for the solution of dispersion, propagation, and equilibrium problems commonly encountered in real fluid flows. Theoretical accuracy analysis techniques. Prerequisites: Undergraduate course in fluid mechanics; Math. 601 and/or basic course in linear algebra; knowledge of one programming language.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of civil engineering. May be repeated for credit. Prerequisites: Approval of instructor and of department head.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

The following M.M. courses (Mechanics and Materials found in the Interdisciplinary Engineering section) are part of the curriculum in civil engineering.

601. Theory of Elasticity. (3-0). Credit 3.
603. Foundations of Solid Mechanics. (3-0). Credit 3.
605. Energy Methods. (3-0). Credit 3.
607. Flow and Fracture of Solids. (3-0). Credit 3.
608. Elasticity of Structural Elements. (3-0). Credit 3.
609. Materials Science. (3-0). Credit 3.
613. Principles of Composite Materials. (3-0). Credit 3.
618. Designing with Composites. (2-3). Credit 3.
620. Processing and Testing of Composite Materials. (2-3). Credit 3.
632. Structural Stability. (3-0). Credit 3.
633. Theory of Plates and Shells. (3-0). Credit 3.
636. Theory of Thermal Stresses. (3-0). Credit 3.
640. Theory of Shells. (3-0). Credit 3.
641. Plasticity Theory. (3-0). Credit 3.
647. Theory of Finite Element Analysis. (3-0). Credit 3.
650. Dynamic Fluid-Solid Interactions. (3-0). Credit 3.
651. Viscoelasticity of Solids and Structures I. (3-0). Credit 3.
652. Viscoelasticity of Solids and Structures II. (3-0). Credit 3.
689. Special Topics in . . . Credit 1 to 4.

OCEAN ENGINEERING
(O.E.)

The graduate program in ocean engineering is broad-based and is designed to fit the needs of graduates from most engineering disciplines as well as naval architecture graduates. An ocean engineer must know about the ocean environment and its measurable parameters; the behavior of materials within the ocean environment; the transfer of communication characteristics of the ocean; and operational, instrumentation and other hardware capabilities within the ocean.

Some of the specialization areas within ocean engineering include coastal and ocean structures, marine engineering and naval architecture, instrumentation and communications in the ocean, wave and storm prediction, offshore pipelines design, coastal sediment processes and dredging.

No foreign language is required for the Ph.D. in ocean engineering.

630. Dynamics of Ocean Vehicles. (3-0). Credit 3. Dynamics and stability of motion of immersed and floating structures and ocean vehicles. Maneuverability and control. Behavior of ocean vehicles and stationary platforms in waves. Design considerations leading to motion reduction. Applications to surface vessels, submersibles and drilling rigs. Prerequisites: C.E. 311, M.E. 459 or equivalent, or approval of instructor.

675. Coastal Engineering I. (3-0). Credit 3. Small amplitude wave theory and applications to engineering problems. Analysis of wave data. Wave forces on coastal structures. Wave run-up on seawalls and breakwaters. Control of oil spills and offshore pipelines. Prerequisite: Approval of instructor.

676. Ocean Engineering. (3-0). Credit 3. Review of concepts of linear structural dynamic analysis for time and frequency domain simulations, functional design of off-shore platforms, pipelines, floating structures and moorings. Environmental loading problems. Hydrodynamic phenomena including wind and current interaction, vortex shedding and wave forces; structure-fluid interaction models. Prerequisites: O.E. 300, 301, or approval of the instructor.

677. Coastal Engineering II. (3-0). Credit 3. Non-linear wave theories and their application to engineering problems; wave forces on off-shore structures; floating, hydraulic and pneumatic breakwaters; off-shore pipelines; diffusion in coastal waters; oil spill containment and collection. Prerequisite: C.E. 675 or approval of instructor.

681. Seminar. (0-2). Credit 1. Reports and discussion of current research and of selected published technical articles. May not be taken for credit more than once in master's degree program and twice in Ph.D. program.

682. Coastal Sediment Processes. (3-0). Credit 3. Sediment properties and size distribution, fluvial sediment transport equations, movement of material by the sea, review of pertinent wave theories, littoral drift, inlet stability, coastal protection structures, similarity in sediment transport, movable bed models, sediment tracing, Aeolian sand transport, case studies. Prerequisite: Approval of instructor.

683. Estuary Hydrodynamics. (3-0). Credit 3. Development of applicable equations for tidal dynamics applied to real estuaries. Technology for determination of mean velocities, circulation patterns, water depths, turbulent dispersion patterns, etc. for solution of environmental problems in estuaries. Physical and mathematical models. Prerequisites: Basic fluid mechanics; approval of instructor.

685. Problems. Credit 1 to 6 each semester. Special topics not within scope of thesis research and not covered by other formal courses.

686. Offshore and Coastal Structures. (3-0). Credit 3. Fundamental design and analysis techniques; offshore platform analysis by computer (STRUDL, STRAN), pile driving analysis of large offshore piles by the wave equation, finite element analysis of underwater shells of revolution. Solutions to problems submitted by industry to the class during the semester. Prerequisite: Approval of instructor. Cross-listed with C.E. 686.

687. Marine Foundation Engineering. (2-2). Credit 3. Foundation engineering problems associated with a marine environment. Settlement and bearing capacity analysis of near-shore and offshore foundations. Computer programs used to analyze axially-loaded piles, laterally-loaded piles and sheet-pile walls. Prerequisites: C.E. 365; approval of instructor. Cross-listed with C.E. 687.

688. Marine Dredging. (3-0). Credit 3. Dredge pump selection; pump and system characteristics; cavitation; types of dredges; continental shelf and deep-ocean dredging; head loss in horizontal and vertical pipes for two and three-phase flow; design of disposal methods for dredged material; environmental effects of dredging. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of ocean engineering. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF COMMUNICATIONS

D. R. Bowers, M. L. Chastain, D. C. Johnson, C. J. Leabo, B. G. Rogers (Head)

JOURNALISM
(Jour.)

601. Mass Communication Processes. (2-3). Credit 3. Intensive training in news writing, photography, television production and typography for mass and specialized media. Typing ability required.

602. Mass Media and Society. (3-0). Credit 3. Relationships between modern society and the media of mass communication, considered as organizations, institutions and systems; rights, responsibilities and characteristics of the mass media, the mass communication practitioner, the audience and society.

603. Methods of Specialized Journalism. (3-0). Credit 3. Writing and placement of magazine and journal articles in specialized areas of media content such as agriculture, ecology, science, business, education, natural resources, etc.; individual projects directed to student's field of interest.

605. Institutional Public Relations. (3-0). Credit 3. Public relations philosophy and methodology, using the principles of persuasion and attitude change, as adapted to public and private institutions.

685. Problems. Credit 1 to 4 each semester. Research problems related to media; individual work fitted to special needs of students.

689. Special Topics in . . . Credit 1 to 4. Investigation and analysis of trends and changing role of media with focus upon current and future problems and responses. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis.

COMPUTING SCIENCE
(See Industrial Engineering)

DAIRY SCIENCE
(See Animal Science)

DEPARTMENT OF ECONOMICS

J. W. Allen, R. K. Anderson, L. Auernheimer, R. L. Basmann, R. C. Battalio, E. G. Furubotn, R. F. Gilbert, M. L. Greenhut, T. J. Gronberg*, J. R. Hanson II, H.-S. Hwang, J. H. Kagel, W. J. Lane, Jr., G. D. Libecap, S. C. Maurice, J. Meyer, J. R. Moroney (Head), S. Pejovich, M. O. Reynolds, T. R. Saving, C. W. Smithson, A. Takayama, S. N. Wiggins

*Graduate Advisor

Graduate study in economics is offered leading to the degrees of master of science and doctor of philosophy. Curricular offerings are designed to equip the student with specialized knowledge for careers in teaching, government and business and to give a sound preparation for continuing graduate study toward the doctorate elsewhere. There is no general Ph.D foreign language requirement.

Prerequisites: To major in economics, the student should present undergraduate credits of 30 semester hours in economics, business administration and the social sciences, of which 21 should be in economics. A strong quantitative background involving work in mathematics and statistics may be used to waive this requirement.

ECONOMICS
(Econ.)

600. Economic Analysis for Public School Personnel. (3-0). Credit 3. Basic economic analysis and reasoning for public school personnel. Understanding how the American economic system is arranged and operates; the role of markets, prices and government. Not to be used towards degree in economics.

601. History of Economic Thought. (3-0). Credit 3. Survey of the period 1776-1848. Original works of Smith, Malthus, West, Ricardo and Mill. Prerequisite: Approval of department head.

603. Public Economics I. (3-0). Credit 3. Economics of taxation and public spending; theoretical and empirical analysis of the shifting and incidence of income, commodity and property taxes; models of optimal taxation and public spending; analysis of taxation and spending in a federal system of government. Prerequisite: Approval of department head.

604. Public Economics II. (3-0). Credit 3. Economics of collective action; theoretical and empirical analysis of externalities; externalities and public policy; the demand and supply of public goods; economic analysis of alternative systems of public choice; models of bureaucratic behavior. Prerequisite: Approval of department head.

605. American Economic Development in World Perspective. (3-0). Credit 3. American economic development between 1800 and the mid-20th century; relationship of American experience to international trends. American economic growth treated as a special case of modern economic growth which appeared following the Industrial Revolution in England.

607. Foundations of Microeconomic Theory. (3-0). Credit 3. Role of prices in directing the actions of individuals and groups of individuals in the processes of production, exchange and consumption of goods and services. Prerequisite: Approval of instructor.

609. Human Resource Economics I. (3-0). Credit 3. Valuation and allocation of human resources. Labor supply of households, labor supply over the life-cycle, determination of wages, human capital, migration, education, labor markets and population. Use of the testable implications of theory and of evidence to explain observed labor market behavior. Prerequisite: Econ. 607 or equivalent.

610. Human Resource Economics II. (3-0). Credit 3. Selected topics and labor markets; unemployment, earnings differentials, effects of occupational licensing, trade unions, income distribution, military manpower and the draft, effects of minimum wage and equal pay provisions, effects of welfare programs, the professional athlete's labor market and others. Developing and analyzing empirical problems. Prerequisite: Econ. 609.

611. Foundations of Macroeconomic Theory. (3-0). Credit 3. Development of modern static national income analysis from general equilibrium system. Roles of fiscal and monetary policy in promoting economic stability. Prerequisites: Econ. 323, 410.

615. The American Economy I. (3-0). Credit 3. Brief survey of development of competitive economic system. Analysis of market system; behavior of both individual and firm. Fluctuations in level of economic activity and macro analytical tools required for understanding causes of such fluctuations. Prerequisite: Graduate classification or approval of department head.

616. The American Economy II. (3-0). Credit 3. Policy; application of micro and/or macro analytical tools to selected problem areas: public finance, international trade and finance, pollution, energy, and regulation of business. Prerequisite: Graduate classification or approval of department head.

619. Theory of the Firm in Economic Space. (3-0). Credit 3. Impacts of distance on classical economic markets and the theory of the firm. Prerequisite: Econ. 323 or approval of department head.

621. Regional Science I. (3-0). Credit 3. Survey of regional economic analysis; industrial and residential location analysis; regional delineation; factor mobility and commodity movements; interregional input-output models; income accounting, balance of payments, gravity models; regional economic growth. Prerequisite: Approval of department head.

622. Regional Science II. (3-0). Credit 3. Regional economic analysis; price discrimination theory and practice, urban and regional economic planning, regional industrial complex analysis, cost-benefit analysis and economic base analysis. Prerequisite: Approval of department head.

623. Theories of Economic Development I. (3-0). Credit 3. Survey of nature and extent of economic development issues; review of theories that facilitate analysis; specific problems confronting less developed nations. Prerequisite: Econ. 330 or approval of instructor.

628. Urban Economics. (3-0). Credit 3. Economic analysis of structure, functions and problems of urban areas; theory of urban, industrial and residential location; land use patterns; urban economic growth and development; and such problem areas as urban poverty, renewal, housing, traffic congestion, pollution and urban public economy. Prerequisite: Approval of department head.

629. Microeconomic Theory I. (3-0). Credit 3. Rigorous and analytical study of determination of prices and quantities of products, composition of national product, and allocation of resources. Students obtain detailed and comprehensive knowledge of literature so that they may act as teachers, researchers and consultants. Prerequisite: Approval of department head.

630. Microeconomic Theory II. (3-0). Credit 3. Rigorous theoretical analysis of the theories of production, cost, factor pricing and factor usage, distribution and general equilibrium. Prerequisites: Econ. 629; Ecmt. 660.

631. Welfare Economics. (3-0). Credit 3. Basic concepts and propositions of welfare theory. Pareto optimality, social welfare functions, external economies, dynamic allocation theory, economic efficiency of alternative market structures. Selected policy issues considered from standpoint of welfare principles derived. Prerequisite: Econ. 607 or 629.

635. Monetary Theory. (3-0). Credit 3. Traditional as well as modern theories of money. General equilibrium systems and role of money in determination of prices, interest rate, income and employment. Factors influencing demand for money as well as its supply. Prerequisite: Econ. 636.

636. Macroeconomic Theory. (3-0). Credit 3. Aggregate economic theory of consumption, investment, money, interest, inflation and employment. Prerequisite: Econ. 410 or 611.

637. Monetary Policy. (3-0). Credit 3. Effect of monetary policy on aggregate economic activity and distribution of resources. Effectiveness of various policies; optimal policy in light of various institutional restrictions that exist. Prerequisite: Econ. 635.

639. Economic Analysis of Regulated Enterprise. (3-0). Credit 3. Scope of governmental regulation in economy of U.S., its evolution and development. Application of tools of economic analysis to problems posed by regulated enterprise. Prerequisite: Econ. 425 or approval of department head.

642. Comparative Economic Systems. (3-0). Credit 3. Impact of economic systems on various aspects of welfare; per capita income, growth, equity, stability, etc. Interrelations among property rights, incentives and economic behavior. Effects of alternative legal structures, rules, traditions, and institutions on efficiency in production and distribution. Applications to selected case studies. Prerequisite: Approval of department head.

646. Macroeconomic Theory II. (3-0). Credit 3. Dynamic models, open economics, disequilibrium analysis, unemployment and inflation. Traditional macro models and recent developments in macro theory. Prerequisite: Econ. 636.

649. Industrial Organization and Economic Regulation. (3-0). Credit 3. Industry structure, conduct, and performance described and analyzed with tools of microeconomics. Prerequisite: Approval of department head.

650. Advanced Industrial Organization. (3-0). Credit 3. Behavior of markets operating under conditions of imperfect information. Construction and scientific evaluation of models designed to explain industry performance. Preparation and presentation of student research

on theoretical and empirical problems. Prerequisite: Econ. 649 or approval of department head.

651. International Economic Policy. (3-0). Credit 3. Interpretation of balance of payments and adjustment to national and international equilibria, through changes in price levels, exchange rates and national incomes. Making international payments, determination of exchange rates under various monetary standards, capital movements, exchange controls and international monetary organization. Prerequisite: Econ. 611 or equivalent.

652. International Trade Theory. (3-0). Credit 3. Classical and neoclassical models of international trade. International price formation, patterns of trade and gains from exchange; specialization and comparative advantage; factor proportions, factor prices and the Heckscher-Ohlin theorem; foreign trade and growth; tariffs, customs unions and commercial policy.

655. Studies in Experimental Economics I. (3-0). Credit 3. Application of experimental methods to issues of interest to economists and related social scientists; choice behavior experiments, survey research, planned economic environments and animal experiments. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Reports and discussions of current research and presentations by visiting economists. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 3 each semester. Individual problems not related to thesis or dissertation. Prerequisites: Graduate classification with major or minor in economics; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of economics. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of Economic Research. (3-0). Credit 3. Design of research experiments in various subfields of economics, and evaluation of research results with the aid of examples taken from the current scientific literature.

691. Research. Credit 1 or more each semester. Thesis research.

See Ag.Ec. 603 and 633 for description of related courses.

ECONOMETRICS
(Ecmt.)

660. Mathematical Economics. (3-0). Credit 3. Use of selected types of mathematical tools in economic theory. Prerequisite: Econ. 323.

661. Mathematical Economics. (3-0). Credit 3. Fundamental properties of integral calculus, difference and differential equations, and their use in economic theory. Prerequisite: Ecmt. 660 or equivalent.

662. Logical Foundations of Economic Science. (3-0). Credit 3. Specialization of the language of economics; properties and relations of first-order economic theories; logical analysis of first-order economic theories and their empirical interpretations; economic applications of logic of quantity and magnitude; measurement in economics. Prerequisite: Approval of instructor.

663. Econometrics. (3-0). Credit 3. Use of statistics in economic theory as device for testing hypotheses, formulation concepts and economic forecasting. Prerequisites: Ecmt. 660; Stat. 608.

664. Intermediate Econometric Theory. (3-0). Credit 3. Empirical distributions of economic variables. Elementary discrete and continuous distributions expressing econometric hypothesis, distributions of estimators and test statistics. Prerequisite: Ecmt. 662, differential and integral calculus or approval of instructor.

665. Econometric Theory and Programming. (3-0). Credit 3. Stochastic and non-stochastic model formulation, identification, methods of solution and interpretation of results; applications of theory and methods to significant economic problems. Prerequisite: Ecmt. 663, 664, Stat. 610 (or registration therein) or approval of department head.

666. Model Building in Econometrics. (3-0). Credit 3. Non-stochastic and stochastic model formulation. Identification, methods of solution and/or estimation, economic interpretations and applications of theory and methods to economic problems. Tools of mathematical and variational programming and statistics used to present received theory and to solve newly formulated problems. Prerequisite: Ecmt. 663.

668. Economics of Risk and Uncertainty. (3-0). Credit 3. Methods used to introduce risk and uncertainty into various economic models; analysis of behavior of individuals, firms and markets in risky situations. Prerequisite: Ecmt. 660.

669. Fundamental Mathematics for Economists. (3-0) Credit 3. Mathematics of non-linear programming; applications to micro-theoretic models of demand and production. Fundamental results from matrix theory and multivariate differential calculus. Systems of differential equations and stability analysis and their economic applications.

670. Advanced Mathematical Economics. (3-0). Credit 3. Basic results from demand and production theory are unified by the duality concept of the envelope theorem. Theory of competitive markets, existence and stability developed in positive and normative analysis. Optimal growth for a macro economy under alternative technologies. Prerequisite: Ecmt. 669.

674. Econometric Theory II. (3-0). Credit 3. Empirical distributions of economic variables. Elementary discrete and continuous distributions expressing econometric hypothesis, distributions of estimators, and test statistics. Continuation of Ecmt. 664. Prerequisite: Ecmt. 664.

DEPARTMENT OF EDUCATIONAL ADMINISTRATION

R. I. Berridge, D. C. Corrigan, D. A. Erlandson*, H. L. Hawkins (Head), J. R. Hoyle, F. W. R. Hubert, J. F. McNamara, L. S. Richardson, R. J. Stalcup, S. L. Stark, P. T. West

*Graduate Advisor

The Department of Educational Administration provides several alternative areas of study. Degrees are offered on the master's and doctoral levels. Interdisciplinary study in the social and behavioral sciences and in public school administration leads to a well-rounded program for the school and college administrator. Preparation for the college professorship in educational administration and research is available. Flexibility in program planning provides adaptation to management in business, industry and related professions.

Programmatically, the diversity of training and experience is for the principal, or middle administrator, and the superintendent on the public school level; and the president, dean, director, department head and professor on the college/university level. Concentrated course work is available in community education, community college (and other higher education), school law and management, public relations, school special services, internships, planning and evaluation, research design and techniques, field services, and inner-city and multi-cultural studies.

All students admitted to the doctoral degree programs in educational administration are expected to demonstrate competency in nine areas of study related to educational administrative settings. The following areas comprise the educational administration common core: economic, legal, organizational, sociological, political and educational foundations; communication; teaching/learning environments; and planning, research and evaluation. After admission to the doctoral program, all students must complete a diagnostic assessment of their competency in the common core areas. This assessment is used for advisement purposes.

Professional Certification — Professional certification programs are offered for superintendents, principals and middle administrators including assistants, directors, deputies, school business managers and other central office personnel. Texas Education Agency-approved plans are adapted to the aspirations and needs of individuals. Basic requirements include a teaching certificate, master's degree and two years of creditable classroom teaching experience. Two levels of certification are available — middle management and superintendency.

Administration of Higher Education — Within the framework of existing doctoral programs of the departments in the College of Education, individuals may pursue an area of concentration in higher education. Professional preparation is offered persons in administrative positions in community-junior colleges, senior colleges and universities or related positions in educational agencies, government and other public and private enterprises offering educational programs. Extensive use is made of Texas A&M University-wide resources relating to student's objectives and the departmental requirements.

Community Education — The specialization focuses on the philosophy and implementation of community education as a vehicle for total community involvement in the educational process while stressing the interdisciplinary nature of leadership in the community. It is aimed at preparing public school administrators or administrators in other public sectors. In cooperation with the Mott Foundation, the Texas A&M Center for Community Education provides direct services to school districts and communities throughout the state.

Instructional Management — Graduate study in educational administration emphasizing instructional management is designed to prepare curriculum directors, assistant/associate/deputy superintendents of curriculum and instruction, broadly based curriculum instructional supervisors and university professors of education. Such studies may be pursued in either the Department of Educational Administration or the Department of Educational Curriculum and Instruction and under either the Ed.D. or Ph.D. program. Texas candidates may also qualify for the mid-management administrator's certificate and the supervisor's certificate. Out-of-state candidates should check with their state education agencies as to whether this program would satisfy their certification requirements.

Public Relations — This multidisciplinary graduate studies specialization in educational administration places special emphasis on communications. Supporting fields also include architecture, computing science, business, curriculum and instruction, English, industrial education, industrial engineering, psychology, philosophy, sociology and urban and regional planning. This specialization is designed to prepare students for positions as public relations specialists in education, business, government and industry.

Research, Planning and Evaluation — The department participates in interdisciplinary planning, research and evaluation offered in cooperation with other departments in the College of Education. Prospective doctoral students who wish to develop an interdisciplinary supporting field in educational planning, research and evaluation should examine the interdisciplinary studies option which is presented in the description of graduate courses in interdisciplinary education.

(Ed.Ad.)

604. The Elementary School Principalship. (3-0). Credit 3. Role of the elementary school principal in organization and administration of elementary schools; management of instruction, educational program planning, legal problems, evaluation and reading programs. Prerequisite: Ed.Ad. 639 or approval of instructor.

605. The Secondary School Principalship. (3-0). Credit 3. Role of the principal in the organization of junior and senior high schools; preparation for instructional management, program planning, evaluation and scheduling. Prerequisite: Ed.Ad. 639 or approval of instructor.

608. School Finance and Business Management. (3-0). Credit 3. School funds on local, state and federal level; budgeting, data processing; other systems of accounting and reporting. Supply management as related to school efficiency. Maintenance of buildings, grounds and equipment. Prerequisites: Ed.Ad. 604, 605, 615 or approval of department head.

609. Public School Laws. (3-0). Credit 3. Constitutional provisions, statutory laws, court decisions, and regulations governing public schools with special reference to Texas and federal relationships.

610. Higher Education Law. (3-0). Credit 3. Legal aspects of administration in institutions of higher education. Statutes and case law related to liability, due process, student rights, admission, employee relations and property use. Prerequisites: Graduate classification; approval of instructor.

613. Educational Facilities Planning. (1-6). Credit 3. Present and future building and equipment needs of school units; efficiency of present plant, operation and maintenance, planning building program; field work as part of a group school plant study.

615. The School Superintendency. (3-0). Credit 3. Organization and administration of systems of schools and their relationships on federal, state, intermediate and local levels. Private, parochial and adult education. Prerequisite: Ed.Ad. 604, 605 or approval of instructor.

616. Administration of Staff Personnel. (3-0). Credit 3. Personnel organization and administration in school systems. Relationship of individual to organization. Organizational health, staffing, remuneration, appraisal, ethics, security, inservice and negotiations. Prerequisite: Ed.Ad. 639 or approval of instructor.

618. Educational Administration in Cross Cultural Environments. (3-0). Credit 3. Designed to provide educational administrators insights and background into the life styles, values and aspirations of minority Americans as related to the administrative process.

619. Contemporary Dimensions of Administering Urban Schools. (3-0). Credit 3. Causes and consequences of racial and socio-economic isolation, impact of school desegregation, urban school politics, alternatives for urban schools, decentralization, community control, urban population trends and housing patterns.

620. Educational Program Evaluation. (3-0). Credit 3. Theory and practice of evaluation of instructional programs including research methods and design strategies to measure program outcomes. Skills to evaluate personnel and projects included as components of evaluation models and management of educational evaluation functions. Open to all graduate students in education.

621. Educational Planning/Futurism. (3-0). Credit 3. Concepts and skills to prepare educational leaders to anticipate and manage the future. System theory, futures methodology, planning models and scenario writing. Designing educational programs for the 21st century. Prerequisite: Approval of instructor.

625. The Community College. (3-0). Credit 3. Purposes, programs, people, organization, control and resources of the community college.

626. Issues and Trends in Community College Administration. (3-0). Credit 3. Community college in relation to other institutions of higher education. Assessment of community college enrollment trends, curriculum changes, personnel problems, finance patterns (federal and state) and contemporary issues. Prerequisite: Ed.Ad. 625.

635. Administration of Special Services. (3-0). Credit 3. To help administrators, counselors, supervisors and teachers develop an understanding of functions, operation and evaluation of special services which support the educational program. Individual study of content and on-site evaluations of organization and administration of school services programs.

636. Practices and Problems in Educational Public Relations. (3-0). Credit 3. Selected contemporary problems and practices in educational public relations; case study approach as a decision-making strategy. Prerequisite: Ed.Ad. 640 or approval of instructor.

637. Administration of Change in Educational Organizations. (3-0). Credit 3. Relationships among individual and group behaviors; roles of administrators. On-site analysis of educational organizations and practical application of change principles. Prerequisite: Approval of instructor.

638. Current Issues in Community Education. (3-0). Credit 3. Current educational issues affecting public education; merging and alternative models of community education. Prerequisites: Ed.Ad. 641; approval of instructor.

639. Foundations of Educational Administration. (3-0). Credit 3. Selected historical, philosophical and sociological foundations and developmental dimensions of educational administration.

640. School-Community Relationships. (3-0). Credit 3. Interpretation of schools to community publics. Promotion of school-community relations through media. Roles of administrators, teachers, non-teaching personnel, pupils, parents and lay groups.

641. Community Education. (3-0). Credit 3. Structure, purpose and strategies of community education as they relate to public school administration.

642. Community Education: Planning and Administration. (3-0). Credit 3. Planning and administration of community education. Skills and techniques of incorporating the community education philosophy into the community and the K-12 program. Prerequisites: Ed.Ad. 641; approval of instructor.

651. Orientation in Business Principles and Procedures. (3-0). Credit 3. Interdisciplinary survey using management science and operations research procedures from various fields of business as a means to improve decision-making and policy-planning educational organizations. Roles of superintendent and school business official. Case studies. Field studies.

652. Educational-Governmental Relationships. (3-0). Credit 3. Interdisciplinary survey course using various fields in political science, comparative government, and American and state history. Interrelationships of educational administration to political organizations.

653. The Nature and Problems of Administrative Behavior. (3-0). Credit 3. Interdisciplinary survey course using case study method. Designed to enhance understanding of organizational theory and the appropriate techniques in decision-making, communication and staff relations required by the educational administrator. Prerequisite: Master's degree or approval of instructor.

655. Administration of Higher Education. (3-0). Credit 3. Survey of management principles in higher education. Functions in delegation, direction, operation, governance and financing applied to postsecondary institutions.

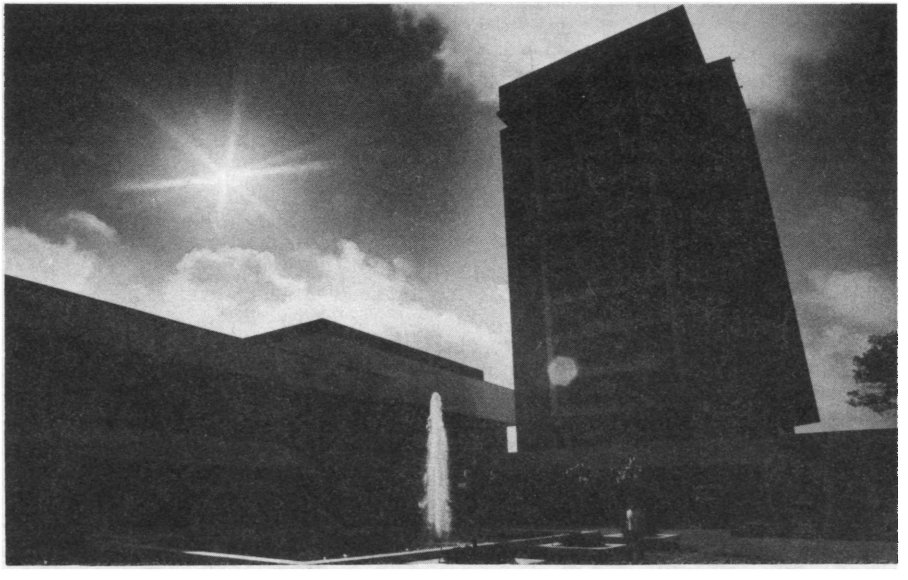
656. Administration of Supervisory Personnel. (3-0). Credit 3. Administration of public school supervisory programs; roles of administrators in the management of supervision; organization of the supervisory staff in small and large schools.

680. Proseminar. (1-0). Credit 1. Major concepts, principles and issues in education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Required of all Ed.D. students. May be repeated for credit. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Problems pertinent to superintendent and principal. Recent developments and research in different areas.

684. Internship. Credit 1 to 6. Designed to give the prospective educational administrator job related experience under supervision in an educational setting appropriate to the selected roles in administration indicated below. Prerequisites are determined by each specific degree, certification or program requirements. A maximum of six hours credit may be earned in each internship. Prior approval required.

(a) Community Educator
(b) Public Relations Specialist
(c) College Administrator
(d) Middle Administrator
(e) School Superintendent



685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problem in field of educational administration. Prerequisite: Prior approval required.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of educational administration. May be repeated for credit.

690. Theory of Educational Administration Research. (3-0). Credit 3. Design of research and inquiry in various areas of educational administration. Application of models and research procedures from the social and the management sciences to policy issues and problems in educational organizations. Case studies. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken for doctor of education degree. Preparation of a record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of major advisor.

DEPARTMENT OF EDUCATIONAL CURRICULUM AND INSTRUCTION

D. G. Armstrong, T. R. Blair, J. K. Campbell, D. W. David, J. J. Denton, C. J. Dockweiler, J. Garcia, D. C. Godwin, D. L. Janke, G. R. Johnson*, J. B. Kracht*, P. C. Limbacher, J. E. Morris, D. E. Norton, W. H. Peters (Head), J. H. Rollins, W. H. Rupley, T. V. Savage, A. C. Seaman, R. E. Shutes, J. C. Stansell‡, W. F. Stenning*, D. L. Wiseman

*Graduate Advisor
‡Certification Advisor

Graduate courses in the Department of Educational Curriculum and Instruction are designed to advance the knowledge and develop the skills of persons in instructional, supervisory and curriculum development roles at all levels of education, from elementary school through the university. Individually planned programs lead to the master of education, master of science, doctor of education and doctor of philosophy degrees in educational curriculum and instruction. Degree programs may be written to meet the requirements for professional teaching and supervisor certificates approved by the Texas Education Agency.

Individual courses and sequences of courses deal with the theory, research and practice related to strategies of teaching, approaches to curriculum development and revision, and techniques of supervision. Though courses are specifically intended to assist practicing school personnel, they have direct relevance to students majoring in other disciplines who intend to teach their subject at either the public school or college level. Departmental seminars supplement the individual counseling of graduate students and serve to interrelate the content of program courses.

Information about prerequisites, research or language requirements can be obtained from the department office. Requirements will be determined by the student's advisory committee.

Curriculum Director — This area of specialization is aimed at developing public school and higher education staff who can design, develop, install and evaluate curriculum across a broad range of subject matter. Extensive theory and application in curriculum are provided with opportunities to participate in the department's curriculum laboratory.

Early Childhood Education — Graduate study in this area of specialization is designed for classroom teachers, supervisors and administrators to enhance teaching strategies, classroom management, parental involvement, program development and operational skills when working with young children. Developmental characteristics and needs of preschool children provide the basis from which early childhood programs, facilities and methods are derived for advanced study.

Educators for Diverse Settings — Within the framework of existing doctoral programs, individuals may pursue a specialization aimed at developing and enhancing educational skills for use in non-school settings. This program is particularly appropriate for those individuals interested in pursuing educational leadership positions in business, industry, agency, and/or governmental settings.

Elementary Education — The department offers a wide range of course work designed to benefit teachers, supervisors and administrators who work at the elementary level. Various emphases can be developed to reflect an individual's specific interests. Generic program components include curriculum development, instructional planning, trends and issues in elementary education.

Higher Education — Within the framework of existing doctoral programs of the departments in the College of Education, individuals may pursue an area of specialization in higher education. Educational curriculum and instruction is particularly suited for individuals teaching, or planning to teach, in post-secondary education settings and having long range goals involving leadership in academic affairs, curriculum development and instruction.

Instructional Management — Graduate study in educational curriculum and instruction emphasizing instructional management is designed to prepare curriculum directors, assistant/associate/deputy superintendents of curriculum and instruction, broadly based curriculum instructional supervisors and university professors of education. Such studies may be pursued in either the Department of Educational Administration or the Department of Educational Curriculum and Instruction and under either the Ed.D. or Ph.D. program. Texas candidates may also qualify for the mid-management administrator's certificate and the supervisor's certificate. Out-of-state candidates should check with their state education agencies as to whether this program would satisfy their certification requirements.

Language Arts Education — This area of specialization is designed for the professional development of persons involved in teaching, curriculum development, research, evaluation and administration in the area of language arts. It is intended to prepare students for language arts positions in public schools, community colleges, senior colleges and universities, and state educational agencies as well as related positions in business and industry.

Mathematics Education — Graduate preparation is offered in the several areas related to the teaching of mathematics and the mathematics curriculum. This area of specialization is aimed at preparing master teachers of mathematics, curriculum specialists in the discipline, and mathematics education specialists for college-level teaching and research. Students from areas other than education will find ample opportunities to develop an appropriate level of expertise in mathematics education.

Reading — This area of specialization focuses on the theoretical and research based aspects of the reading process, reading acquisition and reading diagnosis-remediation. Emphasis is also placed on the implications emerging from theory and research as they relate to both the preparation and improvement of preservice and inservice reading teachers' instruction.

Research, Planning and Evaluation — The department participates in interdisciplinary planning, research and evaluation offered in cooperation with other departments in the College of Education. Prospective doctoral students who wish to develop an interdisciplinary supporting field in educational planning, research and evaluation should examine the interdisciplinary studies option which is presented in the description of graduate courses in interdisciplinary education.

Science Education — This area of specialization focuses upon preparing individuals to become better science teachers at all levels of education. It includes courses from a selected science area plus science education courses.

Secondary Education — The department offers a wide range of course work designed to benefit teachers, supervisors and administrators who work at the secondary education level. Various emphases can be developed to reflect an individual's specific interests. Generic program components include curriculum development, instructional planning, trends and issues in secondary education.

Social Studies Education — Individuals selecting this area of specialization are provided with a combination of experiences selected from courses focusing on professional social studies education, general educational curriculum and instruction, and history and the social sciences. Participants are introduced to ideas of leading social studies educators particularly as those ideas relate to preparation of curricula and to development of instructional practices.

Supervisor — The department provides the program necessary for certification as an elementary and secondary school supervisor.

(Ed.C.I.)

601. College Teaching. (3-0). Credit 3. Review of research studies related to college settings; college-level teaching strategies; cognitive interaction analysis.

602. Cultural Foundations of Education. (3-0). Credit 3. Contributions of behavioral sciences applied as analytic tools in solving problems of curriculum and instruction.

603. Analysis of College Teaching. (3-0). Credit 3. A series of behaviorally defined teaching skills. Skills practiced in five-minute lessons (microteaching), which are videotaped and replayed for analyzation.

604. Reading Diagnosis. (2-3). Credit 3. Appraisal and diagnosis of reading problems. Practicum in administration and interpretation of individual reading inventories. Prerequisite: Ed.C.I. 649, 674 recommended.

605. Creative Application of Technology to Education. (2-3). Credit 3. Identification and solution of learning problems using a learning systems approach; creative application of educational technology (programmed instruction, electronic carrels, etc.).

606. Foundations of Higher Education. (3-0). Credit 3. Change, continuity and controversy in higher education from the medieval prototype to the modern multiversity. Developments, analysis and interpretation of causes and effects; educational and social policies, institutional control, curriculum and teaching-learning.

607. Programs and Procedures in Supervision. (3-0). Credit 3. Designed for teachers, supervisors and administrators. Philosophy, organization and administration of supervision of both elementary and secondary schools. Required for mid-management and supervisor's certificate.

608. Supervision of Student Teachers. (3-0). Credit 3. Performance objectives, observation systems, conferencing and evaluation procedures related to supervision of student teaching. Public school teacher's role in supervision of student teachers.

614. Reading Research and Trends. (3-0). Credit 3. Exploration of recent research in reading. Identification of trends and patterns in issues attached, research designs employed, and consistent findings. Generation of new research hypotheses and guidelines for improving current practice. Prerequisites: Doctoral classification; 12 graduate hours in reading.

615. Advanced Reading Diagnosis and Remediation. (3-0). Credit 3. Evolving theory, research and controversy in reading diagnosis and remediation. Analysis of trends. Prerequisites: Doctoral classification; 12 graduate hours in reading, including Ed.C.I. 604 and 642.

616. Organization and Supervision of Reading Programs. (3-0). Credit 3. Organization of school reading programs; role of reading supervisor in program implementation, staff development, program evaluation. Coordination of reading services with total curriculum. Prerequisites: Doctoral classification; approval of instructor.

618. Teaching Elementary School Mathematics. (3-0). Credit 3. Contemporary issues in teaching elementary school mathematics; the active learning instructional mode.

619. Teaching Basic Concepts of Mathematics. (3-0). Credit 3. Content and pedagogy of middle/junior high school mathematics programs.

620. Teaching Secondary School Algebra. (3-0). Credit 3. Content and pedagogy of selected contemporary programs in school algebra.

621. Teaching Secondary School Geometry. (3-0). Credit 3. Contemporary issues in informal and formal school geometry; emerging curricular alternatives.

630. Junior/Community College Curriculum. (3-0). Credit 3. Factors influencing the scope and sequence of the curriculum for junior/community colleges. Comprehensive junior/community college curriculum, major divisions of the curriculum, basic and applied fields, community services, student activities, library and new curriculum models.

637. Advanced Elementary School Methods. (3-0). Credit 3. Analysis of teaching; learning environments for the purpose of improving instruction. Instructional strategies. Prerequisites: Ed.C.I. 644 and 673 or approval of instructor.

638. Trends in Curriculum and Instruction. (3-0). Credit 3. Recent research and development in theories and practices of curriculum and instruction. Curriculum innovations, school organization and new instructional media.

642. Clinic Teaching in Reading. (1-6). Credit 3. Practicum in recognition, diagnosis, remediation and corrective procedures of reading-study problems; demonstration and laboratory analysis of physiological and psychological factors related to reading disabilities. Prerequisites: Ed.C.I. 351, 604.

643. Current Issues in Elementary Education. (3-0). Credit 3. Current issues affecting the elementary school. Curriculum, instruction and organization in light of current social and educational change. Prerequisite: Elementary Provisional Certificate or equivalent.

644. Curriculum Development. (3-0). Credit 3. Curriculum development. Bases of curriculum design. Problems of balance, scope, organization, sequence, selection and articulation.

645. Society and Education in World Perspective. (3-0). Credit 3. Comparative education; interrelationships among societal institutions and particular roles that education plays in different cultures and political systems. Prerequisites: Ed.C.I. 402.

646. Instruction Theory. (3-0). Credit 3. Theoretical basis for research and training in instruction. Systematic study of existing research on key factors influencing instructional effectiveness. Exploration of interaction among variables of instruction. Prerequisite: Ed.C.I. 675.

647. Curriculum Theory. (3-0). Credit 3. Theoretical basis for curriculum conceptualization, development, evaluation and implementation. Value and empirical basis of curriculum decision-making strategies for curriculum change. Prerequisite: Ed.C.I. 644.

649. Reading Instruction in High School and College. (3-0). Credit 3. Basic principles of reading instruction; nature and scope of total reading program; methods, materials and organization of developmental, corrective and speed-reading programs in high school and college.

650. Foundations of Reading Instruction. (3-0). Credit 3. Psychological, linguistic and physical factors related to reading performance; implications for content and teaching methods; appraisal of current research and related reading for teachers, supervisors and reading specialists. Prerequisites: Ed.C.I. 649 and 674, or approval of instructor.

652. Parental Involvement in Early Childhood Education. (3-0). Credit 3. Dynamics of the family unit, school-home communication systems, legalities of parent participation in the school, parent involvement, parent training and home bound programs. Development of programs with parents.

653. Classroom Management in Early Childhood Education. (3-0). Credit 3. Methods of classroom management, principles of child guidance, establishing positive educational environments, interpreting children's needs and methods of discipline as related to teaching strategies in early childhood education. Prerequisite: Approval of instructor.

654. Organization and Operation of Early Childhood Education Programs. (3-0). Credit 3. Comprehensive survey of the various types of preschool centers serving the needs of young children; operating procedures, programs and services provided. Experimental educational research projects now being conducted with young children.

655. Program Development for Early Childhood Education. (3-0). Credit 3. Developing language-experience based curriculum guides specifically for young children. Instructional theory directed toward the development of language-experience based curriculum units. Prerequisite: Ed.C.I. 644.

662. Philosophical Theories of Education. (3-0). Credit 3. Selected historical theories of education from Plato to Skinner. Evaluating educational ends and means; the nature of knowledge, its acquisition and transmission.

670. Social Studies in Elementary and Secondary Education. (3-0). Credit 3. Methodology course focusing upon the implementation, both practical and theoretical, of the objectives of social studies: current trends, resource materials, demonstrations of teaching methods.

672. Curriculum and Methodology of Language Arts. (3-0). Credit 3. Advanced methodology course for teachers of language arts courses and their supervisors. Total curriculum development, attitudes and procedures for fostering developmental skills and creativity.

673. Analysis of Teaching Behavior. (3-0). Credit 3. Identification of beliefs and assumptions regarding teaching; review of research on teacher effectiveness; alternative methods for gathering data regarding dimensions of teaching behavior; development of teacher analysis systems.

674. Developmental Reading in the Elementary School. (3-0). Credit 3. Methods and materials of reading instruction in the elementary grades. Past, present and emerging programs; organization and administration of programs and classroom management; teaching reading to special groups; issues in reading.

675. Teaching Strategies: Patterns of Learning. (3-0). Credit 3. Learning and teaching theory and research applied to development of teaching strategies appropriate for various contents, objectives and instructional situations. Variables influencing learner behavior and approaches to optimization of teacher behavior. Prerequisite: E.Psy. 602 or 673 recommended.

676. Teaching Strategies: Critical Problems. (3-0). Credit 3. Critical issues in curriculum and instruction. Solving educational problems through observation and evaluation. Developing plans to gather information to improve education systems. Prerequisite: Approval of instructor.

677. Strategies for Teaching the Disadvantaged. (2-2). Credit 3. Research concerning the cognitive and affective aspects of learning relative to students from low socioeconomic status backgrounds. Practical applications to curriculum and instruction.

680. Proseminar. (1-0). Credit 1. Structured seminar on major concepts, principles and issues in education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Required of all Ed.D. students. May be repeated for credit. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Professional roles and responsibilities, research, special topics and other issues relevant to master's and doctoral students in curriculum and instruction.

684. Professional Internship. Credit 1 to 6 each semester. On-the-job training for educational curriculum and instruction majors under the supervision of successful, experienced personnel from the University. Conducted in a setting appropriate to the student's projected career aspirations and areas of specialization.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the field of education.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of curriculum and instruction. May be repeated for credit.

690. Theory of Curriculum and Instruction Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of curriculum and instruction. Communication of research proposals and results. Evaluation of current research of faculty and student and review of current literature. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for doctor of education degree. Preparation of a record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of major advisor.

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

C. R. Anderson, M. J. Ash, D. G. Barker, C. A. Borman (Head), L. A. Boyd, M. Duffy, E. T. Goetz, L. H. Hope, J. J. Koldus III, C. E. McCandless, J. F. McNamara, W. R. Nash*, D. J. Palmer, R. R. Reilley, C. R. Reynolds, A. J. Roach, D. Smith, W. F. Stenning, V. L. Willson

*Graduate Advisor

The Department of Educational Psychology offers study for the Ph.D. and Ed.D. degrees in educational psychology. Students seeking the Ph.D. may emphasize six areas of study: counseling psychology; gifted and talented education; human learning and development; planning, research and evaluation (college-wide); school psychology; and special education. While each of the areas can prepare students for employment as university teachers and researchers, non-academic careers can also be pursued in areas appropriate to the study programs. For example, the counseling psychology emphasis is designed to prepare students as counseling psychologists in college and university counseling centers or other social service settings. Each of the areas could lead to positions with school districts as program coordinators, staff specialists, school psychologists and the like.

Students seeking M.Ed. and M.S. degrees may pursue a general program of study or emphasize one of the following areas: agency counseling, gifted and talented education, school counseling and student personnel services. School counseling prepares students for certification by the Texas Education Agency as school counselors.

In conjunction with its training in all areas of study, the department operates the Educational Psychology Services Center as a vehicle for student preparation and as a service to the University, as well as to the public and its schools. The center provides a modern laboratory for practicum experiences in counseling, educational assessment and research.

Preparation as a professional in the areas of emphasis offered in the department requires attention to personal characteristics of the individual and his or her socialization into the profession as well as to successful completion of academic course work. In particular, students should exhibit an orientation toward fostering human development and possess characteristics conducive to helping relationships. Accordingly, the department requires that students desiring to pursue certification or degree programs satisfy the demands of the screening committee for the area of emphasis desired. These faculty committees require students to submit personal references, complete selected tests, and be interviewed by appropriate faculty members. Formal admission to a degree program, an area of emphasis or a certification program is contingent upon the appropriate screening committee's decision concerning the individual's total fitness and promise as a professional person in the area of emphasis for which application is made. Students in all areas of study will periodically have their total progress in professional development reviewed by a committee of the faculty offering that area of study to determine whether or not they shall be permitted to continue.

The deadline for fall admissions to the doctoral program is February 1. Admissions are announced on April 1. Potential master's students may apply at any time.

Field experiences in appropriate schools, colleges or social agencies are required in all degree programs. A full year of full-time, professional internship is required of all doctoral students in counseling psychology.

Because of the professional training involved, enrollment in a number of courses is limited to students majoring in the department. Some courses are limited to students admitted to specific areas of study. Approval by the department head is required for enrollment in these courses.

The department participates in interdisciplinary planning, research and evaluation offered in cooperation with other departments in the College of Education. Prospective doctoral students who wish to develop an interdisciplinary supporting field in educational planning, research and evaluation should examine the interdisciplinary studies option which is presented in the description of graduate courses in interdisciplinary education.

Within the framework of existing doctoral programs of the departments in the College of Education, individuals may pursue an area of emphasis in higher education. This emphasis in the department focuses on educational psychology and related services.

EDUCATIONAL PSYCHOLOGY
(E.Psy.)

602. Educational Psychology. (3-0). Credit 3. Scientific concepts of learning, memory, and the principle influences in learning process. Effects of development, aptitude, motivation, and environment on learning. Role of tests in learning.

612. Individual Assessment in Education. (3-0). Credit 3. Educational applications of individual assessment. Diagnostic measures of intelligence, language abilities, perception and achievement. Video-taping of student test administration is required for purposes of supervision and self-evaluation. Limited to 12 students per semester. Prerequisites: E.Psy. 622, Psy. 624; approval of department head.

614. Laboratory in Educational Assessment and Diagnosis. (1-6). Credit 3. Student test administration competencies and a minimum of 150 hours of supervised experience in administration, analysis, and reporting of individual diagnostic instruments. Prerequisites: E.Psy. 612; approval of department head.

618. Psychological Services in the Schools. (3-0). Credit 3. Practices and procedures of the psychologist in the school setting. Ethical and legal considerations, professional relationships, and emerging trends and issues.

619. Gifted and Talented Children. (3-0). Credit 3. Psychological characteristics of gifted and talented children. Introduction to identification techniques, educational programs, instructional approaches, and special problems. Prerequisite: Approval of instructor.

622. Measurement and Evaluation in Education. (3-0). Credit 3. Principles of psychological testing applied to education. Uses and critical evaluation of achievement and aptitude, interest, and personality tests and performance in educational settings.

625. Test Construction. (3-0). Credit 3. Planning, construction, analysis, and evaluation of written and performance tests. Test item analysis, reliability studies, and validity studies. Development of test norms, score transformations, and equivalent forms of tests. Prerequisite: E.Psy. 439 or 622.

626. Research Applications of Educational Measurement. (3-0). Credit 3. Psychometric theory applied to advanced problems of measurement in educational research. Principles underlying development and use of measurement methods in education. Prerequisites: E.Psy. 622, 625, Stat. 651, 652 or equivalents.

627. Structured Personality Assessment in Counseling. (3-0). Credit 3. Personality evaluation using structured assessment instruments; variety of self-report personality inventories; the Minnesota Multiphasic Personality Inventory. Prerequisites: E.Psy. 622; approval of department head.

630. Foundations of Guidance. (3-0). Credit 3. Philosophical, psychological, and sociological concepts fundamental to guidance and related helping professions.

631. Techniques of Counseling. (3-0). Credit 3. Methods and procedures descriptive of the counseling process. Dynamics of counselor-counselee relationship. Interviewing techniques. Use of test results in counseling. Prerequisites: E.Psy. 622 or 630; Psy. 634.

632. Educational and Occupational Information. (3-0). Credit 3. Theories of career development, sources, classification, and analysis of educational and occupational and social information. Occupational trends, local occupational surveys. Use of occupational information by classroom teacher and guidance specialist.

633. Introduction to Group Process. (2-3). Credit 3. Principles, procedures, and processes of group approaches to assisting individuals in their personal growth and development in educational settings. Participation as member of a personal growth group required. Prerequisite: E.Psy. 630.

634. Group Counseling. (3-0). Credit 3. Major contemporary approaches to group counseling. Experiential learning in a simulated group process. Integration of theory and practical applications. Prerequisites: E.Psy. 631 and 633 or equivalent.

635. Practicum in Group Counseling. (0-10). Credit 3. Supervised practice in application of group counseling strategies and methods to client types and social environments appropriate to the professional interests of counseling psychologists. Prerequisites: E.Psy. 639, 633, 634 and application six weeks prior to registration.

636. Techniques of Research. (3-0). Credit 3. Fundamental concepts and tools of research applied to psychological and educational problems. Rationale of research, analysis of problems, library skills, sampling, appraisal instruments, statistical description and inference, writing the research report, and representative research designs.

637. Experimental Design in Education. (3-0). Credit 3. Preparation in experimental research design in educational studies; application of statistical methods in these designs. Prerequisite: Six hours of statistics.

639. Counseling Practicum I. (2-3). Credit 3. Supervised experience in individual counseling. Cases assigned in the counseling laboratory on campus. Off-campus counseling in schools and various agencies also assigned at supervisor's discretion. Prerequisites: E.Psy. 631; approval of department head six weeks prior to registration.

646. Issues in Child and Adolescent Development for Educators. (3-0). Credit 3. Theoretical orientations, issues, research strategies, and empirical findings of developmental psychology relevant to education. Prerequisite: Psy. 634 or equivalent.

662. Issues and Trends in Counseling Psychology. (3-0). Credit 3. Recent research and developments affecting counseling psychology as a profession. Ethical considerations, professional relationships, emerging trends and issues.

664. Counseling Practicum II. (1-6). Credit 3. Supervised experience in individual and group counseling requiring advanced technical skills. Continuing counseling relationships with various, selected subjects. Prerequisites: E.Psy. 639; approval of department head six weeks prior to registration.

665. Psychology of Career Development. (3-0). Credit 3. Historical concepts, foundations, and present status of career development theory. Research, issues, practical applications, and future projections of career development theory.

666. Practicum in Counselor Supervision. (1-6). Credit 3. Supervised experience in directing counseling and guidance activities of students involved in practicum and field experiences. Intended for individuals preparing to become counselor educators or supervisors. Prerequisites: E.Psy. 664, approval of department head and application six weeks prior to registration.

668. Early Childhood Behavioral Development. (3-0). Credit 3. Social and individual factors affecting child development from conception to age 6. Implications of developmental psychology for early childhood education. Observation and research will augment the theoretical framework.

669. The College Student. (3-0). Credit 3. Nature, needs, and characteristics of American college students. Developmental tasks, peer group relations, and impact of college environment on student development. Research from behavioral sciences.

670. Student Personnel Work in Higher Education. (3-0). Credit 3. Survey of student personnel services in higher education; principles, philosophy, and major theoretical issues. Organization and administration of specialty areas.

672. Theories of Counseling. (3-0). Credit 3. Comprehensive and intensive study of major theoretical positions in counseling; implications for research and practice. Prerequisite: E.Psy. 631.

673. Learning Theories for Educators. (3-0). Credit 3. Comprehensive study of classical and current learning theories; their significance to modern education.

674. Verbal Learning and Verbal Behavior. (3-0). Credit 3. Current theory and research in verbal processes in children and adults. Variables influencing verbal learning. Application of research findings to educational programs involving verbal learning. Prerequisites: E.Psy. 673; approval of instructor.

675. Seminar in Counseling Psychology. (3-0). Credit 3. Intensive consideration of topics pertinent to professional activities of counseling psychologists. Ethical and legal considerations, emerging techniques, and program management. Prerequisites: E.Psy. 664, 672 and approval of department head.

676. Marriage and Family Counseling. (3-0). Credit 3. Basic concepts and techniques in marriage and family counseling. Marital communication and growth relationships. Prerequisites: E.Psy. 631, 633 and approval of department head.

680. Proseminar. (1-0). Credit 1. Structured seminar on major concepts, principles, and issues in education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Required of all Ed.D. students. May be repeated for credit. Prerequisite: Approval of instructor.

682. Seminar in . . . (1-0). Credit 1. Knowledge, skills, and attitudes in special education, counseling, psychological foundations of education, and school psychology. Specific topics are announced for each seminar offered. May be repeated for credit.

683. Field Practicum in . . . Credit 1 to 4. Supervised experience in professional employment settings in educational psychology. Wide range of practical experiences and activities as listed below that are closely supervised by departmental faculty. Repeatable to twelve hours total. Prerequisite: Approval of instructor.

a — Special Education
b — Guidance
c — Educational Assessment
d — School Psychology
e — Counseling Psychology
f — Instructional Psychology
g — Applied Research
h — Gifted and Talented Education

684. Professional Internship. Credit 1 to 4 each semester. Limited to advanced doctoral students. University-directed experience in a professional employment setting. Full-time participation and responsibility in experiences related to career specializations in counseling or school psychology. Repeatable to 9 hours total. Prerequisite: Approval of department head six weeks prior to registration.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of educational psychology. May be repeated for credit.

690. Theory of Educational Psychology Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of educational psychology. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study or project undertaken as the terminal requirement for Doctor of Education degree. Preparation of a record of study summarizing the rationale, procedure, and results of the completed project. Prerequisite: Approval of major advisor.

SPECIAL EDUCATION
(Sp.Ed.)

608. Psychosocial Variables in Special Education. (3-0). Credit 3. Social and personality characteristics of pupils in special education settings. Relevant research and theories. Implications for future educational practice and research. Prerequisite: Sp.Ed. 610 or equivalent.

610. The Exceptional Child. (3-0). Credit 3. Exceptional and handicapped individuals: identification, characteristics, remedial, and treatment programs. Implications for educational intervention for regular and special educators.

611. Learning Characteristics of Exceptional Children. (3-0). Credit 3. Learning behavior of exceptional children. Educational, psychological, and medical information relevant to the learning-disabled in public schools. Educationally relevant conceptual models.

613. Individualized Teaching of Exceptional Children. (3-0). Credit 3. Teaching strategies for exceptional children. Management of educational data on individual pupils. Collection, analysis, teacher interpretation of data, and formulation of recommendations for educational change. Prerequisite: Sp.Ed. 610, 611, or approval of department head.

615. Individual Instruction Programming. (1-6). Credit 3. Laboratory experiences in developing prescriptions for individual teaching of learning-disabled children. Translation of diagnostic test results into programs of individual instruction. Prerequisite: Sp.Ed. 613.

616. Field Experiences in Special Education. (1-6). Credit 3. Participation in an approved special education program. Supervised by course professor and a certified professional in special education. A minimum of 150 hours of scheduled, supervised experience, daily log of pertinent activities, and an in-depth case study required. Prerequisites: E.Psy. 614 or Sp.Ed. 615; approval of department head.

EDUCATIONAL TECHNOLOGY

(See Industrial Education)

DEPARTMENT OF ELECTRICAL ENGINEERING

P. E. Allen, A.-K. Ayoub, S. P. Bhattacharyya, A. J. Blanchard, C. W. Brice III, R. K. Cavin III, A. K. Chan, B. K. Colburn, J. S. Denison, A. J. Druce, O. Eknoyan, T. R. Fischer, R. L. Geiger, J. D. Gibson, D. M. Green, N. C. Griswold, D. R. Halverson, M. Ham, J. W. Howze*, W. B. Jones, Jr. (Head), J. S. Kilby, R. D. Nevels, R. W. Newton, P. S. Noe, J. H. Painter, R. K. Pandey, D. L. Parker, W.A. Porter, V. T. Rhyne, B. D. Russell, C. Singh, N. R. Strader II, L. Tsang

*Graduate Advisor

The Department of Electrical Engineering offers programs for graduate study leading to the research-oriented master of science and doctor of philosophy degrees and to the professional master of engineering degree. Courses in the department may also be applied to the interdisciplinary doctor of engineering degree. The M.S. and Ph.D. programs provide specialization in-depth and include a research (thesis or dissertation) requirement. The M.Eng. and D.Eng. programs are designed to provide the depth and breadth necessary for the practice of engineering at advanced levels.

Current areas of specialization include digital systems and computers, communications, controls, linear and nonlinear systems theory, digital signal processing, solid state electronics, analog circuits, power, electromagnetics and instrumentation systems. Interdisciplinary engineering programs are available with other areas of specialization.

Well equipped laboratories are available for work in all of these areas. Special laboratory facilities are available to graduate students in solid-state electronics, integrated circuit design, remote sensing and electric power systems. A DEC VAX 11/780 computer and other mini- and micro-computers are available for computer aided design, digital signal processing and other research programs.

There is no foreign language requirement for the Ph.D. or D.Eng. programs in electrical engineering.

(E.E.)

601. Linear Network Analysis. (3-0). Credit 3. Signal theory treatment of continuous and discrete signals and systems. Vector spaces, projection and sampling theories, Fourier, Laplace and Z Transforms.

605. Linear Control Systems. (3-3). Credit 4. Application of state variable and complex frequency domain techniques to analysis and synthesis of multivariable control systems. Prerequisite: E.E. 420 or equivalent.

606. Nonlinear Control Systems. (3-0). Credit 3. Techniques available to analyze and synthesize nonlinear and discontinuous control systems. Modern stability theory, time-varying systems, DF, DIDF, Lyapunov Theory, adaptive control, identification and design principles for using these concepts. Examples are drawn from a variety of electronic and electromechanical systems. Prerequisite: E.E. 605.

615. Methods of Electric Power Systems Analysis. (3-0). Credit 3. Digital computer methods for solution of the load flow problem. Load flow approximations. Equivalents. Optimal load flow. Prerequisite: E.E. 460 or approval of instructor.

620. Network Theory. (3-0). Credit 3. Development and application of advanced topics in circuit analysis and synthesis in both the continuous and discrete time and frequency domains. Prerequisites: E. E. 323 and 326 or equivalent.

622. Active Network Synthesis. (3-0). Credit 3. Methods of analyzing and synthesizing active networks. Sensitivity analysis, methods of rational fraction approximation, OP AMP modeling and stability. Prerequisite: E.E. 457 or equivalent.

626. Analog Circuit Design. (3-0). Credit 3. Principles of designing analog circuits suitable for integrated circuit fabrication. Fabrication techniques from a designer's viewpoint; student will design and build on a multichip basis an actual integrated circuit of own design. Circuit modeling and analysis. Prerequisites: E.E. 326 and 457 or equivalent.

628. Linear System Theory. (3-0). Credit 3. Application of functional analysis and geometric concepts to the analysis and synthesis of control systems. Prerequisite: E.E. 605.

633. Optimum Control Systems. (3-0). Credit 3. Variational approach to the development of algorithms for the solution of optimum control problems. Necessary and sufficient conditions, numerical methods, and analysis and comparison of optimal control results to classical theory. Prerequisite: E.E. 605.

635. Electromagnetic Theory. (3-0). Credit 3. Maxwell's equations, boundary conditions, Poynting's theorem, electromagnetic potentials, Green's functions, Helmholtz's equation, field equivalence theorems; applications to problems involving transmission scattering and diffraction of electromagnetic waves. Prerequisites: E. E. 322 and 451 or equivalent.

638. Antennas and Propagation. (3-0). Credit 3. Application of Maxwell's equations to determine electromagnetic fields of antennas. Radiation, directional arrays, impedance characteristics, aperture antennas. Prerequisite: E.E. 451.

643. Electric Power System Reliability. (3-0). Credit 3. Design and application of mathematical models for estimating various measures of reliability in electric power systems. Prerequisite: E.E. 460 or approval of instructor.

644. Discrete-Time Systems. (3-0). Credit 3. Linear discrete time systems analysis using time domain and transform approaches. Digital filter design techniques with digital computer implementations. Prerequisite: E. E. 601.

646. Statistical Communication Theory. (3-0). Credit 3. Concepts of probability and random process theory necessary for advanced study of communications, stochastic control, and other electrical engineering problems involving uncertainty. Applications to elementary detection and estimation problems. Prerequisite: Registration in E.E. 601 or approval of instructor.

647. Information Theory. (3-0). Credit 3. Definition of information; coding of information for transmission over a noisy channel including additive gaussian noise channels and waveform channels; minimum rates at which sources can be encoded; maximum rates at which information can be transmitted over noisy channels. Prerequisite: E.E. 646 or equivalent probability background.

648. Electromagnetic Wave Propagation. (3-0). Credit 3. Electromagnetic surface waves; direct and ground-reflected space waves; tropospheric refraction, reflection and scattering; ionospheric refraction, reflection and scattering. Prerequisite: E.E. 451.

650. Control of Dynamic Stochastic Systems. (3-0). Credit 3. Optimum stochastic control, estimation and identification techniques with application to communication and control systems. Dynamic programming algorithms developed for the control of uncertain dynamic systems. Kalman filtering algorithms developed in the context of state estimation for dynamic stochastic systems. Prerequisites: E.E. 646, 605.

651. Microprogrammed Control of Digital Systems. (3-0). Credit 3. Hardware and software concepts involved in the design and construction of microprocessor-based digital systems. Microprocessor architecture; bussing; interfacing; data input/output; memories; and software development for operation and testing. Design projects with microprocessors and related components. Prerequisite: E.E. 448 or approval of instructor.

652. Digital Systems Design. (3-3). Credit 4. Digital systems design; synchronous sequential machines, iterative networks, fast tabular minimization algorithms, state reduction, state assignment optimization, partition theory and incompletely specified machines. Practical

case studies in digital systems design in the laboratory emphasize individual effort in the use of hardware (or software) applications for practical real-world problems.

653. Electronic Computer Design. (3-3). Credit 4. Design of digital computers; arithmetic unit design, control, and memory. High-speed addition, subtraction, multiplication and division; micro- and macro-programming; magnetic memory devices. Design with integrated circuit components; MSI devices. Prerequisite: E.E. 448.

655. Asynchronous Switching Circuit Design. (3-0). Credit 3. Design of asynchronous sequential switching circuits; primitive flow-tables, state reduction, state assignment, hazards and delay. Relationship of asynchronous to synchronous digital systems; the need for race-free assignments in asynchronous design. Prerequisite: E.E. 448 or equivalent.

656. Physical Electronics. (3-0). Credit 3. Elementary quantum theory. Statistical mechanics. Lattice dynamics. Semiconductor theory. Dielectrics. Magnetic materials. Quantum electronics. Introduction to quantum devices, such as the laser. Prerequisite: Graduate classification or approval of instructor.

661. Modulation Theory. (3-0). Credit 3. Optimum receiver principles and signal selection for communication systems with and without coding; system implementation, and waveform communication using realistic channel models. Prerequisite: E.E. 646.

662. Estimation and Detection Theory. (3-0). Credit 3. Probabilistic signal detection theory and parameter estimation theory. Neyman-Pearson, UMP, and locally optimal tests. Discrete time Markov processes and the Kalman and Wiener filters. Bayesian, maximum likelihood and conditional mean estimation methods. Prerequisite: E.E. 646.

665. Electric Power Systems Engineering. (3-0). Credit 3. Electric power system engineering: transient voltages in power systems, electric utility economics, evaluation of power generation sources, d-c power transmission, load forecasting and current problems of interest. Group study, reports, design problems. Prerequisites: Graduate classification; approval of instructor.

666. Power System Faults and Protective Relaying. (3-0). Credit 3. Calculation of power system currents and voltages during faults. Protective relaying principles, application and response to system faults. Prerequisite: E.E. 460 or approval of instructor.

667. Power System Stability. (3-0). Credit 3. Steady-state, dynamic and transient stability of power systems. Solution techniques. Effect of generator control systems. Prerequisite: E.E. 460 or approval of instructor.

670. Microwave Semiconductor Devices. (3-0). Credit 3. Basic theory of solid state microwave devices and mathematical formulations leading to the development of their equivalent circuits. Tunnel diode, IMPATT diode, BARITT diode, Schottky gate FETs and IMPATTs, bulk-effect devices, Gunn diode, optoelectronic devices. Prerequisites: E.E. 656 or registration therein; graduate classification.

671. Solid State Devices. (3-0). Credit 3. Development of mathematical analysis and systematic modeling of solid state devices. Relationships of measurable electrical characteristics to morphology and material properties of solid state devices, p-n junction, bipolar and unipolar transistors. Prerequisite: E.E. 656 or approval of instructor.

673. Fundamentals of Microelectronics. (3-0). Credit 3. Microelectronic systems and fabrication technologies; methods of engineering analysis and device characterization. Junction diodes, Schottky diodes, bipolar transistors, junction and MOS field-effect devices, solar cells, light emitting diodes, charge coupled devices, magnetic bubbles, liquid crystal displays, and other newly developed devices and circuits. Prerequisite: Graduate classification or approval of instructor.

677. Control of Electric Power Systems. (3-0). Credit 3. Modeling, analysis, and real-time control of electric power systems to meet the requirements of economic dispatch of voltage and power. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Reports and discussion of current research and of selected published technical articles. May not be taken for credit more than once in master's degree program nor twice in Ph.D. program. Prerequisite: Graduate classification in electrical engineering.

684. Professional Internship. Credit 1 to 4. Engineering research and design experience at industrial facilities away from the Texas A&M campus. Design projects supervised by faculty coordinators and personnel at these locations. Projects selected to match student's area of specialization. Prerequisites: Graduate classification and one semester of coursework completed.

685. Problems. Credit 1 to 4 each semester. Research problems of limited scope designed primarily to develop research technique.

689. Special Topics in . . . Credit 1 to 4. Advanced topics of current interest in electrical engineering. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

ENGINEERING

681. Professional Development Seminar. (1-0). Credit 1. Topics of interest related to the professional practice of engineering.

684. Professional Internship. Credit 1 or more each semester. Supervised experience of one academic year in industry where students can learn to apply their textbook-based skills to problems in the real-world environment. Prerequisites: Admission to the doctor of engineering program and graduate classification.

DEPARTMENT OF ENGINEERING DESIGN GRAPHICS

J. T. Coppinger*, J. H. Earle* (Head), R. A. Hartman, T. C. Pollock

*Graduate Advisor

The graduate courses in engineering design graphics provide a supporting area for advanced degrees for those who are preparing for the teaching profession and industry.

Modern facilities and current equipment are available to enhance study and instruction. These facilities include a complete graphics library, a reproduction and visual aids center, photographic and darkroom facilities, a graduate study area, modernly equipped classrooms with closed-circuit television, a computer graphics facility and special equipment for each course.

(E.D.G.)

603. Engineering Graphics Standards. (3-0). Credit 3. Current engineering practices; application of ANSI standards. Metrication, tolerances of position and form, techniques of preparing standard types of working drawings. Prerequisite: E.D.G. 105.

610. Technical Illustration I. (3-0). Credit 3. Introduction to technical illustration; pictorial systems: axonometrics, obliques, and perspectives. Shade and shadow theory; industrial applications, short cuts, and time-saving techniques. Prerequisites: E.D.G. 105 or approval of instructor.

611. Technical Illustration II. (3-0). Credit 3. Introduction to commercial methods and materials of technical illustration. Preparation of illustrations for reproduction. Report illustration, illustration for publications. Time-saving techniques and methods. Various media including airbrush renderings.

685. Problems. Credit 1 to 4 each semester. Special research problems to fit needs of the individual student. Prerequisites: E.D.G. 106; I.Ed. 323; graduate classification; approval of instructor.

DEPARTMENT OF ENGINEERING TECHNOLOGY

C. A. Bertrand, J. F. Botsford, T. W. Comstock*, D. W. Morgan, D. A. Rice

*Graduate Advisor

The graduate program in engineering technology offers courses leading to the master of science degree in industrial technology. This program interfaces with engineering, psychology, the physical and biological sciences, business administration and a number of other programs. Minors or supporting areas are permitted in these and other areas.

The master of science degree in industrial technology provides graduate level instruction for the individual seeking preparation for technical-management, production-supervision, technical sales, industrial sales management and mid-management positions in industry. Instruction in the major department involves an in-depth, technical study of production and manufacturing related functions. Instruction in supporting areas provides opportunity for further development of a selected technical specialty, or to further broaden training in areas generally supportive of a selected technical specialty. The degree is intended primarily to add depth of an application oriented nature to related undergraduate programs, especially industrial distribution, industrial technology, and engineering technology. The degree may be planned for 32 semester hours including a thesis or 36 hours without a thesis.

(E.T.)

604. Industrial Communications and Training Systems. (2-2). Credit 3. Industrial communications techniques; development of industrial survey research, conference and committee programs, large and small group presentations, in-house bulletins, industrial employee training programs and other operating communications procedures. Prerequisite: E.T. 404 or approval of department head.

620. Industrial Plant Operations. (3-0). Credit 3. Industrial plant operations as applied to the factors involved in making day-to-day and long range operational decisions. Survey of techniques currently in use in industry for making decisions about such things as plant location, layout, control and material flow. Prerequisites: C.S. 201, E.T. 429 or equivalent or approval of department head.

626. Machine Tool Production and Management. (2-3). Credit 3. Machine tool operations as applied to production of metal goods. Evaluation, selection and set up of tooling for operation of equipment; production machine tools including numerical control machine tools. Scheduling and metal goods production management practices. Prerequisite: E.T. 380 or equivalent.

629. Industrial — Technological Supervision. (3-0). Credit 3. Modern industrial supervision techniques with regard to interpersonal relationships, societal changes, and the effects of technological developments. Prerequisite: E.T. 429 or equivalent.

635. Industrial Automation. (2-2). Credit 3. Principles and techniques of automating machine tool operations and industrial processes. Prerequisites: E.T. 403 or registration therein; E.T. 447 or equivalent.

636. Materials Technology. (2-2). Credit 3. Characteristics and application of the newer materials of industry. Materials research techniques and materials-oriented product development. Prerequisite: E.T. 207 or approval of department head.

681. Seminar. (1-0). Credit 1 each semester. Group study and discussion of current developments and problems related to the various technology options. Films, reports and discussions with industrial representatives. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 4 each semester. Designed to allow master's candidates to undertake and complete with credit limited investigations not within thesis research and not covered by other courses. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of engineering technology. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis in technology option. Prerequisite: Graduate classification.

DEPARTMENT OF ENGLISH

H. Andreadis, S. L. Archer*, R. W. Barzak, D. A. Berthold, F. D. Burt*, M. B. Busby, G. H. Cannon, P. Christensen, W. B. Clark, R. H. Costa, E. Cowan, J. Crane, T. W. Crusius, C. Dale, C. L. Gibson, N. S. Grabo*, S. A. Grider, J. P. Guinn, Jr., P. C. Hunter, Jr., T. H. Jordan, R. S. Kellner, H. P. Kroitor, J. A. Lepick, J. Loving, C. Machann, K. A. O'Keeffe, P. A. Parrish, L. J. Reynolds, M. Richardson, D. H. Stewart* (Head), W. C. Turner, J. E. Van Domelen, E. C. Want

*Graduate Advisor

The graduate program in English offers courses leading to the degrees of master of arts and doctor of philosophy. Graduate study increases understanding and appreciation of English and American literature, provides training in techniques of critical investigation, broadens understanding of the English language, and enhances skill in the use of the language. Graduate work in English prepares students primarily for teaching in schools, community colleges and universities. It can also prepare them for careers in linguistics, writing, editing and other professional and business fields.

Both the M.A. degree (thesis option) and the M.A. degree (non-thesis option) require Engl. 603. In addition, the thesis option requires nine hours of course work in literature, and the non-thesis option requires 12 hours of course work in literature. The thesis may be written on a subject in English literature, American literature, linguistics or rhetoric and composition.

A minimum of 64 credit hours beyond the M.A., or 96 hours beyond the B.A., is required for the Ph.D. degree in English. The student's program must include a minor of 12 hours. The dissertation may be written on a subject in English literature, American literature, linguistics or rhetoric and composition.

To be admitted to either program, a student should have a baccalaureate degree and should gain admission to the Graduate College. Students who hold baccalaureate degrees in fields other than English may be admitted provisionally and required to make up deficiencies. A Ph.D. candidate will normally be expected to hold the M.A. degree.

A student may meet the Ph.D. language requirement by demonstrating comprehensive knowledge of one language, or reading knowledge of two languages, or reading knowledge of one language plus six hours of course work assigned by the student's committee.

(Engl.)

603. Bibliography and Literary Research. (3-0). Credit 3. Introduction of basic techniques of research and scholarly procedure in literature. Research reports.

605. Old English. (3-0). Credit 3. Cross-listed with Ling. 605. Introduction to Old English literature and language (phonology, morphology, syntax, lexicon and dialectology) through extensive reading of the literature of the period. Research papers. Credit cannot be given for both Engl. 605 and Ling. 605.

606. Beowulf. (3-0). Credit 3. Cross-listed with Ling. 606. Literary and linguistic study of Beowulf. Prerequisites: Engl. 605, Ling. 610; or approval of instructor. Credit cannot be given for both Engl. 606 and Ling. 606.

610. History of the English Language. (3-0). Credit 3. Cross-listed with Ling. 610.

612. Chaucer. (3-0). Credit 3. Cross-listed with Ling. 612. A literary and linguistic study of Chaucer's works. Bibliographical reports and research papers. Credit cannot be given for both Engl. 612 and Ling. 612.

613. Studies in the Renaissance. (3-0). Credit 3. Drama of the English Renaissance, exclusive of Shakespeare. Research papers.

614. Studies in the Renaissance: Nondramatic Literature. (3-0). Credit 3. Major writers of nondramatic prose and poetry of the English Renaissance.

615. Seventeenth Century English Literature. (3-0). Credit 3. Poetry and prose of chief writers of 17th century: Bacon, Donne, Jonson, Herrick, Milton and Dryden. Research papers.

616. Studies in the Eighteenth Century: The Age of Pope. (3-0). Credit 3. Poetry and prose to 1750, concentrating on Defoe, Addison, Swift, Pope and Smollett; aesthetic, scientific, and religious ideas. Research papers.

617. Studies in the Eighteenth Century: The Age of Johnson. (3-0). Credit 3. Prose, including the novel, in latter half of century, concentrating on Fielding, Johnson, Boswell, Goldsmith and Sterne; aesthetic, scientific and philosophic ideas. Research papers.

619. Studies in Shakespeare. (3-0). Credit 3. Readings in Shakespeare's plays with attention to requirements and needs of individual students; sources of plays; textual studies; parallel readings in Shakespearean criticism from 18th century to present. Research papers. Prerequisite: A course in Shakespeare.

620. Business Communication. (1-0). Credit 1. Cross-listed with B.A. 620. Prerequisite: Approval of instructor.

621. Milton and His Contemporaries. (3-0). Credit 3. Poetry and prose of John Milton, with emphasis on *Paradise Lost.* Milton's predecessors and contemporaries as they contribute to understanding the milieu of Milton. Research papers.

631. Studies in the Nineteenth Century: Earlier Romantics. (3-0). Credit 3. The major earlier Romantic writers of poetry and prose, with concentration on two or three authors each time course is offered. Representative authors: Blake, Wordsworth, Coleridge, Lamb, Hazlitt. Research papers.

633. Studies in the Nineteenth Century: Later Romantics. (3-0). Credit 3. The major later Romantic writers of poetry and prose, with concentration on two or three authors each time the course is offered. Representative authors: Byron, Shelley, Keats, DeQuincey. Research papers.

634. Studies in the Nineteenth Century: The Victorian Age. (3-0). Credit 3. Prose and poetry from Carlyle to Shaw. Research papers.

635. Studies in Victorian Poetry and Prose. (3-0). Credit 3. Major Victorian writers of poetry and nonfiction prose, with concentration on two or three authors each time the course is offered. Representative authors: Tennyson, Browning, Rossetti, Morris, Swinburne, Arnold, Carlyle, Ruskin, Mill, Newman, Pater, Shaw. Research papers.

641. Studies in the English Novel. (3-0). Credit 3. Major English novelists from 1740 to 20th century. Analysis of eight to ten novels — style, characterization, plot, atmosphere and social commentary — against their intellectual, historical and social backgrounds. Research paper.

647. Studies in Modern British Drama. (3-0). Credit 3. Dramatic literature of British Isles from 1880's to present, with some consideration of influence from the Continent. Representative dramatists: Wilde, Shaw, Pinero, Barrie, Galsworthy, Synge, O'Casey, Eliot, Fry, Osborne. Research papers.

649. Studies in the Twentieth Century: British Literature. (3-0). Credit 3. Selected authors since 1900: Yeats, Joyce, Huxley and others. Development of particular literary movement or literary form. Research papers.

650. Studies in the Twentieth Century: American Literature. (3-0). Credit 3. Selected authors since 1900: Robinson, Frost, Eliot, Lewis, Faulkner, Hemingway and others. Particular literary movement or literary form. Research papers.

654. History of Rhetoric to 1900. (3-0). Credit 3. Key concepts of rhetoric, surveying primary authors and works from 5th century Greece to the 19th century.

655. Modern Rhetorical Theories. (3-0). Credit 3. Works of modern rhetorical theorists, including Burke, Richards, Ong, Moffet, Young, Christensen, Perelman, Kinneavy and others; application and evaluation of these theories.

660. Technical Writing for Publications. (3-0). Credit 3. Organization, presentation and style of reports and articles in professional journals. Article or articles of substantial length from the student's research are required.

661. Analysis of Composition. (3-0). Credit 3. Practice and theory in organization — sentence, paragraph, development of paper; rhetorical analysis of expository writing; diction, writing and assigning compositions; teaching techniques.

662. Analysis of the English Language. (3-0). Credit 3. Cross-listed with Ling. 662. Phonological, morphological, syntactic and lexical components of the English language; transformational theory as well as traditional and structural grammar. Credit cannot be given for both Engl. 662 and Ling. 662.

663. Analysis of Literature. (3-0). Credit 3. Characteristics of literature: point of view, structure, techniques of development, style and rhetorical devices, and theme and meaning. Types of literature: poetry, plays, novel, short story. Literary criticism: principles and application.

664. Analysis of Business and Technical Writing. (3-0). Credit 3. Theory of teaching business and technical writing. Evaluation of current research and its relation to current practice.

671. Studies in American Literature: The Beginnings to 1820. (3-0). Credit 3. Colonial, Revolutionary, and Post-Revolutionary literature and the backgrounds; various forms of early literature and individual writers. Research papers.

672. Studies in American Literature: The Literary Milieux of Poe, Hawthorne, and Melville. (3-0). Credit 3. Selected works of Poe, Hawthorne, Melville, and other writers and literary groups associated with American romanticism. Research papers.

674. Studies in American Literature: The Age of Transcendentalism. (3-0). Credit 3. Backgrounds of transcendentalism in Europe; the movement in the U.S.; works of Emerson, Whitman, Thoreau and others. Research papers.

675. Studies in American Literature: The Gilded Age. (3-0). Credit 3. Social and literary backgrounds of Gilded Age; emergence of American humor and realism, and their development in Mark Twain and early Henry James. Research papers.

677. Studies in American Poetry. (3-0). Credit 3. Major American poets — for example, Edward Taylor, Poe, Whitman, Emily Dickinson, Robert Frost — and the influence of American poetry and American culture on each other. Research papers.

683. Theory and Practice of Literary Criticism. (3-0). Credit 3. Important theories of literary criticism for students of English and American literature; functional emphasis in critical practice. Research papers.

685. Problems. Credit 1 to 6 each semester. Readings to supplement the student's knowledge of English or American literature or of the English language in areas not studied in other courses. Research papers. Prerequisites: Graduate classification; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of English. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of English Research. (3-0). Credit 3. Theory of investigative research in areas of English (e.g. rhetoric-composition, linguistics, literature); current research and its application. Evaluation of current research and its relation to programs. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis.

697. Seminar in the Teaching of English Composition. (3-0). Credit 3. Theory of teaching of college composition and rhetoric. Supervised teaching. Evaluation of current research and its relation to current practice. May be repeated for credit with three credit hours applying toward any degree.

LINGUISTICS
(Ling.)

602. Sociolinguistics. (3-0). Credit 3. Interrelationships between sociology and linguistics, especially the particular qualities of a given group's speech that help lead to social and economic barriers against that group; the role of language as chief vehicle of communication in a given sociological situation. Prerequisite: Approval of instructor.

605. Old English. (3-0). Credit 3. Cross-listed with Engl. 605. Credit cannot be given for both Engl. 605 and Ling. 605.

606. Beowulf. (3-0). Credit 3. Cross-listed with Engl. 606. Credit cannot be given for both Engl. 606 and Ling. 606.

608. General Linguistics: Syntax and Semantics. (3-0). Credit 3. Nature and structure of language; work in phonetics and phonemics, morphology, syntax, lexicography and generative-transformational models. Prerequisite: Course in linguistics.

610. History of the English Language. (3-0). Credit 3. Inductive study of phonological, grammatical and lexical history of English language, with brief discussion of some other Indo-European languages; kinds and principles of linguistic changes in general, as reflected in English. Cross-listed with Engl. 610. Prerequisite: Engl. 662 or approval of instructor.

612. Chaucer. (3-0). Credit 3. Cross-listed with Engl. 612. Credit cannot be given for both Engl. 612 and Ling. 612.

625. Applied Linguistics: English as a Second Language. (3-0). Credit 3. Relevant linguistic principles, organization and methodology in TESOL for non-native speakers of English; development and administration of TESOL in U.S. and abroad. Prerequisites: Ling. 409 or equivalent and Ling. 602 or 662.

662. Analysis of the English Language. (3-0). Credit 3. Cross-listed with Engl. 662. Credit cannot be given for both Engl. 662 and Ling. 662.

666. Language Varieties: Regional and Social. (3-0). Credit 3. Methods and principles of linguistic dialectology; close work with published fascicles of the Linguistic Atlas of the U.S. and Canada and other data, as modified by dialectal implications from transformational theory. Prerequisites: Approval of instructor.

667. Linguistics and Literature. (3-0). Credit 3. Linguistic methods and principles applicable to understanding of literature, with a view to development of student's skills in making linguistic analyses of various kinds of literature. Prerequisites: Engl. 662 or 666; or approval of instructor.

669. Theory of Grammar. (3-0). Credit 3. Major 20th-century approaches to grammar and their implications for the description and teaching of language, especially English. Prerequisite: One graduate linguistics course or approval of instructor.

DEPARTMENT OF ENTOMOLOGY

P. L. Adkisson, D. E. Bay, J. H. Benedict, D. L. Bull, H. R. Burke, J. R. Cate, Jr., R. N. Coulson, R. L. Crocker, R. E. Frisbie, T. W. Fuchs, F. E. Gilstrap, O. H. Graham, R. L. Hanna, J. A. Harding, K. F. Harris, M. K. Harris, R. L. Harris, J. A. Jackman, L. L. Keeley, G. M. McWhorter, F. G. Maxwell* (Head), R. T. Mayer, Jr., R. W. Meola, J. K. Olson, T. L. Payne, F. W. Plapp, D. R. Rummel, J. C. Schaffner*, M. F. Schuster, J. E. Slosser, J. W. Smith, Jr., W. L. Sterling, M. D. Summers, M. H. Sweet, P. D. Teel, G. L. Teetes, J. G. Thomas, H. W. Van Cleave, S. B. Vinson, J. K. Walker, Jr.

*Graduate Advisor

Work is offered in the various phases of entomological science including taxonomy, morphology, parasitology, physiology, toxicology, ecology and economic, forest and urban entomology. Adequate facilities are available for research in these fields including well-equipped research laboratories. Modern analytical equipment for biochemistry and insecticidal determinations, including radioisotope techniques, is available as well as apparatus for insecticide toxicity studies. Insect biologies may be studied under controlled conditions of temperature, photoperiod and humidity. A large working collection of insects is available to students interested in taxonomic research.

Prerequisite to major graduate work is the completion of no less than two years of approved entomological training, except that for a part of this requirement credit in certain other biological sciences may be substituted. Comprehensive courses in the biological sciences and general chemistry (and, in most cases, organic chemistry) are required of all students. In addition to the elementary undergraduate courses pertaining to various lines of major work, specific requirements are dependent upon previous training and professional experience.

(Ento.)

601. Principles of Systematic Entomology. (3-0). Credit 3. Principles, methods and history of systematic entomology; literature, newer techniques in the field and International Rules of Zoological Nomenclature. Prerequisite: Graduate classification in entomology or other biological sciences.

602. Phylogeny and Classification of Insects. (3-0). Credit 3. Phylogenetic relationships of the classes of arthropods; evolution of insects. Geological history of insects. Classification and relationships of higher insect taxa. Prerequisite: Graduate classification in entomology or other biological sciences. (Offered in 1980-81 and alternate years thereafter).

605. Aquatic Entomology. (3-3). Credit 4. Principles and practices concerning aquatic entomology. Biology and classification of each group of aquatic insects. Basic concepts of limnology as they apply to insects. Techniques of collecting, mounting and rearing of aquatic insects. Prerequisite: Ento. 201 or 313 or approval of instructor.

607. Economic Entomology. (3-3). Credit 4. Biologies, economic importance and control of insects and other arthropods from a pest management viewpoint. Team taught by instructors specialized in various aspects of entomology. For non-entomology majors only with special emphasis on the needs of county agricultural agents, vocational agriculture teachers and private consultants. Prerequisite: Ento. 201 or equivalent.

608. Principles of Biological Control. (3-0). Credit 3. Theory and practices relating to the role and use of natural enemies in arthropod and plant population regulation; review and analysis of projects in biological control; biology and behavior of entomophagous arthropods. Prerequisite: Ento. 201 or equivalent or approval of instructor.

609. Invertebrate Pathology. (3-3). Credit 4. General invertebrate pathology and microbiology; noninfectious and infectious diseases of invertebrates, the biological relationships between microorganisms and invertebrates, and application of entomogenous pathogens in entomology. Prerequisite: One course in microbiology and Ento. 313 or equivalent; or approval of instructor. Cross-listed with Biol. 609.

610. Host Plant Resistance. (3-0). Credit 3. Host plant resistance programs from the standpoint of the plant breeder, plant pathologist, and entomologist. Team taught with each discipline represented. Roundtable discussion of assigned reading and lectures. Prerequisite: Approval of instructors. Cross-listed with Agro. 610 and Pl.Pa. 610.

615. Insect Physiology. (3-3). Credit 4. Physiological processes of insects; metabolism nutrition, neuro-endocrinology, nerve action, cell structure, respiration, circulation, excretion and flight. Functional integration and regulatory processes of total organism. Prerequisite: Ento. 306 or equivalent.

617. Acarology. (3-3). Credit 4. Systematics, morphology, physiology, and ecology of ticks and mites. Management of acarine pests of humans, animals and plants; role of parasitic species in causation and transmission of diseases. Prerequisite: Ento. 208 or equivalent.

618. Medical and Veterinary Entomology. (3-3). Credit 4. Taxonomy, biology, and epidemiological role of insects that directly and/or indirectly affect the health and well-being of humans and animals. Prerequisite: Ento. 208 or equivalent.

619. Insect Toxicology. (3-3). Credit 4. Classification and properties of major types of insecticides; chemistry, metabolism, and mode of action. Selectivity, use hazards, residues and resistance. Environmental problems: biological magnification, persistence and effects on nontarget organisms. Prerequisite: One course in organic chemistry, Ento. 615 or approval of instructor.

620. Insect Biochemistry and Endocrinology. (3-0). Credit 3. Recent information and concepts in the area of insect biochemistry. Intermediary metabolism and its regulation by hormones and the role of hormones in insect growth and development. Prerequisite: Background in physiology or biochemistry; or approval of instructor.

681. Seminar. (1-0). Credit 1. Oral reports and discussions of current research and developments in entomology and related fields; designed to broaden understanding of problems in field and to stimulate research. Prerequisite: Graduate classification.

684. Professional Internship. Credit 1 to 4 each semester. On-the-job training in the fields of pest identification, home and garden pest control, medical and veterinary pest control, and pest management of food and fiber crop pests. Prerequisite: Graduate classification in the master of agriculture program in economic entomology.

685. Problems. Credit 1 to 4 each semester. Entomological problems not pertaining to thesis or dissertation. Prerequisites: Graduate classification with major or minor in entomology; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of entomology. May be repeated for credit. Prerequisite: Graduate classification.

691. Research. Credit 1 or more each semester. Research problems on taxonomy, life histories, biological control, ecology and physiology of insects, and toxicology of insecticides. Prerequisite: Graduate classification.

DEPARTMENT OF FINANCE

S. K. Cooper*, W. E. Etter**, D. R. Fraser, J. P. Friedman, J. C. Groth, R. L. Haney, Jr., J. Meyer, C. A. Phillips, R. M. Richards (Head), P. S. Rose, G. C. Uselton

*Doctoral and M.S. Student Advisor
**M.B.A. Student Advisor

The Department of Finance offers graduate studies leading to M.B.A., M.S. and Ph.D. degrees and course work supporting the College of Business Administration's M.B.A. degree. These programs provide training in financial management.

The M.B.A. degree program consists of 48 credit hours of which 12 credits hours may be concentrated in the department. Areas of course work include corporate finance, management of financial institutions, investment management, money and capital markets and real estate finance. The M.S. degree program is designed to give a greater degree of specialization in finance. The Ph.D. program emphasizes financial theory and research tools and is structured to prepare students for teaching and/or research careers in finance.

Additional information, including specific departmental requirements, may be obtained by contacting the department or the office of the dean, College of Business Administration.

(Fin.)

629. Financial Management I. (3-0). Credit 3. Introductory course in M.B.A. program. Analysis of finance function, credit and equity markets, financing and dividend decisions; mechanics of financial analysis. Prerequisites: Acct. 640; B.Ana. 646.

630. Financial Management II. (3-0). Credit 3. Basic concepts of finance applied to solution of business problems. Financial analysis skills further developed and refined; investment and financing decisions analyzed. Prerequisites: Acct. 640; Fin. 629.

632. Investment Management. (3-0). Credit 3. Introductory course in investments. Nature and functioning of securities markets. Various investment media and tools for analysis of these media. Analysis of debt and equity securities. Alternative trading strategies evaluated. Prerequisite: Fin. 629 or approval of instructor.

634. Theory of Finance. (3-0). Credit 3. Theoretical issues and problems of finance. For doctoral or masters students who seek an in-depth understanding of theory underlying financial decision-making. Financial theory pertaining to investment, financing, and dividend decisions. Prerequisite: Fin. 630 or approval of instructor.

635. Financial Management for Engineers I. (3-0). Credit 3. External and internal factors affecting financial decision-making in the firm. Fundamental concepts of accounting and managerial economics. Prerequisite: Approval of advisor.

636. Financial Management for Engineers II. (3-0). Credit 3. Financial management of the business firm; financial analysis, financial planning, and asset management. Prerequisite: Fin. 635 or approval of graduate advisor.

637. Issues and Practices in Corporate Finance. (3-0). Credit 3. Financial theory and analysis. Case analysis is used, focusing on the financial decision-making process. Prerequisite: Fin. 630 or equivalent.

638. Management of Financial Intermediaries. (3-0). Credit 3. Functioning of various institutions. Differences in the asset and liability structures of institutions. Problems in financial intermediary management arising from changing economic conditions.

639. Real Estate Development Analysis. (3-0). Credit 3. Financial aspects of real estate development; project investment characteristics and merits. Prerequisites: Graduate classification; approval of instructor.

642. Analysis of Money and Capital Markets. (3-0). Credit 3. U.S. money and capital markets. Changes in the supply of and demand for money and capital as they influence the policies of financial intermediaries, fiscal and monetary authorities and nonfinancial firms. Interest rates; factors affecting their level and structure. Flow of funds in the U.S. economy. Prerequisite: Fin. 629 or approval of instructor.

645. International Finance. (3-0). Credit 3. Problems confronted by financial managers of firms with international business operations. International money and capital markets. Exchange rate risks and political risks. Prerequisite: Fin. 629 or approval of instructor.

660. State and Local Financial Administration. (3-0). Credit 3. Financial problems confronted by large cities. Principal problems of public financial management; planning, programming and budgeting; tax assessment and administration; debt management; financial reporting. Prerequisites: Graduate classification; approval of instructor.

670. Planning, Programming, Budgeting Systems. (3-0). Credit 3. Analytical techniques for identifying and selecting goals, developing alternative programs for reaching goals most efficiently, and measuring performance against costs of programs in both short-term and long-term contexts. Public sector of the economy. Prerequisites: Graduate classification; approval of instructor.

672. Real Property Finance. (3-0). Credit 3. Primary and secondary mortgage markets. Mortgage markets' institutional organization, alternative mortgage instruments, creative financing techniques, loan underwriting factors and risk hedging strategies. Prerequisite: Fin. 629 or approval of instructor.

673. Real Property Valuation. (3-0). Credit 3. Procedures used to estimate the market value of real property. Market analysis and valuation techniques most appropriate for appraising income-producing properties. Demonstration appraisal report. Prerequisites: Fin. 629 or equivalent or approval of instructor.

675. Analysis of Real Estate Investment Decisions. (3-0). Credit 3. Analytical techniques for real estate investment decision-making which emphasize the importance of income tax considerations, the magnitude of relevant cash flows, and the timing of both. Case histories used to analyze investment problems. Prerequisite: Fin. 629 and Acct. 640 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. Critical examination of subject matter presented in current periodicals, recent monographs and bulletins in field of finance.

685. Problems. Credit 1 to 4 each semester. Directed study of selected problems using recent developments in business research methods. Prerequisites: Graduate classification; approval of instructor.

688. Doctoral Seminar. (3-0). Credit 3. Historical development of the conceptual framework of finance theory and practices; analysis of current research and controversial issues in the field. For doctoral students only. Prerequisite: M.B.A. or equivalent.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of finance. May be repeated for credit.

690. Theory of Research in Finance. (3-0). Credit 3. Design of research in the various subfields of finance and the evaluation of research results using examples from the current research literature. May be repeated for credit. Prerequisite: Graduate classification in finance.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

FLORICULTURE

(See Horticultural Sciences)

FOOD SCIENCE AND TECHNOLOGY

E. E. Burns, O. D. Butler, Jr., Z. L. Carpenter, A. B. Childers, Jr., K. C. Diehl, Jr., C. W. Dill, T. R. Dutson, J. M. Faubion, G. Finne, F. A. Gardner, N. D. Heidelbaugh, G. T. King, O. R. Kunze, W. A. Landmann, R. W. Lewis, R. Nickelson, F. A. Orts, K. C. Rhee, K. S. Rhee, R. L. Richter, L. W. Rooney, L. H. Russell, Jr., J. W. Savell, G. C. Smith, D. A. Suter, V. E. Sweat, R. N. Terrell, C. Vanderzant

The interdepartmental curriculum in food science and technology is administered through the office of the dean of the College of Agriculture. Graduate training in food science and technology is designed to provide advanced training in the basic sciences, processing technology, and engineering with emphasis on foods. Courses of study lead to the degrees of master of science, master of agriculture or doctor of philosophy.

Departments participating in granting degrees in food science and technology include Agricultural Engineering, Animal Science (meat, seafood, and dairy products), Biochemistry and Biophysics, Horticultural Sciences, Poultry Science, Soil and Crop Sciences (cereals and oil seeds) and Veterinary Public Health. Programs may be developed from the offerings of various departments and colleges which serve the needs of a food scientist.

Degree programs for graduate students are prepared on an individual basis by the student's graduate committee in consultation with the student. Support areas such as microbiology, chemistry, nutrition, biochemistry, engineering, statistics and many others may be readily arranged.

A minimum of 32 semester hours and a thesis are required for the M.S. degree (thesis option); a minimum of 36 semester hours is required for the M.S. degree (non-thesis option). For the professional M.Agr. degree, a minimum of 36 semester hours and an internship are required. Six semesters of full-time graduate study (96 semester hours) beyond the B.S. degree and a dissertation are part of the minimum requirements for the Ph.D. degree.

(F.S.T.)

605. Chemistry of Foods. (2-3). Credit 3. Chemistry of dairy foods and meats relating to their composition and characteristic properties important to their subsequent manufacture into food products. Prerequisite: Bich. 410 or 603.

606. Microbiology of Foods. (3-0). Credit 3. Nature and function of beneficial and defect-producing bacteria in foods. Food-borne illness. Effects of processing, storage and distribution. Techniques for isolation and identification from foods. Cross-listed with D.S. 606.

607. Physiology and Biochemistry of Muscle as a Food. (2-2). Credit 3. Biochemical, histological, anatomical and physical characteristics of muscle cells and factors associated with transformation of muscle cells into meat. Prerequisite: Bich. 410 or approval of department head. Cross-listed with An.Sc. 607.

608. Seafood Preservation and Processing. (3-2). Credit 4. Principles and practices involved in the processing and preservation of seafood. Prerequisite: Chem. 232 and Biol. 206 or D.S. 320 or approval of department head.

611. Poultry Processing and Distribution Technology. (3-2). Credit 4. Poultry and egg composition, mechanisms of poultry and egg quality preservation, effects of storage environments, time and product treatment. Evaluation of commercial methods of product assembly, processing, distribution and quality control. Evaluation of physical, microbiological, functional and chemical methods of quality determination. Cross-listed with P.S. 611.

630. Cereal Grains for Human Food. (3-3). Credit 4. Fundamental concepts of dry milling, wet milling, oil extraction, baking, malting, brewing, storage, sanitation and quality evaluation and control interrelated with physical and biochemical properties of cereals and their products. Use of instruments and techniques to evaluate cereal quality. Prerequisite: Approval of instructor. Cross-listed with Agro. 630.

631. Chemical and Physical Characteristics of Cereals. (3-0). Credit 3. Properties of cereals and cereal products as affected by growth, storage and physical, chemical and biological factors. Dough structure and rheology and enrichment of cereal products. Prerequisite: Bich. 410. Cross-listed with Agro. 631. (Offered in 1980-81 and alternate years thereafter.)

634. Oilseed Proteins for Foods. (3-0). Credit 3. World production, composition, processing technologies, uses of products (oil, meal, protein concentrates and isolates, and texturized products) in feeds and foods; present and potential food applications of oilseed proteins. Prerequisites: Chem. 228, 317. Cross-listed with Agro. 634. (Offered in 1981-82 and alternate years thereafter.)

635. Oil and Fat Food Products. (3-0). Credit 3. Composition, properties and reactions; sources, handling and storage of raw materials; extraction refining and bleaching; hydrogenation, deodorization, esterification and interesterification; fractionation; uses in salad oils, shortenings, margarine, bakery products and other foods. Prerequisites: Chem. 228, 317. Cross-listed with Agro. 635. (Offered in 1980-81 and alternate years thereafter.)

636. Principles of Food Analysis. (3-0). Credit 3. Classical and modern analytical methods and instruments in terms of their principles, applications and limitations as applied to analyses of foods, food ingredients, food additives and other food products for chemical, physical, functional, nutritional and organoleptic characteristics. Cross-listed with Agro. 636. Prerequisites: Chem. 228, 317; F.S.T. 314 or approval of instructor.

644. Food Quality. (3-0). Credit 3. Physical, chemical and biological properties of foods. Fundamental attributes of flavor, color, odor, texture. Esthetic, ethnic and nutritional requirements. Role of additives. Regulatory standards and quality control regimes. Current techniques in food investigations. Cross-listed with Hort. 644. Field trip required for which departmental fee may be assessed to cover costs.

647. Technology of Meat Processing and Distribution. (3-0). Credit 3. Quantitative and qualitative characteristics of meat and meat products as related to food technology processing operations; manufacturing, preservation, packaging and merchandising. Cross-listed with An.Sc. 647.

657. Food Additives, Ingredients and Regulatory Compliance. (3-0). Credit 3. Identification nomenclature, purpose, and function of additives used in meat and non-meat food products. Governmental regulatory agencies, their organization and control over food ingredient labeling; commercial supplies and basic manufacturing operations used in food ingredients. Cross-listed with An.Sc. 657. Prerequisite: Approval of instructor.

667. Industrial Processed Meat Operations. (2-2). Credit 3. Application of scientific principles and business practices to manufactured meat products. Interrelationship among marketing, manufacturing, product development, regulatory compliance and quality assurance in commercial processed meat operations. Cross-listed with An.Sc. 667. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Oral reports and discussions of current research and developments in food technology designed to broaden understanding of problems and to stimulate research.

684. Professional Internship. Credit 1 to 4. Experience in application of formal training to a commercial operation under supervision of operations manager and designated faculty member. Student will investigate matter of mutual interest and report results in a professional paper approved by the graduate committee.

685. Problems. Credit 1 to 4 each semester. Directed study of selected problems emphasizing recent developments in research techniques.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of food science and technology. May be repeated for credit.

691. Research. Credit 1 or more each semester. Investigations leading to thesis or dissertation in various areas of food science and technology.

DEPARTMENT OF FOREST SCIENCE

T. E. Avery, R. D. Baker* (Interim Head), R. L. Bury, R. S. Dewers, D. F. Durso, A. W. Ezell, W. J. Lowe, J. G. Massey, R. G. Merrifield, T. L. Payne, E. J. Soltes, J. P. van Buijtenen

*Graduate Advisor

The objective of graduate education in the Department of Forest Science is to provide opportunities to extend knowledge and skills beyond those received at the baccalaureate level. Toward this end, the department offers programs leading to the M.Agr., M.S. and Ph.D. degrees.

Candidates for the M.Agr. degree pursue a multidisciplinary program in natural resources development. This is a professional program which is relatively broad in scope and which offers opportunities for student involvement in management and operational activities in the natural resource field. Candidates for the M.S. or Ph.D. degrees may include support courses from a number of disciplines related to the forest sciences, including ecology, economics, engineering (in cooperation with the Departments of Agricultural Engineering and Civil Engineering), entomology, genetics, mensuration, pathology, remote sensing, silviculture, soils and wood technology, and wood chemistry and wood energy. Much of the course work in these specialized disciplines is available through other departments within the University.

Standards for admission to either of the master's degree programs, or to the doctoral degree program, are as described in this catalog. The only exception is that Ph.D. students are required to complete a qualifying examination prior to registration in the second semester. The examination is administered in the candidate's proposed area of specialization by an appointed faculty committee. Standards for graduation from either of the master's degree programs, or from the doctoral degree program, are also as described in this catalog. There is no uniform foreign language requirement for the Ph.D. degree in forestry.

All of the Department's advanced degree programs are "unstructured" in terms of exact course content. This has the advantage of enabling degree candidates, with the advice and counsel of their graduate committee, to choose that set of courses which appears best suited to their background and educational aims.

(F.S.)

601. Forest Ecology. (3-0). Credit 3. Forest communities and successions, interrelationships of various life forms of forest stands. Occasional field trips. Prerequisite: Approval of instructor.

602. Advanced Silviculture. (3-0). Credit 3. Advanced silvicultural methods, techniques, and problems; current research and technical literature. Prerequisite: F.S. 305 or equivalent.

606. The Research Process. (3-0). Credit 3. Nature and objectives of graduate work, the scientific method, and basic and applied research. Introduction to design of experiments and analysis of data. Principles of organization of project proposals, theses, and scientific reports.

607. Chemistry and Utilization of Biomass. (3-2). Credit 4. Chemistry and processing of biomass materials; relationships between composition, component properties and current utilization. Opportunities and limitations inherent in the use of biomass materials as renewable food, chemicals and energy feedstocks for the future. Prerequisite: One semester of organic chemistry.

621. Management of the Urban Forest Resource. (3-0). Credit 3. Developing a complete tree management plan for any city. Environmental benefits of urban trees; tree ordinances; street inventory systems; funding sources for planting programs; and equipment and personnel needs. Prerequisite: Graduate classification.

633. Forest Genetics. (3-0). Credit 3. Cross-listed with Gen. 633.

634. Forest Genetics Laboratory. (0-3). Credit 1. Cross-listed with Gen. 634.

661. Photo Interpretation. (2-2). Credit 3. Photographic processes related to interpretation; principles, methods, and techniques of photo interpretation; applications in soils, engineering materials, geology, geomorphology, water resources, transportation, and urban planning. Prerequisite: Approval of instructor. Cross-listed with C.E. 661.

681. Seminar. (1-0). Credit 1. For graduate students and staff members in forestry. Presentation and discussion of current scientific work in forestry and closely related subjects.

684. Professional Internship. Credit 1 to 4. Application of forestry principles in a working environment. Prerequisite: Limited to graduate students seeking a professional degree in forestry.

685. Problems. Credit 1 to 4 each semester. Designed for investigations not included in students' research for thesis or dissertation. Problems to be selected in some aspect of forest science.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of forest science. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Research in an approved aspect of forest science for thesis or dissertation credit.

GENETICS

K. J. Aufderheide, E. C. Bashaw, C. R. Benedict, L. S. Bird, A. J. Bockholt, J. Caldwell, T. C. Cartwright, R. C. Fanguy, J. R. Gold, I. F. Greenbaum, G. E. Hart, J. R. Johnson, J. S. Johnston, N. M. Kieffer, R. J. Kohel, W. F. Krueger, H. O. Kunkel, C. R. Long, C. W. Magill, J. M. Magill, F. R. Miller, J. C. Miller, Jr., J. L. Nordstrom, G. A. O'Donovan, H. J. Price, P. J. Rizzo, K. F. Schertz, G. L. Schroeter, J. D. Smith, M. D. Summers, J. W. Templeton, J. P. van Buijtenen, J. R. Wild, J. E. Womack, R. F. Young

Genetics, the science of heredity and variation, occupies a central position in biology. Many of the recent significant research developments in the life sciences have occurred in this dynamic discipline. Multiple opportunities exist for the further development of genetic theory and for the application of genetic principles to improve animal and plant species.

Graduate study in the various areas of genetics is supervised by the interdepartmental genetics faculty, whose training, teaching and research are directly related to genetics. Supporting coursework is available in such fields as biochemistry, biophysics, computer science, cytology, pathology, physiology and statistics.

Research areas which may be pursued include biochemical genetics, cytogenetics, developmental genetics, immunogenetics, molecular genetics, population genetics, quantitative genetics and somatic cell genetics as well as forest genetics, animal breeding and plant breeding. Commonly used experimental organisms include bacteria and their viruses, Neurospora and other fungi and many species of higher plants and animals.

Graduate programs in genetics leading to the master of science and the doctor of philosophy degrees may be administered in the Departments of Animal Science, Biochemistry and Biophysics, Biology, Forest Science, Plant Sciences, Poultry Science, Range Science and Soil and Crop Sciences. Graduate assistantships and fellowships are available in each department. Applications to the Graduate College should specify the department in which the student expects to do research. The language requirement will be determined by the student's administrative department.

For course descriptions of the following, see the respective departmental listings.

ANIMAL SCIENCE
(An.Sc.)

616. Quantitative Genetics II. (3-0). Credit 3.

628. Animal Breeding. (2-2). Credit 3.

FOREST SCIENCE
(F.S.)

633. Forest Genetics. (3-0). Credit 3.
634. Forest Genetics Laboratory. (0-3). Credit 1.

PLANT SCIENCES
(Genetics, Gen.)

603. Genetics. (4-0). Credit 4.
604. Genetics Laboratory. (0-3). Credit 1.
607. Genetics of Differentiation. (3-0). Credit 3.
608. Genetics of Microorganisms. (3-0). Credit 3.
612. Population Genetics. (3-0). Credit 3.
613. Quantitative Genetics I. (3-0). Credit 3.
620. Cytogenetics. (3-0). Credit 3.
625. Speciation. (3-0). Credit 3.
631. Biochemical Genetics. (3-0). Credit 3.
633. Forest Genetics. (3-0). Credit 3.
634. Forest Genetics Laboratory. (0-3). Credit 1.
681. Seminar. (1-0). Credit 1.
685. Problems. Credit 1 to 4 each semester.
689. Special Topics in . . . Credit 1 to 4.
690. Theory of Research in Genetics. (3-0). Credit 3.
691. Research. Credit 1 or more each semester.

POULTRY SCIENCE
(P.S.)

613. Concepts of Breeding Systems. (3-0). Credit 3.

RANGE SCIENCE
(R.S.)

610. Range Grasses and Grasslands. (2-3). Credit 3.

SOIL AND CROP SCIENCES
(Agronomy, Agro.)

603. Cytological and Histological Principles in Plant Breeding. (2-3). Credit 3.
641. Plant Breeding I. (3-0). Credit 3.
642. Plant Breeding II. (3-0). Credit 3.

DEPARTMENT OF GEOGRAPHY

G. F. Bass, R. S. Bednarz, E. F. Cook, E. R. Hoskins, P. J. Hugill, C. Kimber*, J. M. McCloy, C. W. Pennington (Head), J. Sonnenfeld, F. H. van Doorninck, Jr., K. L. White

*Graduate Advisor

Graduate work in geography is offered at both the master's and doctoral levels. The department has wide interests in human-environment relationships, and students are encouraged to work in physical, biological and social sciences. Staff interests include cultural, historical, behavioral, resource, plant geographical, geomorphic, urban and economic studies. Certain courses (612-616) reflect a staff research interest in nautical archeology.

Graduate students are expected to be involved with research work throughout their studies; most graduate courses are taught as seminars requiring research papers rather than as lectures. For information concerning the Ph.D. language requirement, contact the graduate advisor. A non-thesis option is available for masters level students.

A number of the courses listed below are offered in alternate years. Requests for schedule information should be directed to the department head.

(Geog.)

605. Processes in Cultural Geography. (3-0). Credit 3. Evolution of cultural landscapes. Processes of innovation, diffusion and adaptation in context of developing human-environment relationships.

606. Agricultural Origins and Dispersals. (3-0). Credit 3. Origin and spread of agriculture over the world. Single versus multiple origins. The several complexes: Near East, Far East, Africa, America. A research seminar. Prerequisite: Approval of department head.

612. Preclassical Seafaring. (3-0). Credit 3. Seafarers and watercraft of the ancient Near East and Mediterranean until ca. 700 B.C. Types of watercraft used, routes, cargoes, voyages of exploration and economics of maritime trade. Cross-listed with Anth. 612.

613. Classical Seafaring. (3-0). Credit. 3. Culture history of Mediterranean seafarers between ca. 700 B.C. and end of Byzantine Empire. Types of ships and boats, sea law, naval tactics, harbor-works, routes, cargoes and economics of trade. Cross-listed with Anth. 613.

614. Eastern Seafaring. (3-0). Credit 3. Culture history of people and watercraft of China, Southeast Asia and Oceania. Types, characteristics, origins and spread of Chinese junks and Oceanic canoes. Research seminar. Prerequisite: Approval of department head. Cross-listed with Anth. 614.

615. History of Wooden Ships. (3-0). Credit 3. Design and construction of preserved and excavated sailing ships, the expertise of their builders and technology involved in ancient and early shipbuilding. Cross-listed with Anth. 615. Prerequisite: Anth. 612.

616. Research and Reconstruction of Ships. (2-2). Credit 3. Techniques of recording and interpreting excavated ships; preservation of hulls; ship drafting, modeling, lofting, testing and other methods used in research and/or reconstruction of ships. Cross-listed with Anth. 616. Prerequisites: Anth. 612, 615.

619. Man's Impact on His Environment. (3-0). Credit 3. Evolving views of man and nature; conflicts of ecoethics and economics of local and national interest, of the present and posterity; coping with environmental degradation, natural hazard and resource depletion. Alternative-consequences approach to decisions.

620. Man and Nature. (3-0). Credit 3. Human alterations of landscapes, the atmosphere and waters of the earth; interference with natural chemical cycles; disturbance of ecological equilibria, depletion of natural resources. Roles of technology and population growth. Prerequisite: Approval of instructor.

624. Plant Geography. (3-0). Credit 3. Differences and similarities among the various floras and vegetations of the world. Composition, local productivity, distributions and plant migrations of taxa at different levels. Studies of man's impact may be included. Research seminar system used; particular emphasis of the course varies from year to year. Prerequisite: Approval of department head.

630. Behavioral Geography. (2-2). Credit 3. Sources of variability in individual and group relationships with the environment: biocultural factors, perception, personality and the non-human environment. Review of concepts, application of research techniques and development of individual research projects, generally centering on a class theme which will vary from semester to semester. Prerequisite: Approval of department head.

635. Man in Extreme Environments. (2-2). Credit 3. Human adjustment to novelty, risk and stress in environment: the arctic, desert and tropics; high altitude and submarine environments; the "battlefield" and other high risk regions of earthquake, tornado, hurricane and flood. Strategies of adjustment, control and adaptation. Research paper. Prerequisite: Approval of department head.

650. Cultural Geography of Middle America. (3-0). Credit 3. Investigation of the patterns of distribution of the peoples of Middle America, Mexico, the Caribbean, and Central America by cultural origin, technological level, and changing political affiliation. Research seminar. Focus will vary according to semester and instructor. Students are expected to defray a portion of the expenses of the field trip. Prerequisite: Approval of department head.

670. Field Geography. (1-6). Credit 3. Advanced field geography. Review of basic field techniques. Various forms of field collection of data to complement library material; field mapping of human and physical phenomena; analysis of data gathered in the field. Students must participate in an extended field trip and are expected to demonstrate their abilities to identify and resolve a problem which can only be solved by the examination of field data.

681. Seminar. (1-0). Credit 1. Reports and discussions of current research and selected topics. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 6 each semester. For students with major or minor in geography to undertake investigations in special aspects of geography. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of geography. May be repeated for credit.

690. Theory of Research. (3-0). Credit 3. General concepts of scientific research; specific analytical techniques in the sub-fields of geography.

691. Research. Credit 1 or more each semester. Original research in various areas of geography. Research for thesis or dissertation.

DEPARTMENT OF GEOLOGY

W. M. Ahr, R. R. Berg, E. F. Cook, R. C. Fletcher, M. Friedman, A. Hajash, Jr., J. W. Handin, E. R. Hoskins, B. Johnson, K. J. Koenig, C. C. Mathewson, D. W. Mohr, R. K. Popp, M. C. Schroeder, J. H. Spang, R. J. Stanton, Jr. (Head), T. T. Tieh*, T. E. Yancey

*Graduate Advisor

Graduate work in geology is offered at both the master's and doctoral levels. Programs are designed to provide the student with an understanding of the fundamentals of geology and of related disciplines. Research investigations comprise a significant part of each program.

Opportunities for research at both the M.S. and Ph.D. levels are available in ground-water investigations, sedimentation, clay mineralogy, paleontology and paleoecology, stratigraphy, structural geology, tectonophysics, petrology, field geology, engineering geology and geochemistry.

The Center for Tectonophysics provides unique opportunities for research in the following areas: design and analysis of physical and numerical models of structural processes; deformation of rock specimens under conditions which simulate the physical and chemical environment at depth in the earth's crust; study of deformation mechanisms in experimentally and naturally deformed rocks; interpretation of geologic structures in terms of the results of laboratory studies.

The Center for Sedimentology serves as a focus for graduate-level teaching and research in areas such as origins of sedimentary rocks, factors controlling the origin and distribution of petroleum and mineral deposits in sediments, and techniques for determining the depositional environment of ancient sediments from their lithologic and paleontologic attributes. Graduate students participating in the Center will arrange their program through the appropriate academic department as determined by their background and interests.

Research efforts in engineering geoscience and mineral resources provide the graduate student with interdisciplinary research opportunities and reflect the close research associations that exist between the Department of Geology and the Departments of Civil Engineering, Geophysics, Petroleum Engineering, Urban and Regional Planning, and Soil and Crop Sciences. Graduate students participating in these areas of interest follow the basic geology requirements but develop research interests in a variety of fields such as coastal engineering, land planning, geothermal energy, river processes, landslide mechanics and slope stability, rock mechanics, ground water resources, coal mining and reclamation, and expansive soils.

Although degree level is not a requirement for professional practice in geology, the B.S. should usually be considered as preparatory, the M.S. should be considered the professional degree, and the Ph.D. should be considered the teaching and research degree. The M.S. degree is granted thesis option only.

In addition to the Graduate College requirements for the Ph.D., the student's committee chairman, with advice from the other committee members, will determine, on an individual basis, the student's needs in either foreign language or other broadening areas of study. The graduate faculty will also require an early evaluation of all Ph.D. candidates regarding the student's potential as a research scientist.

(Geol.)

600. Earth Science for Secondary School Teachers. (2-3). Credit 3. Survey of fundamental principles of physical geology, geologic processes, the Earth's oceans, climate and weather, and Earth history; origin and nature of solar system. Designed to aid secondary school instructors in presenting earth sciences. Prerequisites: Graduate classification; approval of department head.

603. Rocks and Minerals. (2-3). Credit 3. Rocks and minerals and megascopic determination by means of their physical properties. Origins of minerals, rocks and mineral deposits. For secondary school teachers. Prerequisites: Geol. 600; graduate classification; approval of department head.

609. Field Geology. Credit 2 to 6. Individual instruction in advanced and specialized field methods, geologic interpretation, and field evaluation procedures. Choice of topics and locations of field studies will vary depending upon individual and specific needs. Prerequisite: Geol. 300 or approval of instructor.

612. Structural Geology. (3-0). Credit 3. Mechanical principles important to structural geology and experimental results relating to rock deformation followed by applications to natural deformation. Mechanisms, rather than geometries. Primarily for students not concentrating in structural geology but who desire an advanced general course. Prerequisite: Approval of instructor.

614. Continuum Mechanics of Geologic Materials. (3-0). Credit 3. Continuation of Geop. 611. Power-law fluid, plastic solid and anisotropic materials. Analysis of plane-strain and plane-stress in elasticity and viscous flow problems using complex variable theory; slip-line treatment of plane flow of a rigid-plastic solid. Prerequisites: Geop. 611; Math. 308. Cross-listed with Geop. 614.

618. Sedimentology. (3-0). Credit 3. Mechanisms of transportation and deposition of ancient eolian, fluvial, and marine sediments. Dispersal and depositional patterns. Physical bases for sequences of textures, structures and grain fabrics in sedimentary rocks. Prerequisites: Geol. 306; Math. 152 or approval of instructor.

619. Petroleum Geology. (3-0). Credit 3. Properties of reservoir rocks; origin, migration, and accumulation of petroleum; geologic interpretation of borehole logs and fluid-pressure measurements and the role of hydrostatic and hydrodynamic pressures in oil accumulation. Prerequisite: Geol. 404 or approval of instructor.

620. Geology of Ground Water. (3-0). Credit 3. Principles of occurrence and movement of water beneath Earth's surface, and influence of various geologic situations upon its behavior. Factors applying to estimates of supply. Engineering aspects of ground water. Prerequisite: Approval of instructor.

622. Stratigraphy. (3-0). Credit 3. Principles of correlating and naming stratigraphic units; interpretation of sedimentary environments based on composition, texture and sedimentary

structures; prediction of sandstone-body morphology of cored sections. Prerequisite: Graduate classification or approval of instructor.

623. Carbonate Rocks. (3-0). Credit 3. Fundamental properties of carbonate rocks; depositional and diagenetic microfacies; interpretation of depositional models in carbonates. Practical work on core samples representing a suite of ancient depositional and diagenetic environments. Emphasis on improving skills in energy and mineral exploration in carbonate terranes. Prerequisites: Graduate classification; Geol. 303, 306 or approval of instructor.

629. Regional Geology of North America. (3-0). Credit 3. Regional geology of North America examining the accumulation and deformation of the rock units involved. Structural form and style are emphasized, but the entire geologic history is investigated. Prerequisite: Graduate classification or approval of instructor.

630. Urban Geology. (2-2). Credit 3. Fundamentals of engineering geology as applied to the planning, development and design of urban areas; properties of Earth materials, land form analyses and geologic processes. Designed as service course for graduate students interested in urban studies, planning, design, etc. Not for civil engineering or geology majors. Prerequisite: Graduate classification.

631. Engineering Geomorphology. (3-0). Credit 3. Active surface processes as they influence engineering construction; erosion, rivers and floods, slope processes, subsidence, coastal processes, ice, weathering and groundwater. Prerequisite: Graduate classification in engineering or geoscience.

632. Site Investigation. (2-3). Credit 3. Photogrammetry, photogeology, remote sensing, engineering geophysics, and field methods applied to site investigations. Identification of geologic characteristics significant to engineering construction. Prerequisite: Graduate classification in engineering or geoscience.

637. Fundamental Geology I. (3-0). Credit 3. Fundamental geologic principles taught at a graduate level. For students with little or no undergraduate background in geology who are pursuing studies that cross traditional disciplinary boundaries. Mineralogy, petrology, geomorphology and structural geology. Prerequisite: Approval of department head.

638. Fundamental Geology II. (3-0). Credit 3. Fundamental geologic principles taught at a graduate level. For students with little or no undergraduate background in geology who are pursuing studies that cross traditional disciplinary boundaries. Sedimentary petrology, stratigraphy and paleontology. Prerequisite: Approval of department head.

640. Aqueous and Sedimentary Geochemistry. (3-0). Credit 3. Basic solution geochemistry and equilibria concepts to formation and alteration of sedimentary materials of low temperature origin. Geochemistry of fluids in natural aqueous environments; diagenesis and weathering. Prerequisite: Approval of instructor.

646. Geology and Diagenesis of Clays. (2-3). Credit 3. Geologic significance and role of clay minerals and related phyllosilicates in the depositional and diagenetic environments. Prerequisite: Approval of instructor.

650. Paleoecology. (2-3). Credit 3. Interrelationships of organisms and environment in the fossil record. Methods and criteria available for interpreting ancient environments. Critical review of classic studies and current research in paleoecology. Prerequisite: Approval of instructor. Offered in 1981-82 and alternate years thereafter.

652. Biogeology. (2-3). Credit 3. Major trends and processes in the evolution of life through geologic time. Interrelationships of biological and physical processes in earth history. Application of paleontology to current problems in geology. Critical review of modern developments in biogeology. Prerequisite: Geol. 305 or approval of instructor.

659. Volcanic Geology. (3-0). Credit 3. Thermochemical volcanic phenomena of the dynamic Earth; heat flow; melting and eruptive mechanisms; chemical petrology of volcanic rocks; significance of volcanism to climate, energy sources, economic deposits, paleomagnetism, geochronology and archaeology; volcano control and prediction; extraterrestrial volcanism. Prerequisite: Approval of instructor. Offered in 1981-82 and alternate years thereafter.

660. Theoretical Petrology. (2-3). Credit 3. Thermodynamics for geologists with petrologic applications; derivation and use of thermodynamic equations; relationships between measured quantities and thermodynamic generalizations; concept of chemical potential; phase rule and phase relations in silicate systems. Other potential topics include influence of volatiles upon silicate systems, and kinetics of nucleation and crystal growth. Prerequisite: Approval of instructor.

661. Igneous and Metamorphic Rock Systems. (2-3). Credit 3. Origin and evolution of igneous and metamorphic rocks. Laboratory research problems concentrate upon the petrogenesis of genetically related suites of igneous and metamorphic rocks. Prerequisite: Approval of instructor.

662. Sedimentary Petrology. (2-6). Credit 4. Genesis and diagenesis of sandstones, limestones and shales. Studies of primary rock properties to enable synthesis of depositional models. Laboratory work includes staining methods and preparation and study of thin sections, loose-grain mounts, polished slabs and acetate peels. Prerequisite: Geol. 303 and 304 or approval of instructor.

663. Mineralogy. (2-6). Credit 4. Structure, chemistry, physical properties and geological occurrence of minerals. Important rock-forming and ore minerals. Prerequisite: Approval of instructor.

664. Mechanical Analysis in Geology. (3-0). Credit 3. Mechanical analysis of geological problems based on concepts of stress, strain, strength, elasticity, viscosity and plasticity. Folding, faulting, dike formation, hydraulic fracturing, magma and glacial flow, and cooling of magmatic bodies. Prerequisites: Math. 253; approval of instructor.

665. Structural Petrology. (2-3). Credit 3. Mechanisms of rock deformation from single crystal to mountain range. Techniques for mapping stresses and strains and for inferring physical conditions and mechanical behavior at time of deformation. Laboratory assignments on descriptive techniques include petrographic microscope-universal stage methods, field procedures and data analysis. Prerequisites: Geol. 303, 312; approval of instructor.

666. Principles of Geodynamics. (4-0). Credit 4. Geological and geophysical methods and phenomena pertinent to geodynamics. Plate tectonics; seismicity and seismology; magnetics; gravity; heat flow; igneous, metamorphic and sedimentary petrology; paleontology; and rock mechanics. Cross-listed with Geop. 666 and Ocn. 666. Prerequisite: Approval of instructor.

667. Structural Geology II. (3-0). Credit 3. Application of theoretical and experimental results to problems in natural rock deformation. Structural mechanisms on the phenomenological, laboratory and natural scales with emphasis on the genesis of structural features in layered rocks. Prerequisites: Geol. 665, Geop. 611, 615.

681. Seminar. (1-0). Credit 1. Reports and discussions of current research and selected topics from geologic literature. Prerequisite: Graduate classification.

685. Problems. Credit 1 or more each semester. A course to enable graduate students with major or minor in geology to undertake limited investigations not within their thesis or dissertation research and not covered in established curricula. Prerequisites: Graduate classification; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Lectures and readings in special topics not otherwise covered in other courses. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Original research on problems in various phases of geology. Research for thesis or dissertation.

DEPARTMENT OF GEOPHYSICS

M. Caputo, R. L. Carlson, N. L. Carter* (Head), G. P. Eaton, D. A. Fahlquist, R. C. Fletcher, A. F. Gangi, J. W. Handin, T. W. C. Hilde, E. R. Hoskins, B. Johnson, G. M. Jones, J. M. Logan, J. E. Russell, T. W. Spencer, R. R. Unterberger

*Graduate Advisor

The degrees of master of science and doctor of philosophy are offered in geophysics. Geophysics includes all areas of scientific inquiry which deal with the physical state of the planets and with the dynamic physical processes which act on and within the planets. The deep interior, crust, atmosphere, oceans and space all lie within the province of the geophysicist. To work effectively in so broad an area requires considerable depth and breadth of understanding of physical principles and considerable proficiency in mathematics. Thorough undergraduate training in an earth or physical science is ordinarily regarded as a necessary prerequisite for advanced study.

Current research areas of members of the department include studies in theoretical and model seismology bearing on the internal structure of the Earth, earthquake mechanisms and seismic exploration; studies in experimental rock deformation bearing on the failure strength of rocks, friction in rocks, the rheological properties of rocks and earthquake prediction; studies of the anisotropy and anelastic properties of sedimentary rocks and application to exploration, and regional and global seismology; marine studies of the structure of the oceanic crust and continental margins in the Gulf of Mexico, the Caribbean Sea and the Western Pacific; studies of magnetic anomalies near mid-ocean-ridge systems and the magnetization of oceanic crust; the analysis of magnetic and gravity anomalies and application to exploration and global geophysics; gravity anomalies near trenches, convection in the mantle and global tectonics; thermal interaction of the core and mantle; the physical nature of the core; radar and sonar probing in salt and potash to predict rock conditions in advance of mining; mining engineering and geophysics; and mineral resource development.

An AMDAHL 470 computer system is operated by the Data Processing Center for faculty and student research. The department operates a complete programmable calculator system including a plotter and a cassette tape unit. The research vessel *Gyre* is available for research in the marine environment. Special department facilities include a seismic field station equipped with telemetered output; an analog computer and a two-dimensional seismic modeling laboratory for study of elastic-wave propagation in earth structures and the radiation fields generated by brittle fracture; an exploration-type, 36-channel digital seismic recording system; a 30-kilowatt peak-power, low-frequency radar for long-range underground electro-magnetic-wave propagation and two smaller radars operating at different frequencies for short-range probing; a LaCoste-Romberg gravity meter; and two matched optically-pumped Rb^{87} vapor magnetometers for high-sensitivity (.01γ) recording; 12 sets of instruments for measuring triaxial deformation.

(Geop.)

604. Marine Geophysics. (3-3). Credit 4. Geophysical exploration methods. Analysis and interpretation of seismic reflection and refraction profiles and gravity, magnetic and heat-flow anomalies. Structure of oceanic and continental crust as deduced from geophysical measurements. Analysis and interpretation of data from both marine and continental areas. Prerequisites: Math 122; Phys. 218, 219; or approval of instructor.

606. Kinematic Aspects of Plate Tectonics. (2-0). Credit 2. Plate motions on planes and spheres, evolution of triple junctions, determination of relative and absolute poles of rotation, and the means by which such motions are described. Prerequisite: Approval of instructor.

607. Rheology and Plate Dynamics. (3-0) Credit 3. Fundamental understanding of the rheology of rocks, as a function of physical conditions, with applications to the driving forces for plate motions and the generation of first-order lithospheric structures mainly at plate boundaries. Prerequisites: Geop. 611, 615; Geol. 665 or approval of instructor.

611. Geomechanics. (3-0). Credit 3. Development of continuum mechanics and its application to rock deformation. Stress, strain, stress equilibrium, constitutive relations. Governing equations for elastic solids and viscous fluids formulated and used to solve elementary boundary-value problems which have application to structural geology and solid-state geophysics. Prerequisite: Math. 221 or equivalent.

614. Continuum Mechanics of Geologic Materials. (3-0). Credit 3. Continuation of Geop. 611. Power-law fluid, plastic solid and anisotropic materials. Analysis of plane-strain and plane-stress in elasticity and viscous flow problems using complex variable theory; slip-line treatment of plane flow of a rigid-plastic solid. Prerequisites: Geop. 611; Math. 308. Cross-listed with Geol. 614.

615. Experimental Rock Deformation. (2-3). Credit 3. Results of laboratory testing of mechanical properties of rocks at high pressure and temperature; interaction of theoretical, experimental, petrofabric and field studies of rock deformations as applied to problems in structural geology, seismology and engineering. Philosophy of experimentation, apparatus design, data interpretation and extrapolation. Prerequisite: Geop. 611 or Geol. 665 or approval of instructor.

627. Electromagnetic Wave Propagation in Earth Materials. (3-0). Credit 3. Maxwell's equations and electromagnetic wave propagation in vacuum, lossless dielectrics and lossy earth materials. Snell's law, Fresnel's equations, Brewster angle, radiation polarization types, attenuation, reflection and refraction. Criteria for invisibility, theory of dielectrics and its application to earth materials. Matching theory and practical applications of wave propagation to geophysical problems. Laser principles and applications of laser radar. Prerequisites: Knowledge of vectors and complex numbers; Phys. 416 or E.E. 451 or equivalent or approval of instructor.

640. Field Methods in Rock Mechanics. (2-0). Credit 2. Field instrumentation for measuring in situ stress, strain and displacement in rock mechanics investigation; instrument design and construction, limitations, assumptions, applications and data interpretation. Prerequisite: Geol. 312 or equivalent or approval of instructor.

651. Theoretical Seismology. (3-0). Credit 3. Wave propagation in unbounded and bounded elastic media. Seismic reciprocity and the elastodynamic representation theorem. Radiation patterns from earthquake sources. Body waves, Rayleigh waves, Stoneley waves, Love waves and Lamb waves. Characteristic equation for surface waves in a layered half-space. Dispersion and phase and group velocities. Methods of stationary phase and steepest descents; Cagnaird-deHoop technique. Ray theory in an inhomogeneous earth. Inversion of travel times. Viscoelastic wave propagation. Normal modes of vibration of the earth. Prerequisites: Geop. 436, 611 or approval of the instructor. (Offered spring 1982, and alternate years thereafter).

653. Analysis of Gravity and Magnetic Fields. (3-0). Credit 3. An advanced lecture-seminar course in the application of potential theory to the analysis of the Earth's gravity and magnetic fields and to the solution of geologic problems. Critical study and evaluation of techniques for the interpretation of gravity and magnetic data. Prerequisite: Geop. 475 or approval of instructor.

657. Planetary Interiors. (3-0). Credit 3. Structure, composition and physical state of planetary interiors with primary emphasis on the Earth. Constraints on models of the Earth's interior imposed by seismic, gravity, heat-flow and electrical conductivity data. Thermodynamics of the Earth. Geomagnetism. Earth motion, rotation and deformation; the Earth tides. Prerequisites: Geop. 446, 611 or approval of the instructor. (Offered Spring 1983 and alternate years thereafter).

666. Principles of Geodynamics. (4-0). Credit 4. Cross-listed with Geol. 666 and Ocn. 666. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Discussion of subjects of current importance. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 6 each semester. For graduate students with a major or minor in geophysics to undertake limited investigations not within their thesis or dissertation research and not covered in established curricula. Prerequisites: Graduate classification; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Prerequisites: Graduate classification and approval of instructor.

690. Theory of Geophysical Research. (2-0). Credit 2. Theory and design of research problems and experiments in various subfields of geophysics. Communication of research proposals and results. Evaluation of current research of faculty and students and of that in the scientific literature. May be repeated for credit.

691. Research. Credit 1 or more each semester. Research toward thesis or dissertation.

DEPARTMENT OF HEALTH AND PHYSICAL EDUCATION

B. S. Beall, J. M. Chevrette, L. J. Dowell*, J. R. Elledge, C. P. Gabbard, R. S. Hurley, G. T. Jessup, M. J. Little, E. Mamaliga, L. D. Ponder* (Head), G. E. Richardson, N. G. Schmidt, C. H. Shea, H. Tolson

*Graduate Advisor

Graduate study in health education and physical education is offered leading to the master of education, master of science, doctor of education and doctor of philosophy degrees. A foreign language is not required for the doctoral degree.

Graduate courses in health education are designed to assist in the advanced preparation of master teachers, researchers and administrators in school health education or community education. Graduate courses in physical education are designed to assist in the advanced preparation of coaches, teachers and administrators at the elementary and secondary school levels, and master teachers, researchers and administrators at the college level. A professional teaching certificate in health education and in physical education may be earned in the department.

The department maintains laboratories in exercise physiology, motor learning, child movement, kinematics and adapted physical education for graduate students concentrating in these areas.

A specialization in cardiac rehabilitation is offered in conjunction with Baylor College of Medicine. This program culminates in a nine-month internship in the Cardiac Rehabilitation Program at Methodist Hospital in Houston. Study in this area prepares graduates for the American College of Sports Medicine certification program in cardiac rehabilitation.

A specialization in allied health teacher education and administrative leadership is offered in conjunction with Baylor College of Medicine. It is designed to prepare instructional and/or administrative personnel for allied health teaching programs in either community colleges, hospitals or four-year colleges of allied health professions. This program is open only to individuals with a baccalaureate degree, appropriate certification and experience in an allied health field.

The department participates in interdisciplinary planning, research and evaluation offered in cooperation with other departments in the College of Education. Prospective doctoral students who wish to develop an interdisciplinary supporting field in educational planning, research and evaluation should examine the interdisciplinary studies option which is presented in the description of graduate courses in interdisciplinary education. Within the framework of existing programs of the departments in the College of Education, individuals may pursue an area of emphasis in higher education.

HEALTH EDUCATION
(H.E.)

601. Readings in Health and Physical Education. (3-0). Credit 3. Cross-listed with P.E. 601.

620. Sex Education in Schools. (3-0). Credit 3. Instruction in and development of an understanding of the physical, mental, social, emotional and psychological phases of human relations as they are affected by male and female relations. Understanding humans' sexuality as a health entity and as a source of creative energy and total life development.

621. Principles of Health Education. (3-0). Credit 3. Background and development of health education as an applied science; foundations of personal health; health concepts and principles.

622. Issues and Trends in Health Education. (3-0). Credit 3. Current issues and trends in health and their implications for health education.

624. Drugs and Human Health. (3-0). Credit 3. Beneficial and harmful uses and effects of drugs. Motivations behind drug abuse, especially among youth, and implications of this problem on the individual and society. Legislative and educational efforts in this area.

626. Health Careers. (2-2). Credit 3. Allied health professions and other health related occupations; vocational opportunities. Laboratory experiences will include visitation and observations of practitioners in the field.

631. Community and Public Health. (3-0). Credit 3. Community health problems; public health laws; national, state and local health agencies.

636. Advanced Tests and Measurements. (2-2). Credit 3. Prerequisite: H.E. 425. Cross-listed with P.E. 636.

650. Allied Health Education. (3-0). Credit 3. Tasks associated with the development, implementation and evaluation of educational programs and program materials for the allied health professions. Pedagogical concepts and procedures. Clinical instruction techniques. Prerequisite: Training and certification as a practitioner in an allied health profession.

651. Administration of Allied Health Education. (3-0). Credit 3. Administrative problems, issues and processes involved in programs designed to educate personnel for the allied health professions and services. Prerequisite: H.E. 650.

680. Proseminar. (1-0). Credit 1. Structured seminar on major concepts, principles and issues in health education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Prerequisite: Doctor of education student in the College of Education.

681. Seminar. (1-0). Credit 1. Reports and discussions of topics of current interest in health education.

682. Seminar in . . . (1-0). Credit 1. Issues, developments and trends in school and public health education. Specific topics will be designated for each seminar as it is offered. Prerequisite: Approval of department head.

683. Practicum in Health Education. (1-6). Credit 3. Observations and study of health practices and methods used in school, public and institutional health settings. Prerequisite: Approval of department head.

684. Professional Internship. Credit 1 to 6 each semester. Designed to permit students the opportunity for on-the-job training with professionals in schools and public and institutional health agencies. Prerequisites: Twelve semester hours of selected graduate work and approval of department head.

685. Problems. Credit 1 to 4. Directed study of selected problems in health education.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of health education. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of Health Education Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of health education. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. May be repeated for credit. Prerequisite: Approval of department head. Cross-listed with P.E. 690.

691. Research. Credit 1 or more. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for doctor of education degree. Preparation of a record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of major advisor.

OUTDOOR EDUCATION
(O.Ed.)

600. Field Studies in Outdoor Education. Credit 3. A field-based learning experience designed for public school and college teachers and youth agency personnel to develop an environmental awareness; to develop teaching strategies in outdoor education activities; and to learn techniques for implementing outdoor education programs. May be repeated once for credit. Prerequisite: Approval of instructor.

608. Leadership in Outdoor Education. (2-2). Credit 3. School and college programs in outdoor education for teachers and recreation leaders to develop skills for leadership and organization of outdoor adventure programs.

PHYSICAL EDUCATION
(P.E.)

601. Readings in Health and Physical Education. (3-0). Credit 3. Study of published reports and research in fields of health and physical education. Cross-listed with H.E. 601.

606. Psychological Aspects of Sport and Physical Activity. (3-0). Credit 3. Human behavior in sport and physical activity. Exceptional performances; sport and personality; movement perception; motivation in sports; and maturation and physical activity.

610. Administration of Interschool Athletics. (3-0). Credit 3. For school superintendents, principals and athletic directors. Various problems in administration of interschool athletic program.

614. Philosophy and Principles. (3-0). Credit 3. Major schools of philosophical thought, leaders and forces affecting past and present development of physical education.

622. Supervision of Health and Physical Education. (3-0). Credit 3. Principles and processes of supervision; in-service training of personnel.

623. Administration of Health and Physical Education. (3-0). Credit 3. Administration of comprehensive programs of health, physical education and intramurals.

627. Kinesiology. (3-0). Credit 3. Science of human motion. Relationship between structure and function in accordance with general mechanical laws and interrelated factors. Prerequisite: P.E. 426.

628. Therapeutics. (3-0). Credit 3. Theories and techniques of muscle re-education and application of exercise to orthopedic, medical, post-surgical and neurological disorders. Administration and direction of therapeutic and adapted physical activity programs.

630. Mechanical Analysis of Motor Activity. (3-0). Credit 3. Human movement with emphasis on sports skills by application of principles of mechanics, kinesiology and cinematographical analysis. Prerequisites: P.E. 627; approval of instructor.

633. Principles of Exercise and Physical Fitness. (2-2). Credit 3. Nature of physical fitness, basic principles of exercise and physical fitness, analysis of methods of developing and evaluating physical fitness. Prerequisites: Biol. 219, 220.

636. Advanced Tests and Measurements. (2-2). Credit 3. Tests and measurements; methods of constructing and evaluating tests. Prerequisite: P.E. 425. Cross-listed with H.E. 636.

637. Exercise Physiology. (2-2). Credit 3. Current research in human performance and sport physiology. The nature of cardiorespiratory fitness, muscular efficiency and related topics. Prerequisite: Biol. 652 or approval of department head.

638. Ergonomics. (2-2). Credit 3. Current methods of imposing work in the exercise physiology laboratory and current techniques for evaluating humans' physiological responses to work. Critical analysis of current research in the area of work physiology; physical work capacity in different environments. Prerequisite: P.E. 637; approval of department head.

640. Motor Skill Learning and Performance. (2-2). Credit 3. Factors involved in the learning and performance of motor skills. For teachers, coaches and those concerned with human performance in motor activity. Prerequisite: P.E. 406.

641. Motor Development. (3-0). Credit 3. Motor, physical, and neuromuscular development from prenatal periods to old age. Stages of development, motor system and development of specific movement patterns. Prerequisite: P.E. 406.

680. Proseminar. (1-0). Credit 1. Structured seminar on major concepts, principles and issues in physical education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Prerequisite: Doctor of education student in the College of Education.

681. Seminar. (1-0). Credit 1. Reports and discussions of topics of current interest in physical education.

682. Seminar in . . . (1-0). Credit 1. Issues, developments and trends in physical education. Specific topics will be designated for each seminar as it is offered. Prerequisite: Approval of department head.

683. Practicum in Physical Education. (1-6). Credit 3. Observation and study of rehabilitation and physical education programs in schools and other institutions. Prerequisite: Approval of department head.

684. Professional Internship. Credit 1 to 6 each semester. Designed to give prospective physical education supervisors, administrators and corrective or physical therapist on-the-job clinical training under the guidance of successful, experienced personnel. Prerequisite: Twelve semester hours of selected graduate work and approval of department head.

685. Problems. Credit 1 to 4 each semester. Directed study of selected problems of health, physical education and recreation not related to thesis.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of physical education. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of Physical Education Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of physical education. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. May be repeated for credit. Prerequisite: Approval of department head. Cross-listed with H.E. 690.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for doctor of education degree. Preparation of a record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of major advisor.

DEPARTMENT OF HISTORY

R. J. Q. Adams, A. C. Ashcraft, G. E. Bayliss, R. A. Beaumont, K. L. Bryant, Jr., R. A. Calvert, L. D. Cress, H. C. Dethloff (Head), B. D. Gooch, C. H. Hall, L. D. Hill, Z. J. Kosztolnyik, A. P. Krammer, H. H. Lang*, B. S. Ledbetter, J. H. Lenihan, M. V. Melosi, D. J. Pisani, J. A. Pratt, H. C. Schmidt, D. E. Schob, A. N. Stranges, B. M. Unterberger, F. E. Vandiver

*Graduate Advisor

Graduate study in history is offered leading to the degrees of M.A. and Ph.D. (American history). The graduate program in history is designed to prepare students for careers of teaching and scholarship in schools, colleges and universities, and to train historical specialists for various branches of government, business and social service. The student may specialize in United States history (colonial, early national, Old South, New South, the West, Civil War period, recent, social and intellectual, agricultural, economic, diplomatic and Texas history), European history, Latin American history, military history and the history of science.

Students will find acceptable minors in economics, education, English, management, marketing, political science, some areas of science, sociology, or other social sciences, or a field of history at the master's level other than the major field.

Prerequisites: For a major in history at the master's level, the student must present a minimum of 24 semester hours (including 12 advanced hours) of acceptable courses in his or her major field; and for a minor at least nine semester hours (including at least six advanced hours) in the minor field of study. Those interested in further information concerning the requirements for the M.A. or the Ph.D. (American history) should contact the departmental graduate advisor.

Normally for the Ph.D. in American history the student shall demonstrate a reading knowledge of two modern foreign languages, subject to the approval of the student's advisory committee. In unusual and exceptional cases, with the approval of said committee, a minimum of six semester hours of graduate work outside the major and minor fields of study, completed after the filing of a degree program, may be substituted for one language.

(Hist.)

601. American Colonial Life and Institutions. (3-0). Credit 3. The 17th and 18th century English American colonies. Prerequisite: Approval of department head.

603. The United States: Revolutionary Era, 1750-1789. (3-0). Credit 3. Structure of American society; British policy; the revolutionary movement; independence; Confederation period; social, political, and economic changes; diplomatic affairs. Prerequisite: Approval of department head.

604. The United States: Early National Era. 1789-1829. (3-0). Credit 3. Organization of the new government; the Federalist system; Jeffersonian democracy; the War of 1812; the New Nationalism; political, social and economic problems; territorial expansion. Prerequisite: Approval of department head.

610. The Trans-Mississippi West. (3-0). Credit 3. The West in American history. Political, economic, social and cultural influences of frontier. Prerequisite: Approval of department head.

612. The French Revolution and Napoleon (3-0). Credit 3. Problems relating to French Revolution, Bonaparte's career and First French Empire. Prerequisite: Approval of department head.

613. Twentieth Century United States Diplomacy. (3-0). Credit 3. United States foreign policies from end of Spanish-American War to present; scope, principles, practices, objectives, dangers and lessons learned. Prerequisite: Approval of department head.

615. Colonial Latin America. (3-0). Credit 3. Political, economic, religious, military and related institutions, both in theory and practice, as proposed, developed and applied in Spanish-American colonies and nations. Prerequisite: Approval of department head.

616. United States-Latin American Relations. (3-0). Credit 3. Formation and development of U.S. policy towards Latin America with principal emphasis upon major policies: Monroe Doctrine, interventionism, Pan-Americanism, Good Neighbor Policy and recent trends. Prerequisite: Approval of department head.

621. The United States, 1877-1914. (3-0). Credit 3. Economic, social, political history of the U.S., 1877-1914: growth of industrialism, disappearance of the frontier, labor and farm organizations, the growth of American imperialism, and constitutional development. Prerequisite: Approval of department head.

622. The United States, 1914 to 1945. (3-0). Credit 3. The U.S. during World War I, the Twenties, the Depression, the New Deal and World War II. Prerequisite: Approval of department head.

623. The United States, 1945 to the Present. (3-0). Credit 3. The Cold War, events and issues in the U.S. since 1945. Prerequisite: Approval of department head.

626. Recent American Cultural and Intellectual History. (3-0). Credit 3. Contribution of social and political thought, religion, science, scholarship and education to the history of American civilization. Prerequisite: Approval of department head.

628. Historiography. (3-0). Credit 3. Analysis of historical writing and the philosophy of history. The works of important historians from Herodotus to the present; schools, theories and the function of history. Prerequisite: Approval of department head.

629. United States Historical Bibliography. (3-0). Credit 3. Bibliographical sources and the nature and extent of materials for the study, interpretation and writing of U.S. history. Prerequisite: Approval of department head.

631. Reading Seminar in United States History to 1877. (3-0). Credit 3. Prerequisite: Approval of department head.

632. Reading Seminar in United States History after 1876. (3-0). Credit 3. Prerequisite: Approval of department head.

633. Reading Seminar in the American West. (3-0). Credit 3. Prerequisite: Approval of department head.

634. Reading Seminar in American Agricultural History. (3-0). Credit 3. Prerequisite: Approval of department head.

635. Reading Seminar in American Diplomatic History. (3-0). Credit 3. Prerequisite: Approval of department head.

636. Reading Seminar in the History of the South. (3-0). Credit 3. Prerequisite: Approval of department head.

637. Reading Seminar in the Spanish Borderlands. (3-0). Credit 3. Prerequisite: Approval of department head.

638. Seminar in Medieval Europe. (3-0). Credit 3. Institutional, social and cultural development in Medieval Europe; the era of Charlemagne to the formation of the English parliament. Prerequisite: Approval of department head.

639. Seminar in Nineteenth Century Europe. (3-0). Credit 3. Prerequisite: Approval of department head.

640. Seminar in Twentieth Century Europe. (3-0). Credit 3. Studies in the political, diplomatic and social history of Europe in the 20th century. Prerequisite: Approval of department head.

642. Reading Seminar in Recent Asian History. (3-0). Credit 3. Prerequisite: Approval of department head.

645. Seminar in Modern Military History. (3-0). Credit 3. Topics in modern military history. Provides broad familiarization in current military history studies. Prerequisite: Approval of department head.

670. Russian-American Relations in Asia Since 1894. (3-0). Credit 3. Evolution of relations in Asia from late 19th century, with background on areas of concern, problems and policies. Prerequisite: Approval of department head.

673. Age of Absolutism and Enlightenment. (3-0). Credit 3. Europe from 1648 to 1789, with particular emphasis upon France. Political history of the age supplemented by examination of economic and social institutions and of the Enlightenment. Prerequisite: Approval of department head.

677. Modern Britain. (3-0). Credit 3. Political, social, cultural, economic and diplomatic development of the United Kingdom in the 20th century. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 3 each semester. Individual instruction in selected fields of history. Stresses reports and wide readings in field selected. Prerequisites: Eighteen hours of history and approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of American or European history.

691. Research. Credit 1 or more each semester. Thesis research. Credit given only upon acceptance of completed thesis. Prerequisites: Twelve hours of advanced history and approval of department head.

HORTICULTURAL SCIENCES

W. S. Barham, E. E. Burns, F. T. Davies, Jr., E. R. Emino, J. E. Larsen, J. E. Lazarte, J. A. Lipe, W. N. Lipe, G. R. McEachern, E. L. McWilliams, N. P. Maxwell, J. C. Miller, Jr. (Interim Head), D. L. Morgan, A. E. Nightingale, D. R. Paterson, L. M. Pike, D. W. Reed, J. B. Storey

FLORICULTURE

The field of research in floriculture with ornamental crops affords excellent opportunities for original work. Studies in the propagation, nutrition, culture, harvesting, grading, marketing and improvement of ornamental plants may be undertaken. Also, monographic studies of ornamental groups and their adaptability to use are suitable problems for investigations.

Many of the problems in this field are basically those of plant response in relation to environment, and students should have adequate preparation in botany, plant physiology, genetics, agronomy, plant pathology, entomology, chemistry and floriculture or horticulture.

Programs of study are available leading to the degrees of master of agriculture and master of science.

(Flor.)

609. Taxonomy of Ornamental Plants. (2-2). Credit 3. Families, genera, species and cultivars of horticultural plants; identification, morphological variation, use and adaptability to climatic conditions in the Southwest. Specific problems in horticultural taxonomy, geography, biosystematics and genecology. Prerequisites: Biol. 201, Hort. 206 or approval of instructor.*

610. Tropical Foliage Plants. (2-2). Credit 3. Rare and exotic plants of tropical and subtropical regions of world. Identification, adaptation, cultural requirements, propagation and economic importance. Specific problems in taxonomy, physiology and anatomy of these plants. Prerequisite: Hort. 320.*

615. Greenhouse Problem Diagnosis. (2-2). Credit 3. Greenhouse design, construction and environmental controls as they relate to crop production. Diagnosis of problems encountered in management and maintenance of greenhouse facilities and in the production and care of plants grown in greenhouses for scientific investigations. Prerequisite: Graduate classification.*

616. Plant Reproduction. (2-2). Credit 3. Basic scientific principles underlying highly technical practices involved in reproduction of ornamental, fruit and vegetable plants by asexual methods. Current developments in anatomical, morphological, environmental and physiological factors involved in asexual plant propagation. (See Hort. 614 for sexual propagation.) Prerequisites: Hort. 326; P.Phy. 314 or approval of instructor.*

617. Landscape Horticulture. (2-3). Credit 3. Relations of ornamental plants to environments. Basic underlying scientific principles involved in the culture and use of plants in the physical landscape environments of urban, suburban and rural areas. Culture and maintenance of plants in the landscape. Prerequisite: Flor. 609 or approval of instructor.*

684. Professional Internship. Credit 1 to 4. Program planned to provide professional training in student's particular field of interest. Faculty and employer will supervise the activity. Work-study will be planned as a part of the master of agriculture degree program in greenhouse technology and nursery technology. Prerequisite: Approval of instructor.

685. Problems. Credit 1 to 4 each semester. Individual problems or research not pertaining to thesis or dissertation. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of floriculture. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

*Field trips required for which departmental fee may be assessed to cover costs.

HORTICULTURE

Advanced work in horticulture may be conducted with areas of specialization in fruit production, nut production, vegetable production, ornamental horticulture and nursery crops, and fruit, nut and vegetable processing. Supporting work may be required in several of the related fields such as chemistry, botany, plant pathology, plant physiology, entomology, soils, genetics, nutrition and agricultural engineering. The specific objective of the individual student will guide his or her committee in the choice of courses from the departments mentioned above and others in special cases.

Programs of study leading to the master of agriculture, master of science and doctor of philosophy degrees are available. These degrees are also offered in food science and technology.

(Hort.)

601. Environmental Relations of Fruit Plants. (3-3). Credit 4. Principles of nutrition related to management practices of fruit, nut, ornamental and vegetable plants. Practice in leaf analyses by atomic absorption spectrophotometry and autoanalyzer. Development of skills in hydroponic nutrition research. Prerequisite: P.Phy. 314 or approval of instructor.*

602. Factors Influencing Fruit Production. (3-3). Credit 4. Influence of environmental factors and growth regulators on reproductive and vegetative growth of horticultural crops. Field and lab experiments on environmental relations. Prerequisites: P.Phy. 314 or approval of instructor.*

603. Structure of Vegetable Plants. (3-3). Credit 4. Morphological and anatomical features of important groups of horticultural plants related to production and progressive improvement of crop. Prerequisite: Biol. 453 or approval of instructor.

604. Physiology of Vegetable Plants. (3-3). Credit 4. Chemical, biological and environmental factors in growth and differentiation and their applications to ornamental, fruit and vegetable crops; flowering; rooting; seed and fruit development; tuber and bulb formation; bud, stem and leaf differentiation. Prerequisites: P.Phy. 314, Biol. 453, or approval of instructor.*

614. Vegetable Propagation. (2-3). Credit 3. Reproduction and sexual interaction in ornamental, vegetable and fruit plants; flower development, embryology; fertilization; seed and fruit development; physiology of sex expression. Prerequisite: Approval of instructor.*

615. Origin and Distribution of Horticultural Plants. (2-3). Credit 3. Origin, distribution, and morphology of ornamental, fruit, and vegetable plants; center of origin; dispersal and migration; structure and function of principal tissues and organs. Prerequisite: Approval of instructor.

644. Food Quality. (3-0). Credit 3. Physical, chemical, and biological properties of foods. Fundamental attributes of flavor, color, odor, texture. Esthetic, ethnic and nutritional requirements. Role of additives. Regulatory standards and quality control regimes. Current techniques in food investigations. Cross-listed with F.S.T. 644.*

681. Seminar. (1-0). Credit 1. Student and staff participation in review of literature and reporting on current developments in research on production and processing of horticultural crops. Required of all graduate students in horticulture and floriculture.

684. Professional Internship. Credit 1 to 4. Program planned to provide professional training in student's particular field of interest. Faculty and employer will supervise the activity. Work-study planned as a part of the master of agriculture degree program in fruit and vegetable production, processing and handling. Prerequisite: Approval of instructor.

685. Problems. Credit 1 to 4 each semester. Individual problems of research not pertaining to thesis or dissertation. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of horticulture. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Research in horticultural problems for thesis or dissertation.

*Field trips required for which departmental fee may be assessed to cover costs.

HUMANITIES

(See Philosophy and Humanities)

DEPARTMENT OF INDUSTRIAL EDUCATION

G. E. Baker*, J. L. Boone, Jr.*, M. L. Chastain, D. L. Clark*, F. E. Clark*, M. E. Dennis*, G. D. Gutcher*, D. L. Householder* (Head)

*Graduate Advisor

The Department of Industrial Education offers graduate programs leading to master of education, master of science, doctor of education and doctor of philosophy degrees. Course work emphasizing industrial arts, vocational industrial education, educational technology, technical education or traffic safety education is available within each degree program. Students may earn professional teaching certificates in industrial arts and vocational industrial education for the State of Texas by completing course requirements through this department.

Graduate courses in industrial education are intended to provide the student the opportunity to develop the skills and knowledge generally required of industrial educators, researchers, program directors and departmental administrators. Specific information concerning the requirements for each of the degrees and procedures for meeting those requirements is available from the department upon request.

The department participates in interdisciplinary planning, research and evaluation offered in cooperation with other departments in the College of Education. Prospective doctoral students who wish to develop an interdisciplinary supporting field in educational planning, research and evaluation should examine the interdisciplinary studies option which is presented in the description of graduate courses in interdisciplinary education. Within the framework of existing doctoral programs of the departments in the College of Education, individuals may pursue an area of emphasis in higher education.

EDUCATIONAL TECHNOLOGY

Graduate courses in educational technology are designed to provide a supporting field for doctoral students who are majoring in other disciplines and to provide a major field for students who are seeking a master of education degree in educational technology. The courses stress a systems approach to the art of communication, with emphasis on the design of messages which make effective use of the latest technical equipment available. Internships are used to provide the student with relevant experiences in instructional communications. The courses are open to individuals who desire to improve their teaching skills or who intend to seek employment in schools, government, or industry as media or communications specialists.

(Ed.Tc.)

611. Organization and Administration of Learning Resources. (3-0). Credit 3. Planning, coordination and evaluation of local book and non-book learning resource services. Acquisition of materials and equipment.

613. Utilization of Instructional Materials. (2-2). Credit 3. Communications; senses of hearing and seeing in teaching-learning processes. Selection, preparation, use and evaluation of instructional materials.

615. Selection and Evaluation of Learning Resources. (3-0). Credit 3. Selection of book and non-book learning resource materials for specific needs or for general collections. Use of basic sources of information on commercially prepared materials with emphasis in the student's area of specialization.

621. Graphic Communication. (3-0). Credit 3. Application of research findings and design criteria to graphic communication design techniques. Techniques of preparation and use of programmed slide sets, filmstrips and motion pictures and their application in instructional systems.

631. Instructional Television. (3-0). Credit 3. Use of television in instructional systems. Program design and content specification.

641. Message Design. (3-0). Credit 3. Systematic application of task and learner analysis, research findings and design criteria to the design of instructional materials.

651. Computer Assisted Instruction. (3-0). Credit 3. Design of computer delivered instruction. Basic applications of task analysis, learning theory and programming principles to frame construction and sequencing. Relevant computer languages. Preparation of linear and nonlinear CAI programs.

681. Seminar. (1-0). Credit 1. Problems pertinent to learning resources specialists, school librarians, classroom teachers, audiovisual specialists and school administrators and supervisors. Recent developments and research in different areas.

684. Professional Internship. Credit 1 to 6. Supervised experiences in performing professional functions appropriate to career goals. Prerequisites: Application one month prior to registration and approval of instructor.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in instructional technology not within thesis research and not covered by any other course. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of educational technology. May be repeated for credit. Prerequisite: Approval of instructor.

INDUSTRIAL EDUCATION
(I.Ed.)

601. History of Industrial Education. (3-0). Credit 3. Leaders, movements and agencies; economic, social and philosophical factors which have contributed to development of industrial education in the U.S.

602. Industrial Arts Administration and Supervision. (3-0). Credit 3. Problems of local director or supervisor of industrial arts.

603. Administration and Supervision of Vocational Industrial Education. (3-0). Credit 3. Problems of local director or supervisor of vocational industrial education.

604. Industrial Programs for Community Colleges and Technical Schools. (3-0). Credit 3. Kinds, purpose, size, accreditation, growth and teaching problems in community colleges, technical institutes and adult schools; organization and presentation of industrial subject material in these schools.

606. Organization of Industrial Education Departments. (3-0). Credit 3. Problems in determining types and sizes of industrial education programs for various types and sizes of schools and colleges with plans for organization of each.

609. Innovative Programs in Industrial Arts. (2-3). Credit 3. Developing programs in industrial arts. Design and organizational strategies for teaching these programs.

614. Guidance Seminar. (3-0). Credit 3. Organization of occupational information, educational and vocational guidance, counseling case problems.

616. Methods of Teaching Industrial Education. (3-0). Credit 3. Selection and use of appropriate instructional strategies in industrial education.

618. Tests and Measurements in Industrial Education. (3-0). Credit 3. Testing and measuring devices and their application to industrial education subjects.

619. Related Subjects in Part-Time Cooperative Programs. (2-0). Credit 2. Organization and presentation of content material necessary in part-time cooperative programs, and direction of the study of students engaged in such programs.

620. Human Relations in Vocational Industrial Education. (3-0). Credit 3. Designed to aid vocational industrial and health occupations teachers in establishing and maintaining effective working relationships with students, colleagues and persons in business, industry and the community.

621. Philosophy of Vocational Education. (2-0). Credit 2. Basic principles involved in development and operation of vocational education programs under state and federal vocational laws.

622. Philosophy of Industrial Arts Education. (3-0). Credit 3. Principles involved in development and operation of industrial arts courses and their purpose and function in the field of general education.

626. Classroom Management and Shop Organization. (3-0). Credit 3. Organization of procedures and facilities to facilitate learning, issuing procedures for tools and materials, keeping material inventory, using assignment and progress charts, using student leadership in nonteaching class and laboratory routine, and keeping records.

627. Research and Development in Technical Education. (3-0). Credit 3. Problems related to administration of industrial education research programs. Methods of organizing and conducting teacher improvement programs; methods of conducting organized research.

628. Organization of Vocational Industrial Programs. (3-0). Credit 3. Methods of making surveys, determining needs for various industrial education programs, and organization of curriculum and classes according to state certification requirements.

635. Industrial Design and Development. (3-0). Credit 3. Advanced procedure in preparing teachers for industrial design and development. Historical review of design, effect of aesthetic, social and economic factors on a design concept and relationship between function and production processes.

680. Proseminar. (1-0). Credit 1. Major concepts, principles and issues in education drawn and analyzed from various contributing and theoretical bases. Critical new developments incorporated as they occur. May be repeated for credit. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit I. General discussions of laws, legislation, certification, professional ethics and other current problems relating to industrial education teaching professions. May be repeated for credit.

684. Professional Internship. Credit 1 to 6 each semester. A university-directed internship in educational and industrial practices for the prospective industrial education teacher, supervisor, administrator or researcher. Selected educational or industrial settings appropriate to the student's professional objectives will be used. Prerequisite: Approval of chairman of advisory committee and of department head.

685. Problems. Credit 1 to 4 each semester. Designed to enable the student to undertake and complete with credit limited investigations not within thesis research and not covered by any other course.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of industrial education. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Industrial Education Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of industrial education. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for doctor of education degree. Preparation of record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of major advisor.

SAFETY EDUCATION

The graduate program in industrial education offers a group of courses in safety education for students seeking the master of education, master of science, doctor of philosophy and doctor of education degrees. These programs interface with industrial education, engineering, psychology, business administration, the physical and biological sciences, educational curriculum and instruction, physical education and educational administration. Minors or supporting areas are permitted in these and other areas. Safety education may be combined with industrial education to form a major field.

Graduate courses in safety education are designed to assist in the advanced preparation of safety education instruction, administration and research specialists for education, government and private industry.

(Sa.Ed.)

601. Behavioral Factors in Traffic Safety. (3-0). Credit 3. Personality factors related to unsafe driving behavior. Effect of attitudes, motivations and adjustment on behavior. Principles and methods appropriate in identifying, understanding and modifying unsatisfactory attitudes and behavior.

604. Alcohol and Traffic Safety. (3-0). Credit 3. Relationship between the consumption of alcohol and its effect upon traffic safety. Role of traffic safety education in educating drivers to the risks and problems involved in drinking and driving.

608. Issues and Trends in Safety Education. (3-0). Credit 3. Current issues and trends in safety education. Research and development affecting safety education profession.

610. Administration of Safety Education Programs. (3-0). Credit 3. Safety education programs at national, state and local levels; administrative, instructional and supervisory aspects of the programs in education and industry.

620. Traffic Safety Communications. (3-0). Credit 3. Specialized problems related to traffic safety communications in a transportation oriented society. Design and operation of a communication process to better understand and influence driver behavior. Planning and managing public information and community support program.

624. School and College Accident Prevention. (3-0). Credit 3. Accident prevention and control programs for educational institutions; human, environmental and legal factors affecting program development, implementation and management.

628. Professional Development in Safety Education. (3-0). Credit 3. Problems of safety education at the university level. Review of related research. Development of representative model curricula for the preparation of safety education personnel.

630. Traffic Safety Education Innovations. (3-2). Credit 4. Recent traffic safety education innovations and their applications for improving the quality of classroom and laboratory instruction. Prerequisite: Sa.Ed. 427 and 428 or approval of instructor.

633. Instruction and Techniques in Safety Education Evaluation. (3-0). Credit 3. Measurement and evaluation as related to safety education functions, projects and programs. Unique nature of safety education programming and evaluation designs most appropriate for determining program effectiveness. Prerequisites: Basic courses in statistics and research design.

641. Highway Traffic Accident Reconstruction. (3-0). Credit 3. Theory and practice of analyzing physical damage to vehicles and roadway, and studying accident reports and testimony of survivors and witnesses to determine and reconstruct what occurred in highway traffic accidents.

681. Seminar. (1-0). Credit 1. Group study and discussion of the role of safety education in society. Prerequisite: Approval of instructor.

684. Professional Internship. Credit 1 to 6. Supervised graduate practicums, observations and internships in the various fields of safety education. Prerequisites: Approval of instructor.

685. Problems. Credit 1 to 6. Supervised experiences in performing research appropriate to career goals. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of safety education. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Prerequisite: Approval of committee chairman.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for doctor of education degree. Preparation of a record of study summarizing the rationale, procedure and results of the completed project. Prerequisite: Approval of committee chairman.

DEPARTMENT OF INDUSTRIAL ENGINEERING

INDUSTRIAL ENGINEERING: R. P. Beals*, L. T. Blank, G. L. Curry, B. L. Deuermeyer, N. C. Ellis (Head), R. M. Feldman, J. W. Foster III (Division Head), M. J. Fox, Jr., A. Garcia-Diaz, J. K. Hennigan, G. L. Hogg, R. D. Huchingson, R. J. Koppa, D. T. Phillips, D. R. Smith, R. E. Young

COMPUTING SCIENCE: S. B. Childs, D. Colunga, D. D. Drew (Division Head), D. K. Friesen, J. E. Kalan, W. M. Lively*, U. W. Pooch, S. V. Sheppard, D. B. Simmons, G. N. Williams

BIOENGINEERING: Y. Fares, W. A. Hyman* (Division Head), G. E. Miller, P. J. Sharpe*, H. Wu

INDUSTRIAL HYGIENE AND SAFETY ENGINEERING: C. L. Gilmore, W. L. Johnston, R. B. Konzen* (Division Head), H. J. Suggs, R. J. Vernon

*Graduate Advisor

The graduate programs in the Department of Industrial Engineering are quite broad and are designed to develop the student's understanding in modern engineering principles, applications and research. The department is organized to serve as the focal point for the academic programs in engineering dealing with man, man and machine, and man and the biological, natural and social environment. Courses are available in the areas of human factors engineering, labor relations, bioengineering, industrial hygiene, safety engineering, computing science, operations research and industrial engineering. The master's degrees available at present in the Industrial Engineering Department are the master of engineering in industrial engineering and bioengineering; master of computing science; and master of science

degree in industrial engineering, bioengineering, computing science, safety engineering and industrial hygiene. The degree of doctor of philosophy is available in industrial engineering, bioengineering, and computing science. The department also offers courses and faculty supervision for students pursuing the doctor of engineering degree. The graduate courses listed below indicate the depth of work available in each of these areas.

The graduate research program within the department is equally as broad as the academic program. Mission-oriented research is underway or has been conducted in such diverse areas as artificial intelligence and automation, behavioral and human factors engineering, bioengineering, management engineering, manufacturing engineering, service systems engineering, operations research and optimization, computer graphics, social and political systems engineering, medical engineering, computing science, software engineering, production design engineering, industrial operations, biomechanics, maintainability engineering, bionics, ecological systems engineering, industrial hygiene, safety engineering and labor relations.

Facilities for study and research are unequaled. An excellent, fully equipped Data Processing Center provides a laboratory for all students. In addition, research laboratories are available in the department in production engineering, bioengineering, industrial hygiene and safety engineering, numerical control and interactive graphics, computer hardware and software systems, medical engineering, food engineering, ecological systems engineering and maintainability engineering. These laboratories are excellently equipped and provide students with an exceptional research opportunity. Research projects are underway which provide students with the opportunity to obtain engineering experience as they complete the requirements for their advanced degrees.

Specific requirements for graduate degrees are available on request from the department. Demonstration of the knowledge of a foreign language is not part of the minimum requirements for a doctor of philosophy degree in the Department of Industrial Engineering.

BIOENGINEERING
(B.E.)

602. Instrumentation and Measurement in Biological Systems. (3-3). Credit 4. Information extraction from biological systems; interface matching. Transducers commonly used in bioengineering given as the interface between biological signals and instrumentation systems. Prerequisites: Phys. 219; E.E. 331 or equivalent; B.E. 401 or approval of instructor.

603. Information Processing in Bioengineering. (3-3). Credit 4. Methods for evaluating alternative approaches in computing systems for biomedical applications. Provides some familiarity with the wide variety of existing software and available programming resources.

607. Clinical Engineering. (3-0). Credit 3. Responsibilities, functions and duties of the hospital based biomedical engineer including program organization, management, medical equipment acquisition and use, preventive maintenance and repair and hospital safety. Prerequisites: B.E. 305 or equivalent and approval of instructor.

612. Experimentation. (2-3). Credit 3. General concepts forming the basis of the scientific method and design of experiments. Analytical instrumentation and measurement methods useful in biomedical research. Criteria for the selection, care and use of experimental animals and human subjects in biomedical research. Prerequisite: Approval of instructor.

614. Modeling of Biological Systems. (3-0). Credit 3. Principles, objectives and approaches to describing physiological phenomena with mathematical models with emphasis on mammalian systems. Prerequisite: Approval of instructor.

619. Engineering Analyses of Artificial Internal Organs. (3-0). Credit 3. Design, development and evaluation of artificial internal organs. Prerequisites: V.P.P. 335 or equivalent; B.E. 452.

623. Rehabilitation Engineering. (3-0). Credit 3. Survey of the origin and incidence of client disabilities and an overview of the rehabilitation process. Materials and physiological, psychological and biomechanical considerations in the design of orthotic and prosthetic devices. Survey of current rehabilitation devices and techniques. Prerequisites: B.E. 302, 422, 401.

635. Biomaterials Compatibility. (3-0). Credit 3. Relevance of mechanical and physical properties to implant selection and design. Effect of the body environment on metallic, ceramic and plastic materials. Rejection mechanisms used by the body to maintain homeostasis. Prerequisite: Approval of instructor.

638. Control Mechanisms in Living Systems. (3-0). Credit 3. Application of control theory to the electro-physiological and biochemical processes, to the dynamic characteristics, and to the natural and artificial maintenance of homeostasis in living systems. Prerequisites: Bich. 410; B.E. 401; Math. 602; V.P.P. 323; or approval of instructor.

640. Biomembrane Transport Processes. (3-0). Credit 3. Theoretical approaches to quantification of transport in biological membranes; integration of the structural, kinetic, molecular, methodological and comparative aspects of biological membrane transport processes. Prerequisite: B.E. 312, 452, or approval of instructor.

651. Biochemical Engineering. (3-0). Credit 3. Integration of principles of engineering, biochemistry and microbiology; application to the design, development and improvement of industrial processes that employ biological materials. Prerequisite: Approval of instructors. Cross-listed with Ag.En. 651 and Ch.E. 651.

673. Analysis of Biosystems. (3-0). Credit 3. Non-human biological systems; structure and function from a systems engineering viewpoint. Derivation of rate kinetics from physical and chemical laws. Introduction to von Foerster equation describing age-dependent population dynamics and Leslie matrix. Prediction of growth, development, reproduction and mortality of poikilothermic organisms under varying environmental conditions. Prerequisites: One computer course and approval of instructor.

674. Modeling of Biosystems. (3-0). Credit 3. Computer modeling of biological systems based on concepts introduced in B.E. 673. Use of models for pest management decisions, environmental impact assessment, crop productivity, and extension functions. Use of on-site minicomputers with APL capability. Prerequisite: B.E. 673.

675. Tracer Kinetics and Compartmental Analysis. (4-0). Credit 4. Formal and engineering foundation for tracer data analysis for model validation. Theoretical and mathematical basis for compartmental analysis in the biosystems and biomedical fields. Prerequisites: Math. 308; C.S. 203.

681. Seminar. (1-0). Credit 1. Designed to permit student to broaden capability, performance and perspective in bioengineering via his or her own formal presentation and by presentations from other professionals.

684. Professional Internship. Credit 1 or more each semester. Training under the supervision of practicing engineers in settings appropriate to the student's professional objectives. Prerequisites: Approval of student's advisory committee chairman and head of Bioengineering Program.

685. Problems. Credit 1 to 4 each semester. Allows students the opportunity to undertake and complete, for credit, limited investigations not included within thesis or dissertation research and not covered by other courses. Prerequisite: Approval of department head.

689. Special Topics In . . . Credit 1 to 4. In-depth study in areas relating to specific student interests and recent advances in bioengineering. Topics will normally vary and this course may be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

COMPUTING SCIENCE
(C.S.)

603. Assembly Language. (4-0). Credit 4. Computer architecture and system software through the assembly languages of a minicomputer and a large scale computer. Machine structure; assembly language; machine language; addressing techniques; and digital representation of data. Subroutine linkage; reentrant code; and macros. Assembly language programming assignments. Prerequisite: Knowledge of some programming language. Note: This course may not be taken for graduate credit by computing science majors.

611. Survey of Programming Languages. (3-0). Credit 3. Techniques for specifying the syntax and semantics of programming languages. Language concepts such as data structuring, information binding, control structures, execution environments, and extensibility are examined by studying scientific, data processing, list processing and multi-purpose languages. Programming assignments in the various languages. Prerequisites: C.S. 203, 401, or equivalent.

612. Programming Methodology. (3-0). Credit 3. Methodology and techniques involved in the design, production and maintenance of software systems. Prerequisites: C.S. 203, 401 or equivalent.

613. Computer Software Systems. (3-0). Credit 3. Hardware/software evolution leading to state-of-the-art operating systems. Operating system concepts and system elements as separate entities followed by synthesized examples from the areas of minicomputer and large-scale computer applications. Comparison of major manufacturer's current operating systems. Prerequisite: C.S. 403.

614. Computer Architecture. (3-0). Credit 3. Computer architectures and structures from the classical von Neumann machines to state of the art computer organizations such as array, pipeline, and associative processors. Hardware components: instruction set design; memory systems and hierarchies; control units and microprogramming; ALU's; parallelism; lookahead; concurrency; vector computers; stack computers; super computers and direct high level language computers. Prerequisite: CS 301.

615. Database Systems. (3-0). Credit 3. Data processing systems; construction and maintenance of file structures for on-line systems, storage allocation and collection, and design and use of generalized data management systems. Prerequisite: C.S. 303.

621. Computer Methods in Applied Sciences. (3-0). Credit 3. Use of modern and classical algorithms in obtaining numerical solutions to problems from the physical sciences. Student development of a repertoire of computation techniques. Linear and nonlinear least squares, spectral analysis, solution of initial and boundary value problems in differential equations. Problems in ordinary differential equations. Prerequisites: C.S. 407, 458 or equivalents.

622. Computer Communications and Networks. (3-0). Credit 3. Basic hardware/software for computer communications. Synchronous/asynchronous systems. Computer networks, routing, protocols. Time sharing systems, interface between operating system and network. Common carrier services. Prerequisites: C.S. 613.

623. Software Engineering. (3-0). Credit 3. Application of engineering principles to the design, production and maintenance of software systems. Technical and managerial issues. Prerequisites: C.S. 612, 615.

624. Simulation. (3-0). Credit 3. Introduction to simulation and comparison with other problem-solving techniques. Discrete simulation models and review of queuing theory and stochastic processes. Comparison of discrete change simulation languages. Simulation methodology including generation of random numbers and variates and validation of simulation models and results. Selected applications of simulation. Prerequisites: C.S. 458 or equivalent.

625. Artificial Intelligence. (3-0). Credit 3. Concepts and methods of artificial intelligence. Properties of single-goal decision-making systems. Decision-making under certainty, uncertainty, and under risk. Prediction, learning and adaption. Self-organizing systems. Single-level, multi-goal systems. Formal theory of game playing and teams. Multi-level, multi-goal (hierarchical) systems and organization. Prerequisites: C.S. 203, 204.

627. Formal Languages and Automata Theory. (3-0). Credit 3. Semi-formal introduction of computer languages and their relationships to various automata. Regular, context free, context-sensitive grammars and their implementations on finite automata, pushdown automata and Turing machines. Prerequisite: C.S. 611.

628. Compiler Construction. (3-0). Credit 3. Definitions of formal grammars: arithmetic expressions and precedence grammars, context-free and finite-state grammars. Algorithms for syntactic analysis: recognizers, backtracking, operator precedence techniques. Semantics of grammatical constructs: reductive grammars, Floyd productions, simple syntactical compilation. Relationships between formal languages and automata. Prerequisites: C.S. 204, 611.

629. Analysis of Computer Algorithms. (3-0). Credit 3. Methods and techniques of analysis of non-numeric and arithmetic algorithms. Asymptotic time and space behavior of selected algorithms. P and NP problems.

630. Information Storage and Retrieval. (3-0). Credit 3. Structure of semi-formal languages and models for the representation of structured information. Information content by statistical, syntactic and logical methods. Search and matching techniques. Automatic retrieval systems. Question-answering systems. Evaluation of retrieval effectiveness. Prerequisites: C.S. 203, 204, 404.

681. Seminar. (1-0). Credit 1. Reports and discussion of current research and of selected published technical articles. May not be taken for credit more than once in master's degree program nor twice in Ph.D. program.

684. Professional Internship. Credit 1 or more each semester. On-the-job training under supervision of practicing engineers in settings appropriate to professional objectives. Prerequisites: Approval of committee chairman and department head.

685. Problems. Credit 1 to 4. Research problems of limited scope designed primarily to develop research technique.

689. Special Topics in . . . Credit 1 to 4. In-depth study in areas relating to specific student interest, recent advances and societal problems in computing science. Topics will normally vary and this course may be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more. Research for thesis or dissertation.

INDUSTRIAL ENGINEERING
(I.En.)

600. Industrial Engineering Concepts. (4-0). Credit 4. Survey of the major topic areas of classical industrial engineering; engineering economics, work measurements, production engineering, facilities planning and industrial labor relations. Prerequisite: Approval of instructor.

601. Location Logistics of Industrial Facilities. (3-0). Credit 3. Selection of the optimal locations of industrial plants and distribution centers through analytical modeling of the costs of inventory storage, transportation, utilities, labor supply and other cost components. Prerequisites: I.En. 403, 416.

602. Assurance Sciences. (3-0). Credit 3. Introduction to the assurance sciences; topics in reliability, maintainability, quality control, design of experiments and forecasting. Prerequisite: Stat. 601 or I.En. 613 or equivalent.

603. Human Relations in Industry. (4-0). Credit 4. Labor-management relationship and human relations problems encountered during the three stages of union development, i.e., hostility, transition and cooperation. Problems arising from contract administration and those encountered at the bargaining table. Introduction to foreign labor relations systems. Cross-listed with Mgmt. 650.

604. Advanced Work Methods and Measurement. (2-3). Credit 3. Basic techniques and advanced concepts in work methods and measurement systems and their application; line balancing, cost reduction plans, standards for combined manual and decision tasks, computerized determination of standards, physiological criteria of work measurement and management of methods and standards. Prerequisite: I.En. 304 or 600 or approval of instructor.

605. Material Handling Systems. (3-0). Credit 3. Analysis and design of integrated material handling systems; automatic storage and retrieval of unit loads, and identifying and establishing boundary conditions on key parameters required to specify the desired system required for equipment vendors to design appropriate hardware. Prerequisite: I.En. 416 or 600 or approval of instructor.

606. Collective Bargaining in the Public Sector (3-0). Credit 3. Status of collective bargaining in the public sector; federal, state, county and municipal levels. Special problems associated with such special groups as federal employees, teachers, police officers and fire fighters, nurses and other state, county and municipal employees. Nature of grievances, and forms of impasse resolution and their impact on the various collective bargaining and/or professional negotiations.

608. Industrial Case Analysis. (3-0). Credit 3. Practice in applications of principles to the solution of actual case problems involving broad management decisions. Prerequisite: I.En. 304, 315 and 403 or 600 or approval of instructor.

610. Advanced Manufacturing Processes. (2-3). Credit 3. Quantitative study of the nontraditional material removal and forming processes. Economic aspects as well as theory and industrial applications. Electro chemical machining, electrical discharge machining, high energy forming, and laser and electron beam machining. Prerequisite: I.En. 454 or approval of instructor.

611. Arbitration Procedures in Work Practices. (3-0). Credit 3. Status of arbitration in labor relations. Causes of grievances and means of reducing the frequency of cases going into arbitration. Procedures, techniques, and rules of evidence in arbitration. Sensitive areas of collective bargaining. Case studies in arbitration. Cross-listed with Mgmt. 652.

612. Design by Reliability. (3-3). Credit 4. Quantitative reliability analysis in engineering design. Reliability methods applicable to design: component reliability determination, system reliability model analysis, life testing stress/strength analysis, and fault tree analysis. Prerequisite: I.En. 613 and 620 or equivalent.

613. Engineering Data Analysis. (3-0). Credit 3. Selected topics in probability and data analysis for quantitative decision-making in engineering problems. Measurement principles, data collection and data analysis required to solve engineering problems. Introduction to courses in the assurance sciences-reliability, maintainability, quality control and experimental design. Prerequisite: Math. 253 or equivalent.

614. Advanced Quality Control. (3-0). Credit 3. Advanced methods applied to quality control. Acceptance sampling plans from the classical lot by lot attribute plan to sophisticated multi-lot dependent plans. Classical treatments and recent developments in process control. Evaluation, design and maintenance of quality control programs. Prerequisite: I.En. 613 or equivalent.

615. Production and Inventory Control (2-3). Credit 3. Development and application of techniques for demand forecasting requirements, planning, inventory management and production control by means of statistical analysis, optimization methods, simulation techniques and computerized execution of production and inventory control functions. Prerequisite: I.En. 315 or equivalent.

616. Advanced Industrial Analysis. (3-0). Credit 3. Fundamental theory, concepts and procedures required in the efficient design and analysis of industrial statistical experiments. Formulation and application meaningful in the context of the real world. One-factor experiments with and without restrictions on randomization, latin and other squares, factorial experiments, full and fractional two-level factorial experiments, blocking in factorial designs, and response surface methodologies. Prerequisites: I.En. 613 or equivalent.

617. Quantitative Methods in Maintainability. (3-0). Credit 3. Techniques of operations research and engineering data analysis to problems of system maintainability and maintenance. Models of repair and failure, wearout processes, maintainability demonstration and warranties, maintenance and inspection policies, and spare parts policies. Prerequisites: I.En. 613 and 620 or equivalent.

618. Stochastic Processes in the Assurance Sciences. (3-0). Credit 3. Basic stochastic processes necessary to deal with advanced problems in reliability, maintainability and other related areas. Markov decision theory, optimal stopping problems, renewal theory and semi-Markov decision theory. Prerequisites: I.En. 613, 620 or equivalent.

619. Analysis and Prediction. (3-0). Credit 3. Analysis of time dependent by smoothing methods, regression, Bayes methods, time series analysis and autoregressive moving average methods. Methods applied to industrial and production forecasting problems. Prerequisite: I.En. 613 or equivalent.

620. Survey of Operations Research. (4-0). Credit 4. Provides specific capabilities in operations research techniques so that extensions and modifications can be made for practical applications. Mathematical models for optimizing decisions using probability methods, linear and quadratic programming, dynamic programming, game theory and queuing theory. Prerequisite: I.En. 320 and 613 or equivalent.

622. Applied Linear Programming. (3-0). Credit 3. Understanding of mathematics associated with linear programming and proficiency in recognition, definition and solution of all types of applied linear programming problems by manual and computerized methods. Application of this methodology in operations research and industrial engineering problems. Prerequisite: I.En. 620 or equivalent.

623. Nonlinear and Dynamic Programming. (3-0). Credit 3. Understanding of mathematics involved and a proficiency in recognition, definition and solution of quadratic, dynamic and other nonlinear programming problems by manual and computerized methods. Application of methods to problems in operations research and industrial engineering. Prerequisites: I.En. 620 or equivalent.

624. Applied Distribution and Queuing Theory. (3-0). Credit 3. Queuing theory and its applications; single and multiple channels, priorities, balking, batch arrivals and service, and selected non-Markovian topics. Applications; statistical inference and design and control of queues. Prerequisites: I.En. 613, 620 or equivalent.

625. Simulation Methods and Applications. (2-3). Credit 3. Fundamental methods and methodology of systems simulation. Random number generation, random deviate generation, clock routines and statistical analysis of simulation models. Discrete simulation, continuous simulations and combined simulations. GASP IV stressed as a primary simulation language; fundamentals of GPSS, SIMSCRIPT, and Industrial Dynamics. Prerequisites: I.En. 620 and 613 or equivalent.

626. Model Building and Applications of Operations Research. (3-0). Credit 3. Problem-solving environment exposing students to a variety of unstructured problems requiring organization, formulation and solving an appropriate model. Selection and use of an efficient technique. Computer solution procedures. Selected readings in current literature. Prerequisites: Four courses within the I.En. 620 and 660 series or equivalent.

627. Engineering Analysis for Decision Making. (3-0). Credit 3. Principles and application of techniques in analysis of decision processes involving engineering systems under uncertainty. Areas of utility and information theory as related to quantification of information for decision-making. Prerequisites: I.En. 613 and 620 and 303 or 666 or approval of instructor.

628. Applied Game Theory. (3-0). Credit 3. Understanding of mathematics associated with game theory and proficiency in recognition, definition and solution of all types of applied game theory problems. Application of this methodology in operations research, military operations research and industrial engineering problems. Prerequisite: I.En. 620, 622.

629. Engineering Optimization. (2-3). Credit 3. Nonlinear optimization from an analytical and numerical standpoint. Necessary and sufficient conditions, Langrangian multipliers, constrained derivatives, special forms, unidimensional search, gradient based techniques, conjugate directions, derivative free search, penalty functions, projection methods, linearization methods and current literature. Prerequisites: I.En. 620 and 622 or 623, or approval of instructor.

630. Human Operator in Complex Systems. (3-0). Credit 3. Basic understanding of the theory and practice of human factors engineering. Topics are presented within the framework of humans as a functioning systems and their requirements when incorporated in hardware and software systems.

631. Engineering Man-Machine Interface II. (3-0). Credit 3. Understanding of the man-machine interface and development of the capability of applying human performance data in the design of man-machine systems (controls, displays and workplace).

632. Human Factors Engineering in System Design. (3-0). Credit 3. Capability of functioning as a human factors engineer in the system design and development environment. Applications of human factors to design and evaluation of man-machine systems. Prerequisite: Approval of instructor.

633. Human Factors Laboratory. (1-3). Credit 2. Various techniques of measuring and/or monitoring human performance variables under environmental stress. Control of environmental variables necessary to simulate real life problems and conditions. Prerequisite: I.En. 637.

634. Man-Machine Systems Engineering. (3-0). Credit 3. Industrially oriented human engineering tool for systematic analysis, identification and evaluation of man-machine systems leading to development of human factors data for design of hardware; personnel subsystem and system procedures for operation and maintenance. Prerequisite: Approval of instructor.

635. Human Information Processing. (3-0). Credit 3. Background of understanding and relevant data to students concerned with the design of man-machine systems. Value of including a human in the system rests upon the unique ability to translate sensed data into meaningful command signals. Prerequisite: I.En. 630, 631.

636. Biological Control System Analysis. (3-0). Credit 3. Development of mathematical and electromechanical models of biological systems, and the derivation of human transfer function for design applications.

637. Human Factors Engineering. (3-0). Credit 3. Human factors methods, models and problem areas; human performance and criteria for work in stressful environments.

638. Human Operator as a Systems Controller. (3-0). Credit 3. Understanding of the theory and application of the human control process in both manual and automatic control systems, giving the student a capability to develop human factors engineering requirements for the design of control systems. Prerequisite: Approval of instructor.

651. Machining Processes. (2-3). Credit 3. Use of computer and numerical control to achieve optimum conditions for industrial metal machining processes. The theory of metal cutting; analysis of the factors involved in obtaining conditions of minimum cost, maximum production and maximum profit. Prerequisite: I.En. 454 or equivalent.

661. Network-Based Planning and Scheduling Systems. (3-0). Credit 3. Deterministic and stochastic network flow analysis; the science and art of network modeling, minimal cost flow, shortest route, max-flow and the out-of-kilter algorithm. Recent developments in constrained network analysis and stochastic queueing networks and a number of real-world models. Extensive use of computerized algorithms. Prerequisite: I.En. 613 and 620 or equivalents.

663. Engineering Management Control Systems. (3-0). Credit 3. Integration of human relations, planning, and control concepts, systems analysis and design, and principles of management oriented toward engineering functions within an organization. Organizational design and administration as they impact along the product life cycle, i.e., research, design, development, production and use.

664. Principles of Scheduling. (3-0). Credit 3. Sequencing and scheduling, routing and dispatching, and resource constrained scheduling applied to job shops, flow shops and projects. Mathematical programming, queuing and simulation used. Computational complexity of scheduling algorithms. Prerequisites: I.En. 620 and 622 or 623 or equivalent.

665. Production and Inventory Control Modeling. (3-0). Credit 3. Modeling and analysis techniques used to study inventory problems. Review of stochastic processes, convex programming and dynamic programming. Prerequisite: I.En. 615, 620 and 623 or equivalent.

666. Engineering Economy. (3-0). Credit 3. Fundamental concepts and advanced techniques of engineering economic analysis. Evaluation of alternative capital investments considering income taxes, depreciation and inflation. Discounted cash flow analysis of competing projects, break-even analysis and determination of rate of return on investment. Risk and uncertainty in engineering analysis.

681. Seminar. (1-0). Credit 1. Opportunity to present research in a professional atmosphere. Presentations are not restricted to thesis or problem research. Presentations found unacceptable by faculty representative must be repeated with a different subject. Acquaints the student with departmental research activities and procedures in documenting research. Normally taken the first semester in graduate program.

684. Professional Internship. Credit 1 or more each semester. On-the-job training under supervision of practicing engineers in settings appropriate to professional objectives. Prerequisite: Approval of committee chairman and department head.

685. Problems. Credit 1 to 4 each semester. Special topics not within scope of thesis research and not covered by other formal courses. Prerequisite: Graduate classification in industrial engineering.

689. Special Topics in . . . Credit 1 to 4. In-depth study in areas relating to specific student interests, recent advances, and societal problems in industrial engineering. Topics will normally vary and this course may be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research in industrial engineering field; content and credit dependent upon needs of individual student.

SAFETY ENGINEERING
(S.Eng.)

670. Industrial Safety Engineering. (3-0). Credit 3. General concepts and techniques of safety engineering upon which more detailed and advanced applications may be based; applications of safety engineering principles to industrial and commercial systems; the concept of designing optimally safe systems.

671. Product Safety Engineering. (3-0). Credit 3. Provides specialized emphasis required to develop within a student the ability to function in the product design process as a specialist in safety engineering. Safety engineering and human factors principles are focused upon specific problems of accident elimination as related to product liability considerations and legal processing.

672. Safety Engineering in Facilities Design. (3-0). Credit 3. Design of buildings, processes, and auxiliary equipment from the standpoint of loss occurrence and control. Fire protection, environmental health and accident prevention principles are focused on specific problems of loss exposure as related to the facility design and operation. Protective procedures and methods of preventing loss of people and facilities.

674. System Safety Engineering. (3-0). Credit 3. Current system safety engineering analysis techniques; failure mode and effect and fault tree analysis. Engineering economic analysis is reviewed to develop skills for the safety engineer in presenting alternate solutions to management.

676. Safety in Materials Handling. (3-0). Credit 3. Manual and mechanical materials handling systems, selection, placement, and training of personnel; selection of equipment, interaction of manual and mechanical systems, application of equipment standards, and ergonomic principles.

677. Fire Protection Engineering. (2-3). Credit 3. Theory of combustion, characteristics of flammables, fire resistance, fire spread, fire protection principles, public and private fire service organization and equipment; automatic extinguishing systems. Fire protection analysis and design projects.

678. Problems in Safety Engineering. (3-0). Credit 3. Techniques of problem identification and solution based on analysis of input data. Current literature relative to accident causation, hazard identification, risk acceptance, property-business interruption losses and risk management. Preparation of management reports.

679. Safeguarding Mechanical Systems. (2-3). Credit 3. Mechanical systems, theory of mechanical safeguards, evaluation of mechanical systems, development of controls for hazards including noise, point-of-operation, power transmission, ventilation and maintenance. System analysis techniques applied.

680. Industrial Hygiene. (3-0). Credit 3. Recognition of environmental stresses present in man-machine-environment systems and the effect of these stresses on health, safety and performance of humans. Chemical, physical (heat stress, noise, radiation), ergonomic and biological stresses. Principles of epidemiology applied to occupational diseases.

681. Seminar. (1-0). Credit 1. Formal presentations in industrial hygiene and safety engineering by students and professional industrial representatives.

682. Instrumentation for Industrial Hygiene. (3-3). Credit 4. Evaluation of environmental stress factors present in man-machine-environment systems. Introduction to quantitative and qualitative instrumentation used in industrial hygiene. Development of in-depth evaluation techniques as a precursor to the design of engineering controls. Prerequisite: S.Eng. 680 or approval of instructor.

683. Evaluation and Control of the Occupational Environment. (3-3). Credit 4. Detection, evaluation and control of chemical, physical and biological health hazards prevalent in manufacturing, construction and mercantile operations. Procedures and operations with guest speakers and field trips to local industry. Prerequisites: S.Eng. 680 and 682 or approval of instructor.

685. Problems. Credit 1 to 4 each semester. Investigation of topics not within the scope of thesis or dissertation research and not covered by other formal courses.

686. Acoustics and Noise Control. (2-3). Credit 3. Physical and psychological aspects of noise and evaluation and control of the noise problem in the environment. Source, path and level of noise; acoustical properties of materials; damage-risk criteria for hearing; and criteria for noise and vibration in communities, buildings and vehicles.

687. Industrial Ventilation. (2-3). Credit 3. Development of design principles and application of natural, dilution, and local exhaust ventilation to control occupational exposures to conditions conducive to the development of occupational disease. Prerequisites: Math. 209; Phys. 201, 202, or equivalent.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of safety engineering and industrial hygiene. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research in industrial hygiene, safety engineering or related topics for thesis or dissertation.

INTERDISCIPLINARY EDUCATION

P. T. Beatty*, G. J. Conti*, R. A. Fellenz*, K. L. Greenwood*, J. T. Kapes*, L. H. Parrish*, D. F. Seaman* (Coordinator), J. D. Skinkle*, B. N. Stone* ‡

*Graduate Advisor

‡Faculty from other departments in the College of Education and from departments in the College of Agriculture also teach courses and serve as committee members and Graduate Advisors.

Interdisciplinary education within the College of Education provides the setting for graduate study in the areas of adult and extension education and vocational education.

The program in adult and extension education leads to the master of science, master of education, doctor of education or doctor of philosophy degree. The program provides for the professional preparation of administrators, staff development specialists, teachers and professors of adult and extension education, adult education research personnel, and administrators for youth and human service agencies.

The program in vocational education leads to the master of education, doctor of education or doctor of philosophy degree. Among the many program emphases which students may select as part of their programs are vocational development, postsecondary vocational education, international vocational education, vocational special needs, philosophy and policy analysis for vocational education, and vocational education evaluation and research. Either as part of or separate from the degree programs, a student may work on the requirements for Texas certification in occupational orientation, vocational counseling, and vocational administration/supervision.

Students in either program may also pursue an area of specialization in higher education. Courses may be taken in several departments within the College, and supporting field course work may be taken in interdisciplinary education.

An area of specialization in educational planning, research, and evaluation is available to all doctoral students in the College of Education. Such study is designed to prepare students to assume positions as research and development administrators, educational policy analysts, evaluation specialists, educational planners, systems analysts, curriculum coordinators and research professors. This area of specialization includes required core courses and additional electives to be designated by the student's department.

(Id.Ed.)

601. Principles of Vocational Education. (3-0). Credit 3. Principles of vocational education; development, social and economic values, purposes, scope and nature of the different programs of vocational education existing today.

605. Organization and Administration of Vocational Education. (3-0). Credit 3. Administration of comprehensive vocational education programs; operation and implementation of programs as provided for by state and federal legislation.

611. Vocational Student Identification, Placement, and Follow-up. (3-0). Credit 3. Various instruments, methods and techniques used in determining occupational aptitudes and interests of students. Planning, organizing and coordinating placement and follow-up programs.

612. Planning and Organizing Programs of Vocational Guidance. (3-0). Credit 3. Purposes and functions of a guidance program; group guidance procedures; components of a vocational guidance program; techniques of providing vocational guidance services for elementary and secondary students and adults.

615. Developing Curricula in Vocational Education. (3-0). Credit 3. Principles and applied practices in developing curricula for different areas of vocational education. Process of curricular development and improvement using a systems approach.

617. Cooperative Training Program. (3-0). Credit 3. Implementation of standards for cooperative training programs; organization and coordination of cooperative education programs; development and maintenance of required records in cooperative education; correlation of related studies and on-the-job training activities; public relations activities and youth leadership development activities.

620. Evaluation and Analysis in Vocational Education. (2-2). Credit 3. Principles and procedures of evaluation used in developing and conducting programs of vocational education. Field practice in evaluation procedures required.

622. Vocational Education for the Special Needs Student. (3-0). Credit 3. For vocational and special education teachers, administrators, and support personnel who are involved in educating the handicapped at the secondary level. Current issues and practices pertaining to career preparation of the handicapped from a vocational and special needs perspective. Field trips required for which departmental fee may be assessed to cover costs. Prerequisite: Approval of instructor.

630. Adult Learning. (3-0). Credit 3. Research and theory in adult learning. Factors influencing the adult learning process.

631. Foundations for Lifelong Learning. (3-0). Credit 3. Fundamental concepts and definitions relating to lifelong; major historical developments and philosophical roots of adult education; diverse institutional commitments and response to adult learner needs; administrative, programming and instructional practices in the field; emerging issues in adult education. Prerequisite: Graduate classification.

632. Methods of Adult Education. (3-0). Credit 3. Theory and practice of teaching in adult education. Standard techniques as well as more innovative strategies; programmed instruction, simulation and micro-teaching.

633. Adult Literacy Education. (3-0). Credit 3. Important aspects of implementing literacy programs for adults; funding, recruiting, placement, counseling and using community resources.

634. Teaching of Adult Basic Education. (3-0). Credit 3. Practical oriented study of the general knowledge, skills and techniques essential to the teaching of the undereducated adult.

636. Working with Adult Groups. (3-0). Credit 3. Development of skills for facilitating productivity in task-oriented groups of adults. Issues, problems and concepts frequently encountered, and potential solutions.

637. Large Group Instruction for Adults. (3-0). Credit 3. Theories and practices in the planning, promotion, and management of large group activities for purposes of adult and extension education. Prerequisite: Id.Ed. 642 or approval of instructor.

638. Contemporary Issues in Adult Education. (3-0). Credit 3. Pressing contemporary issues facing adult educators. Analyzing issues and seeking approaches to their resolution.

642. Program Development in Adult Education. (3-0). Credit 3. Conceptual tools needed to develop educational programs for adults in a variety of settings. Concepts of planning, implementation, and evaluation.

645. Community Services in Higher Education. (3-0). Credit 3. Procedures for organizing and developing a community services program in a college setting. Organizing, financing, publicizing, staffing, evaluating and other relevant activities. Two field trips required for which departmental fee may be assessed to cover costs.

647. Education for the Older Adult. (3-0). Credit 3. Older adults as unique learners — defining specific physical and psycho-sociological differences between older adults and other learners. Educational implications of specific needs and current educational programs to meet those needs.

650. History and Philosophy of Cooperative Extension. (3-0). Credit 3. Philosophical bases for and historical development of cooperative extension education in agriculture, home economics and 4-H.

657. Administration and Supervision in Cooperative Extension. (3-0). Credit 3. Administration and supervision of cooperative extension at the state, district and county levels; roles of administrators in coordinating all functions of the organization, particularly those affecting personnel.

660. Community Development Education. (3-0). Credit 3. Preparation in the area of community development; role of education; social, economic and political aspects.

661. Management of Family Resources. (3-0). Credit 3. Principles of management of financial and other family resources. Consumer decision-making and development of educational programs in family resource management.

662. Contemporary Concepts in Housing Education. (3-0). Credit 3. Contemporary concepts in housing which are necessary for planning, implementing, and evaluating educational programs in housing.

664. Volunteer Staff Development. (3-0). Credit 3. Principles of volunteer staff development and use in adult and youth education programs.

670. Mathematical Models in Educational Policy Analysis. (3-0). Credit 3. Development and appraisal of educational policy research designs and institutional analyses. Validity and information value of mathematical models applied in the study of selected educational policy issues; impact of court orders on teacher assignments, student achievement and resource allocation patterns. Prerequisites: Stat. 652 and E.Psy. 637 or equivalent.

679. Procurement and Management of Contracts and Grants. (3-0). Credit 3. Funding sources that support research and development activities; methods of securing funding; and management of funded projects. Basic knowledge, skills and sensitivities needed to secure and manage projects supported through contracts and grants. Prerequisite: Graduate classification.

680. Proseminar. (1-0). Credit 1. Structured seminar on major concepts, principles, and issues in education drawn and analyzed from various contributing theoretical and research bases. Critical new developments incorporated as they occur. Required of all Ed.D. students. May be repeated for credit. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. Problems pertinent to vocational, adult, and cooperative extension education. Recent developments and research in appropriate areas.

684. Professional Internship. Credit 1 to 6. Supervised experiences in performing professional functions appropriate to career goals. Prerequisite: Approval of program coordinator.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the fields of adult, vocational, or cooperative extension education.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of interdisciplinary education. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of Interdisciplinary Education Research. (3-0). Credit 3. Theory and design of research problems and experiments in various subfields of interdisciplinary education. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Prerequisite: Approval of student's advisory committee chairman.

692. Professional Study. Credit 1 or more each semester. Approved professional study of project undertaken as the terminal requirement for Doctor of Education degree. Preparation of a record of study summarizing the rationale, procedure, and results of the completed project. Prerequisite: Approval of major advisor.

INTERDISCIPLINARY ENGINEERING

The interdisciplinary engineering program was originated to accommodate outstanding students who wish to major in fields that cross departmental lines. All the faculty for this program are regular members of other engineering departments. The principal areas of specialization under interdisciplinary engineering include mechanics and materials and systems engineering. Other areas of emphasis to cross disciplinary boundaries may be tailored to suit a student's desires subject to Graduate College regulations and the approval of the student's committee. Students interested in this program should contact the dean of the College of Engineering, Zachry Engineering Center.

(Itd.E.)

671. Professional Engineering Ethics and Practice. (2-0). Credit 2. Engineering professional practice; value judgments and ethical considerations related to engineering decisions. Lectures will be invited from professionals practicing in industry and government.

681. Seminar. (1-0). Credit 1. Reports and discussion of current research and of selected published technical articles. May not be taken for credit more than once in master's degree program nor twice in Ph.D. program.

685. Problems. Credit 1 to 4. Research problems of limited scope designed primarily to develop research technique.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of interdisciplinary engineering. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more. Research for thesis or dissertation.

MECHANICS AND MATERIALS

The mechanics and materials course offerings perform three major functions. First, and most importantly, they are interdisciplinary vehicles for staff and students who study and conduct research in those increasingly important problems requiring a blending of mechanics and materials. Second, they provide the base for an area of specialization wherein graduate students can pursue studies in the traditional areas of either applied mechanics or materials science. Third, they provide a coordinated set of service courses for the engineering departments. Interested students should contact the head of the Department of Aerospace Engineering.

(M.M.)

601. Theory of Elasticity (3-0). Credit 3. Analysis of stress and strain in two and three dimensions, equilibrium and compatibility equations, strain energy methods, torsion of noncircular sections, flexure, axially symmetric problems. Prerequisite: Math. 601 or registration therein.

605. Energy Methods. (3-0). Credit 3. Principle of virtual work, Rayleigh-Ritz method, Reissner's Variational Theorem. Applications to linear and nonlinear problems in mechanics. Prerequisite: Math. 601 or registration therein.

607. Flow and Fracture of Solids (3-0). Credit 3. Flow theories and fracture mechanisms of crystalline solids. Elasticity, materials science applications to engineering. Dislocation theory, fracture, creep and fatigue.

608. Elasticity of Structural Elements. (3-0). Credit 3. Torsion of cylindrical bodies and thin-walled sections. Beams: bending, shear and shear center, shear flow and shear-lag. Isotropic and anisotropic plate theory: variational formulation, boundary conditions, stability and vibrations of plates. Higher-order plate theories. Thermal stresses. Prerequisites: M.M. 601 or registration therein; Aero. 304.

609. Materials Science. (3-0). Credit 3. Structure and properties of solid materials. Prerequisites: Graduate classification; approval of instructor.

610. Applied Polymer Science. (3-0). Credit 3. Macromolecular concepts, molecular weight, tacticity, theory of solutions, rubber elasticity, thermal transitions, rheology, crystallinity, heterogeneous systems and the relation of mechanical and physical characteristics to chemical structure. Applications to polymer blends, thermosetting resins, structural adhesives and composites. For students interested in design and processing of fibrous composites. Prerequisite: Graduate classification.

613. Principles of Composite Materials. (3-0). Credit 3. Atomic, molecular, micro/macrostructure with respect to physical and mechanical properties of composite materials. Plastic, metallic, and ceramic matrices reinforced with continuous and discontinuous fibers, whiskers, and particulates. Mechanical and chemical interactions, failure modes, interface, fabrication techniques and structural design concepts. Prerequisite: Approval of instructor.

618. Designing with Composites. (2-3). Credit 3. Application of composite materials principles to the design of composite structures. Designers from industry will participate directly to provide instruction on current design methods. Design projects assigned to provide practical experience with design procedures. Prerequisites: M.M. 613 and approval of instructor.

620. Processing and Testing of Composite Materials. (2-3). Credit 3. Experiments demonstrating the processing, fabrication and curing, and testing of composite materials including typical matrix resins. Acceptance specifications and tests for raw materials and their influence on the finished product. Variables governing the cure cycle. Destructive and nondestructive tests to determine properties of the finished materials.

632. Structural Stability. (3-0). Credit 3. Buckling of columns, frames, arches, rings, plates, and shells, lateral and torsional buckling of beams, Newmark's method, equilibrium method, Rayleigh-Ritz, variational principles. Galerkin method, Treffetz method, review of current literature. Prerequisites: Math. 308; approval of instructor.

633. Theory of Plates and Shells. (3-0). Credit 3. Small-deflection thin plate theory for plates of various shapes and support conditions, bending of anisotropic plates. Plates under combined lateral loads and in-plane forces. Large deflection thin plate theory, theory of shells, stability of plates and shells. Prerequisite: Math. 601 or registration therein.

636. Theory of Thermal Stresses. (3-0). Credit 3. Heat conduction, thermoelasticity and thermoinelasticity as related to thermal stresses. Prerequisites: M.M. 601; approval of instructor.

640. Theory of Shells. (3-0). Credit 3. Continuation of study of theory of shells introduced in M.M. 633. Limited to study of linear shell theory. Equations formulated using Lame's surface parameters. Membrane analysis, bending analysis and shallow shell theory. Prerequisites: M.M. 633.

641. Plasticity Theory. (3-0). Credit 3. Theory of perfectly plastic yield and flow of two and three-dimensional bodies. General theory of shear lines, velocity fields and limiting lines are developed for problems of incipient, steady and pseudo plastic flow. Prerequisite: Math. 601 or registration therein.

647. Theory of Finite Element Analysis. (3-0). Credit 3. Finite elements of a continuum; virtual work principle; plane stress and plane strain; bending of plates; axi-symmetric stress analysis; three-dimensional stress analysis; isoparametric finite elements; recent developments; finite element computer program project; use of several finite element computer programs to solve typical structural problems. Prerequisite: M.M. 467 or equivalent; or approval of instructor.

648. Nonlinear Finite Element Methods in Structural Mechanics. (3-0). Credit 3. Tensor definitions of stress and strain, finite strain, geometric and material nonlinearities; development of nonlinear finite element equations from virtual work; total and updated Lagrangian formulations; solution methods for nonlinear equations; computational considerations; applications using existing computer programs. Prerequisite: M.M. 647 or equivalent.

650. Dynamic Fluid-Solid Interactions. (3-0). Credit 3. Dynamic interaction between fluid and solid systems with applications to space vehicles, nuclear reactors, heat exchangers and structures in general. Hydroelasticity, hydrostatic divergence, flow induced vibrations, instability and compliant surfaces. Prerequisite: Math. 601 and 602 or approval of instructor.

651. Viscoelasticity of Solids and Structures I. (3-0). Credit 3. Linear, viscoelastic mechanical property characterization methods, time-temperature equivalence, multiaxial stress-strain equations. Viscoelastic stress analysis: the correspondence principle, approximate methods of analysis and Laplace transform inversion, special methods. Static and dynamic engineering applications. Nonlinear behavior. Prerequisite: Approval of instructor.

652. Viscoelasticity of Solids and Structures II. (3-0). Credit 3. Thermodynamics of linear and nonlinear viscoelastic materials. Nonlinear constitutive equations based on thermodynamics. Application to civil and aerospace engineering materials and structures. Viscoelastic fracture. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of mechanics and materials. May be repeated for credit. Prerequisite: Approval of instructor.

SYSTEMS ENGINEERING

Systems engineering is the organized, systematic approach for the application of technology to complex engineering problems. Such applications will invariably involve many considerations and constraints which are not purely technological. The human, sociological, economic, business and political factors are combined with the creative design aspects of engineering. Areas of special career interest can be developed by combining graduate courses in an engineering specialty or business with systems engineering to respond to the growing demand of industry and government for systems oriented graduates. Persons interested in this program should contact the dean of the College of Engineering, Zachry Engineering Center.

(Sy.En.)

601. Systems Engineering. (3-0). Credit 3. Processes and patterns of systems engineering: planning, organization and management of programs for developing large, highly complex systems.

620. Preliminary System Design. (2-6). Credit 4. Preliminary design by multidiscipline teams of projects submitted by several industrial firms. Various factors, such as information retrieval and analysis, and marketing and cost-finance analyses, are considered along with actual design procedures. Prerequisite: Graduate classification.

622. Computer-Aided Design. (2-6). Credit 4. Detail design of all subsystems from the preliminary designs of Sy.En. 620 by multidiscipline teams. Computer studies for trade-off decisions and optimization are used extensively to arrive at a finalized design ready for production and/or fabrication. Prerequisite: Graduate classification.

625. Engineering Entrepreneurship. (3-0). Credit 3. Processes of an engineer taking technological innovation from conception to implementation. Processes are examined in the environments of a new business venture, an existing corporation and a government agency. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of systems engineering. May be repeated for credit. Prerequisite: Approval of instructor.

JOURNALISM
(See Communications)

DEPARTMENT OF LANDSCAPE ARCHITECTURE

D. B. Austin*, F. Klatt, Jr., H. C. Landphair, M. D. Murphy

*Graduate Advisor

The Department of Landscape Architecture offers graduate programs leading to the degrees of master of landscape architecture and doctor of environmental design. The programs are intended to develop capabilities beyond those acquired at the undergraduate level and offer educational opportunities not found in daily practice. The work is conducted in an atmosphere which encourages individual investigative effort into the ramifications of landscape conservation and related aspects of land development. Emphasis is placed on the necessity of collaborative professional efforts in the solution of all environmental design problems.

(Land.)

613. Urban Design I. (2-4). Credit 3. Cross-listed with Arch. 613.

620. Open Space Development I. (2-9). Credit 5. Solution of complex open space problems. Subjects may be as diversified as large scale land-planning study or the development of a large residential site. Prerequisite: Graduate classification in landscape architecture.

621. Open Space Development II. (2-9). Credit 5. Continuation of Land. 620; production of plans and reports. Prerequisite: Graduate classification in landscape architecture.

630. Land Development Principles. (1-6). Credit 3. Importance of regional landscape concepts. Ecological studies, landscape conservation studies, recreation potential; methods of bringing about logical regional development to create more pleasant environments in which to live.

631. Land Development Techniques. (1-6). Credit 3. Continuation of Land. 630; interprofessional collaborative efforts. Prerequisite: Land. 630.

667. Development Feasibility and Design. (3-4). Credit 5. Cross-listed with Arch. 667 and Plan. 667.

681. Seminar. (1-0). Credit 1 each semester. Analysis and criticism of selected landscape architectural projects. Lectures, reports and discussions. Prerequisite: Graduate classification in landscape architecture.

684. Professional Internship. Credit 1 to 8. Professional practice under approved arrangement with public or private agencies. Off-campus internships are limited to a maximum of eight hours of credit in any semester.

685. Problems. Credit 1 to 6. Individual problems involving application of theory and practice in planning and design of the environment.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of landscape architecture. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis. Prerequisite: Doctoral classification.

692. Professional Study. Credit 1 or more each semester. Approved professional study or project undertaken as the terminal requirement for the doctor of environmental design degree. Preparation of a record of study summarizing rationale, procedure and results of the completed project. Prerequisite: Approval of committee chairman.

LINGUISTICS
(See English)

DEPARTMENT OF MANAGEMENT

R. Albanese**, T. S. Bateman, B. D. Baysinger, H. Chamberlain, C. C. Cox, R. L. Daft, C. D. Fisher, L. W. Fry, R. W. Griffin, D. Hellriegel, R. D. Johnson, G. D. Keim, L. R. King, W. H. Mobley, M. W. Pustay, J. I. Reynolds, G. H. Rice, Jr., L. F. Schoenfeldt (Head), A. W. Smith, B. D. Stone, Jr., T. F. Urban, D. D. Van Fleet, R. W. Woodman*, S. A. Youngblood, A. Zardkoohi

*Doctoral Student Advisor
**Master's Student Advisor

The Department of Management offers graduate studies leading to M.B.A., M.S. and Ph.D. degrees. These programs provide course work in all aspects of management.

The M.B.A. degree program consists of 48 credit hours of which 12 credit hours may be concentrated in the department. Areas of course work include personnel and industrial relations, business and public policy, policy and strategy, and marine resources management. The M.S. degree program is designed to give a greater degree of specialization in management. The Ph.D. program emphasizes course work in policy and strategy, organizational behavior and theory, and business and public policy.

Additional information, including specific departmental requirements, may be obtained by contacting the department or the office of the dean, College of Business Administration.

(Mgmt.)

602. Markets and Public Policy. (4-0). Credit 4. Nature of business markets and effects of regulatory constraints. Anti-trust law, securities regulations, consumer protection, human resource issues, environmental controls, and regulation effects on business. Prerequisite: Graduate classification.

610. Business and Public Policy. (3-0). Credit 3. Role of business in contemporary society; large corporations, property rights and externalities. Current criticisms of business and social issues such as pollution, discrimination and natural resource use. Prerequisite: Graduate classification.

615. Environmental Law and Policy. (3-0). Credit 3. Legal problems and mechanisms for maintaining the environment; common law and federal and state statutory law. Governmental policies and laws for controlling air, water, solid waste and noise pollution. Prerequisite: Graduate classification.

620. Personnel. (3-0). Credit 3. Practices and problems in the acquisition, maintenance, development and use of personnel; human resource planning, recruitment, selection, training and management development, compensation, performance evaluation and labor relations. General management, rather than technician's, point of view. Prerequisite: Mgmt. 655 or equivalent.

622. Staffing. (3-0). Credit 3. Foundations and operating aspects of staffing in various types of organizations. Constraints and legal requirements affecting personnel selection; sources of personnel, job descriptions, job specifications, interviewing, testing, assessment centers and affirmative action requirements. General management, rather than a technician's, point of view. Prerequisite: Mgmt. 620 or equivalent.

623. Compensation Management. (3-0). Credit 3. Managerial analysis of the role of employee compensation in different types of organizations; job evaluation systems, legal constraints on compensation practices, relation to motivation and satisfaction, wage levels and structures, merit rating, individual and group plans, and fringe benefits. General management, rather than a technician's, point of view. Prerequisite: Mgmt. 620 or equivalent.

624. Seminar in Human Resources. (3-0). Credit 3. Seminar focuses on current research issues in human resource management. Course is tailored to needs and interests of students. Individual research projects. Prerequisite: Mgmt. 620 or equivalent.

625. Management Training in Industry. (3-0). Credit 3. Content and processes of training and development; economics of training, identification of needs, career development, matching needs with methods, learning process, evaluation of effectiveness, and techniques such as in-baskets, simulation, assessment centers and on-the-job training. General management, rather than a technician's, point of view. Prerequisite: Mgmt. 620 or equivalent.

630. Behavior in Organizations. (2-0). Credit 2. Technologies, theory and research are presented to develop human and conceptual skills needed for individual and managerial effectiveness in organizations. Work motivation, leadership, group and intergroup relations, problem solving styles, conflict and interpersonal communication. Prerequisite: Graduate classification or approval of instructor.

632. Organization Design and Theory. (2-0). Credit 2. Alternative forms of organization, organization environment interface, authority responsibility relationships, intergroup power and conflict, decision-making planning and control processes, and applied organizational design. Prerequisite: Graduate classification.

633. Organization Change and Development. (3-0). Credit 3. Complexity and dynamics of change in organization; assessing different strategies for creating change within an organization; examining different roles of change agents; and identifying strategies for building in the capacity for change in organizations. Prerequisite: Mgmt. 630 or equivalent.

634. Seminar in Organizational Behavior. (3-0). Credit 3. Seminar in specific behavioral topics of interest to participants; behavioral reinforcement, motivation, attitude theory and development, creative organizations, group models and process, and interpersonal effectiveness. Prerequisite: Mgmt. 630 or equivalent.

635. Research Topics in Labor Relations. (3-0). Credit 3. Interaction between unions and management, role of government in labor relations, and conflict resolution processes. Selected labor or manpower problems of current importance. Prerequisite: Graduate classification.

643. Legal Relationships. (3-0). Credit 3. Basic legal relationships and issues encountered by managers and organizations; American legal system, court system, selected areas of contract law, and law of negotiable instruments. Prerequisite: Graduate classification.

644. Law and Agriculture. (3-0). Credit 3. Cross-listed with Ag.Ec. 644.

650. Human Relations in Industry. (4-0). Credit 4. Cross-listed with I.En. 603.

652. Arbitration Procedures in Work Practices. (3-0). Credit 3. Cross-listed with I.En. 611.

655. Survey of Management. (3-0). Credit 3. Managerial processes, behavioral processes, management information systems, and personnel processes. Planning and controlling, organizing, decision-making, staffing and performance evaluation, motivation, groups, leadership, and organizational efficiency and effectiveness. Prerequisite: Graduate classification.

656. Due Process of Law and Administrative Procedures. (3-0). Credit 3. Cross-listed with Pol.S. 656.

661. Marine Resources Management. (3-0). Credit 3. Problems and issues of public and private sector management of the ocean resources. Management aspects of fisheries, mariculture, ocean mining, off-shore oil and gas production, marine construction, marine service industries, marine transportation, ports and waterways. Prerequisite: Mgmt. 655 or equivalent or approval of instructor.

662. Marine and Coastal Zone Law. (3-0). Credit 3. Maritime, constitutional, and international law principles relevant to major legal problems involved in developing and using marine and coastal zone resources. Sovereign rights, eminent domain, public ownership, public access, common property, riparian and navigational rights. Prerequisite: Graduate classification.

664. Coastal Zone Management. (3-0). Credit 3. Environmental, social, political, economic and legal aspects of the management of the natural resources of the coastal zone. Uses by humans and various coastal zone management programs are analyzed and compared. Prerequisite: Mgmt. 655 or equivalent or approval of instructor.

672. Management Information Systems. (3-0). Credit 3. Integrative overview of data processing and management information systems; data flow, systems analysis and design, and information technology and economics. User-needs and managerial requirements stressed more than hardware or software. Prerequisite: Mgmt. 655 or equivalent.

675. Leadership. (3-0). Credit 3. Review of research on procedures, styles, and methods of leadership, supervision, management and administration. All aspects of leader role behavior, both in practice and in research; areas in need of further research. Prerequisite: Mgmt. 630 or equivalent or approval of instructor.

678. International Management. (3-0). Credit 3. Problems and issues of international management which arise from economic, political and cultural differences. Lectures, readings and cases used to solve problems faced by expatriate managers as well as issues of home-office management of multinational firms. Prerequisite: Mgmt. 655 or equivalent.

680. Business Policy. (3-0). Credit 3. Top level decision-making within the business firm. Corporate strategy, policy formulation and implementation. Use of cases, business games, research projects, and, when possible, field cases. Should be taken during last semester of M.B.A. program. Prerequisite: Graduate classification in College of Business Administration or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. Critical examination of subject matter presented in current journals, monographs and bulletins in field of management. Prerequisite: Graduate classification.

683. Managerial Planning. (3-0). Credit 3. Long and intermediate range corporate as distinct from operational planning. Corporate-wide strategies and the implementation of strategic plans. Prerequisite: Mgmt. 680 or registration therein or approval of instructor.

684. Professional Internship. Credit 1-6. Directed internship in an organization to provide students with on-the-job training with professionals in organizational settings appropriate to the students' professional objectives. Prerequisites: Approval of committee chairman and department head.

685. Problems. Credit 1 to 4 each semester. Directed study on selected problems using recent developments in business research methods. Prerequisites: Graduate classification and approval of instructor.

687. Seminar in Research Methodology. (3-0). Credit 3. Research methodology applicable to the study of organizational phenomena. Fundamental skills and concepts needed to design and conduct dissertation research. Prerequisite: Stat. 651 or equivalent.

688. Doctoral Seminar. (3-0). Credit 3. Advanced study of the academic discipline of management. Theoretical and research developments and controversial issues in the management literature. Prerequisite: Doctoral classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of management. May be repeated for credit. Prerequisite: Graduate classification.

690. Theory of Research in Management. (3-0). Credit 3. Philosophy of science and the survey of management research methods. Typical topics include research designs, data collection methods, inductive and deductive theorizing, hypothesis formation, empirical indicators and ethics of research. Prerequisites: Advanced graduate classification and statistics; Mgmt. 687 or equivalent.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Prerequisite: Graduate classification.

DEPARTMENT OF MARKETING

C. M. Futrell, S. M. Gillespie, R. T. Hise**, J. H. Leigh, S. W. McDaniel, J. U. McNeal, W. V. Muse, A. Parasuraman, W. M. Pride*, D. H. Robertson (Head), H. G. Thompson, Jr.

*Doctoral Student Advisor
**Master's Student Advisor

The Department of Marketing offers graduate studies leading to M.S. and Ph.D. degrees and course work supporting the College of Business Administration's M.B.A. degree. These programs provide training for students interested in marketing careers.

The M.B.A. degree program consists of 48 credit hours of which 12 credit hours may be concentrated in the department. The M.S. degree program consists of 36 credit hours and is designed to give a greater degree of specialization in marketing than the M.B.A. program. Areas of specialization include product management, sales force management, marketing research, advertising and physical distribution. The Ph.D. program is designed to prepare students for careers in research and teaching as well as specialized staff positions in public and private organizations.

Additional information, including specific departmental requirements, may be obtained by contacting the department or the office of the dean, College of Business Administration.

(Mktg.)

649. Survey of Marketing. (3-0). Credit 3. Marketing concepts and functions from the point of view of the company and the economy.

650. Analyzing Consumer Behavior. (3-0). Credit 3. Theoretical and empirical material on consumer behavior; personality, social class and perception by consumers. Prerequisite: Mktg. 649 or equivalent.

655. Marketing Communications: Personal. (3-0). Credit 3. Personal selling, public relations and customer service. Prerequisites: Mktg. 649 or equivalent.

656. Marketing Communications: Non-Personal. (3-0). Credit 3. Communication processes, diffusion of innovation and promotion activities: advertising, packaging, sales promotion and publicity. Prerequisite: Mktg. 649 or equivalent.

665. Research for Marketing Decisions. (3-0). Credit 3. Methodology related to problems in marketing decision-making; primary and secondary research methodology and analytical techniques for measuring consumer attitudes, advertising effectiveness, etc. Prerequisites: Mktg. 649 or equivalent, and a basic statistics course.

671. Product Innovation. (3-0). Credit 3. Understanding of consumer needs and translating them into new products and services whose design and presentation convey satisfaction of these needs. Prerequisite: Mktg. 649 or equivalent.

673. Service and Public Marketing. (3-0). Credit 3. Marketing concepts and strategy as applied to professional and public organizations such as health and public services, and educational, political and charitable organizations.

675. Marketing Management. (4-0). Credit 4. Marketing management as it relates to overall organization goals. Marketing concepts and functions integrated with other organizational functions, tactics and strategies. Prerequisites: Graduate classification in business administration.

677. Multinational Marketing Management. (3-0). Credit 3. Theoretical and empirical materials on multinational marketing; nature and justification of international trade, analysis of environments faced by multinational firms, and formulation of multinational marketing strategy. Prerequisite: Mktg. 649 or equivalent.

681. Seminar. (1-0). Credit 1 each semester. Critical examination of subject matter presented in current periodicals, recent monographs and bulletins, in field of marketing.

685. Problems. Credit 1 to 4 each semester. Directed study of selected problems using recent developments in business research methods. Prerequisite: Approval of instructor.

688. Doctoral Seminar. (3-0). Credit 3. Historical development of the conceptual framework of marketing theory and practices; analysis of current research and controversial issues in the field. For doctoral students only. Prerequisite: M.B.A. or equivalent.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of marketing. May be repeated for credit.

690. Theory of Research in Marketing. (3-0). Credit 3. Design of research in the various subfields of marketing and the evaluation of research results using examples from the current research literature. May be repeated for credit. Prerequisite: Graduate classification in marketing.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF MATHEMATICS

O. G. Aberth, G. D. Allen, C. A. Asmuth, D. L. Barrow, P. W. Bates, G. A. Battle III, J. G. Bell, G. R. Blakley, J. R. Boone, I. Borosh, J. D. Bryant, C. K. Chui, G. C. Cosner, M. E. Flahive, S. A. Fulling, S. M. Gagola, Jr., S. C. Garrison, S. C. Geller*, L. F. Guseman, Jr.*, R. A. Gustafson, D. J. Hartfiel, D. A. Hensley, A. M. Hobbs, D. L. Johnson, T. R. Kiffe, H. E. Lacey (Head), D. R. Lewis, S. D. London, M. B. Marcus, A. J. Matchett, C. J. Maxson, J. G. Miller, S. C. Milne, F. J. Narcowich, N. W. Naugle, W. L. Perry, J. T. Pitts, H. W. Pu, G. B. Purdy, M. H. Rahe, W. Rundell, L. L. Schumaker, K. C. Smith, R. R. Smith, M. J. Stecher, P. F. Stiller, A. H. Stroud, S. D. Taliaferro, L. B. Treybig, J. R. Walton*, J. D. Ward, J. Zinn

*Graduate Advisor

The Department of Mathematics offers courses from which a graduate student may choose an appropriate sequence for an advanced degree in mathematics. It also furnishes proper mathematical preparation for graduate students majoring in other departments. It requires the knowledge of one foreign language for the Ph.D. degree. The exact form of the requirement is available in writing from any departmental Graduate Advisor.

(Math.)

601. Higher Mathematics for Engineers and Physicists. (4-0). Credit 4. Methods of linear algebra, vector analysis, and complex variables. Prerequisite: Math. 308 or equivalent.

602. Higher Mathematics for Engineers and Physicists. (4-0). Credit 4. Classification of linear partial differential equations of the second order. Fourier series, orthogonal functions, applications to partial differential equations. Special functions, Sturm-Liouville theory, application to boundary value problems. Introduction to Green's functions, finite Fourier integrals. Prerequisites: Math. 601 or Math. 308, 405, and 407.

603. Operator Theory and Partial Differential Equations. (4-0). Credit 4. Theory of operators in partial differential equations and boundary value problems: Laplace and Fourier transforms, adjoint operator, self adjoint and differential operators. Prerequisites: Math. 602 or Math. 311, 312, and 407.

606. Theory of Probability. (4-0). Credit 4. Lebesgue measure and integration, abstract measure and integration, various convergence concepts, random variables, expectation, independence and conditional expectations. Prerequisites: Math. 411 and 447 or approval of instructor.

607. Real Variables I. (4-0). Credit 4. Lebesgue measure and integration theory, differentiation, L^p-spaces, abstract integration, signed measures. Radon-Nikodym theorem, Riesz representation theorem, integration on product spaces. Prerequisite: Math. 410.

608. Real Variables II. (4-0). Credit 4. Banach spaces, theorems of Hahn-Banach and Banach-Steinhaus, the closed graph and open mapping theorems, Hilbert spaces, topological vector spaces and weak topologies. Prerequisite: Math. 607.

609. Numerical Analysis. (3-3). Credit 4. Interpolation, numerical evaluation of definite integrals, and solution of ordinary differential equations. Convergence of methods and error estimates. Math. 609 and 639 are intended to be a two semester introduction to numerical analysis for graduate students with no previous knowledge of numerical analysis. Prerequisite: Knowledge of computer programming (FORTRAN).

610. Numerical Methods in Partial Differential Equations. (3-3). Credit 4. Introduction to numerical methods for solving partial differential equations. Finite difference methods for parabolic, elliptic, and hyperbolic equations and systems; the numerical method of characteristics for hyperbolic equations. Stability and convergence of methods; error bounds. Prerequisite: Math. 417 or 609.

611. Ordinary Differential Equations. (4-0). Credit 4. General methods for first order equations, singular solutions, applications, special methods, linear equations of second order, method of successive approximations, systems of ordinary equations. Prerequisite: Math. 601.

612. Partial Differential Equations. (4-0). Credit 4. General solution of first order equations, second order equations from physics and mechanics. Prerequisite: Math. 611 or equivalent.

613. Graph Theory. (3-0). Credit 3. One or more broad areas of graph theory or network theory, such as planarity, connectivity, Hamiltonian graphs, colorings of graphs, automorphisms of graphs, or network theory. Prerequisite: Math. 431 or equivalent, or approval of instructor.

615. Vector Spaces and Matrices I. (3-0). Credit 3. Vector spaces, determinants, matrix algebra, similarity relation and unitary similarity relation, applications. Prerequisite: Math. 304 or approval of instructor.

617. Theory of Functions of a Complex Variable I. (3-0). Credit 3. Holomorphic functions, complex integral theorems, Runge's theorem, residue theorem, Laurent series, conformal mapping, harmonic functions. Prerequisite: Math. 410.

618. Theory of Functions of a Complex Variable II. (3-0). Credit 3. Infinite products, Weierstrass factorization theorem, Mittag-Leffler's theorem, normal families, Riemann mapping theorem, analytic continuation, Picard's theorems and selected topics. Prerequisite: Math. 617.

620. Fourier Series and Allied Topics. (4-0). Credit 4. Trigonometric series, group structure, convolution algebras, kernels and summability, L^2 functions, Riesz-Fischer Theorem, positive definite functions, the Bochner Theorem, pointwise convergence. Prerequisite: Math. 608 or registration therein.

627. Theory of Numbers. (3-0). Credit 3. Quadratic residues; the Legendre, Jacobi, and Kronecker symbols; quadratic reciprocity; residue characters; character sums; sums of squares; diophantine equations. Prerequisite: Approval of instructor.

629. Mathematics for Managerial, Social, and Natural Sciences. (3-0). Credit 3. Topics in differential and integral calculus; inequalities in two variables; extremum problems and linear programming; matrices and linear systems; least square approximation; applications to problems in social, managerial and natural sciences. Prerequisites: Graduate classification; approval of instructor.

631. Ring Theory I. (3-0). Credit 3. Rings and ideals, chain conditions, radicals, simplicity and semisimplicity, modules, homology. Prerequisite: Math. 653 or approval of instructor.

633. Group Theory I. (3-0). Credit 3. Abelian groups, Sylow theorems, group actions, Jordan-Holder theorem, solvable and nilpotent groups, additional selection topics. Prerequisite: Math. 653 or approval of instructor.

636. Topology I. (3-0). Credit 3. Set theory, topological spaces, generalized convergence, compactness, metrization, connectedness, uniform spaces, function spaces. Prerequisite: Math. 436 or approval of instructor.

637. Topology II. (3-0). Credit 3. Continuation of Math. 636. Prerequisite: Math. 636 or approval of instructor.

638. Calculus of Variations. (3-0). Credit 3. Theory and applications of methods of calculus of variations as applied to optimal problems. Prerequisite: Math. 601.

639. Iterative Techniques. (3-3). Credit 4. Numerical methods for solving linear and nonlinear equations and systems of equations; eigenvalue problems. Prerequisite: Elementary linear algebra and knowledge of computer programming (FORTRAN).

641. Modern Analysis I. (4-0). Credit 4. Theory of function and sequence spaces and their topologies; measure and integration, summability and series. Prerequisite: Math. 607 or approval of instructor.

642. Modern Analysis II. (4-0). Credit 4. Further topics in the theory of function and sequence spaces; duality and representations; integral transform methods with emphasis on L^p. Prerequisite: Math. 641.

643. Algebraic Topology I. (3-0). Credit 3. Fundamental ideas of algebraic topology, homotopy and fundamental group, covering spaces, polyhedra. Prerequisite: Math. 436 or approval of instructor.

644. Algebraic Topology II. (3-0). Credit 3. Homology and cohomology theory. Prerequisite: Math. 643.

651. Optimization I. (3-0). Credit 3. Fundamentals of mathematical analysis underlying theory of constrained optimizations for a finite number of variables, necessary and sufficient conditions for constrained extrema of equality constraint problems, sufficient conditions for fulfillment of constraint qualification, computational methods for concave programming problems and applications. Prerequisite: Math. 410 or approval of instructor.

652. Optimization II. (3-0). Credit 3. Necessary conditions of calculus of variations, elementary theory of games, formulation of basic control problem, Hestenes' necessary conditions for optimal control, transformations, methods of computation and applications. Prerequisite: Math. 651.

653. Algebra I. (3-0). Credit 3. Survey of groups, rings, ideals. Prerequisite: Math. 415 or approval of instructor.

654. Algebra II. (3-0). Credit 3. Survey of modules, field extensions, Galois theory. Prerequisite: Math. 653 or approval of instructor.

655. Functional Analysis I. (3-0). Credit 3. Normed linear spaces, duality theory, reflexivity, operator theory. Banach algebras, spectral theory, representation theory. Prerequisite: Math. 608.

656. Functional Analysis II. (3-0). Credit 3. Topological linear spaces, locally convex spaces, duality in locally convex spaces, ordered topological vector spaces, distribution theory, applications to analysis. Prerequisite: Math. 655.

661. Calculus of Finite Differences. (3-0). Credit 3. Difference calculus; interpolation with remainder theory; Tschebychef, Bernoulli, and Euler polynomials; introduction to difference equations. Prerequisite: Math. 308.

685. Problems. Credit 1 to 4 each semester. Offered to enable students to undertake and complete, with credit, limited investigations not within their thesis research and not covered by any other courses in the curriculum. Prerequisite: Approval of instructor.

689. Special Topics In . . . Credit 1 to 4. Selected topics in an identified area of mathematics. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation.

DEPARTMENT OF MECHANICAL ENGINEERING

R. M. Alexander, D. N. Bingham, W. L. Bradley, D. E. Bray, J. A. Caton, D. W. Childs, M. C. Colaluca, L. R. Cornwell, S. Doughty, J. C. Dutton, R. L. Field, L. S. Fletcher, C. H. Gerhold, R. E. Goforth, R. B. Griffin, S. W. Gyeszly, J.-C. Han, W. M. Heffington, M. Henriksen, R. E. Holmes, G. R. Hopkins* (Head), C. L. Hough, Jr., P. E. Jenkins, C. F. Kettleborough*, T. J. Kozik, T. R. Lalk, M. McDermott, S. C. Malguarnera, B. W. Mooring, G. L. Morrison, W. E. Murphy, S. T. Noah, T. A. Noyes, R. H. Page, J. V. Perry, Jr., J. G. Raczkowski, W. E. Red, T. E. Shoup, H. R. Thornton, W. D. Turner, J. M. Vance, S. K. Varma, P. Weiner

*Graduate Advisor

The graduate program in mechanical engineering is designed to offer a choice in curriculum depending upon career objectives. Students interested in research and/or teaching may follow the master of science and doctor of philosophy route. Those interested in practicing engineering at an advanced level in government or industry may pursue the master of engineering. This degree is offered in those areas of mechanical engineering which have a prescribed plan of study on file in the department. The department also offers courses and faculty supervision for students pursuing the doctor of engineering degree. The following courses are provided to enable each student to tailor an individual program consistent with a degree choice.

Each mechanical engineering graduate course is designed to provide a clear presentation of the underlying principles and theories essential to an understanding of the subject. Analytical and experimental techniques are described when required to apply the subject material to modern problems facing today's engineers. In many cases, the course material supplements active research in mechanical engineering areas currently being done at Texas A&M and other prominent research centers around the world. Active research facilities are available for mechanical testing, fracture testing, metallurgical studies, experimental stress analysis, vibrations and rotating machinery, turbomachinery, fluid dynamics, power generation, combustion, *in situ* lignite gasification, corrosion, solar energy and wind tunnel studies. In addition, new research programs have begun in manufacturing processes, nondestructive testing, and computer-aided design and manufacturing.

There is no foreign language requirement for the Ph.D. program in mechanical engineering. Each student, with the advice of his or her chosen advisory committee, selects courses to develop a strength in an area of specialization composed of the following mechanical engineering subgroups: thermal science, fluid mechanics, solid mechanics, materials science and dynamics.

(M.E.)

601. Advanced Machine Design. (3-0). Credit 3. Advanced problems in design; bearings, brakes and clutches, gears, piping systems, shafts, springs, stress analysis and other related topics. Prerequisite: M.E. 446 or equivalent.

603. Power Plants. (3-0). Credit 3. Engineering problems associated with the production of electrical power; economic availability of fuels, government regulations, combustion and thermodynamic cycle analysis from both a first law and second law point of view. Fossil fuel and nuclear plants.

604. Theories of Engineering Experimentation. (2-3). Credit 3. Experiment planning skills, evaluate errors and their cumulative effects, check and cross check developing data, and lay out these data in an ordered and revealing manner. Experimental error and uncertainty analysis, experiment planning, statistical and graphical data analysis, and instrument response. Prerequisite: Graduate classification.

605. Engineering Analysis. (3-0). Credit 3. Emphasis on current simulation methods of solving problems common to mechanical design; formulation of finite element models; static solutions considering distributed and thermal loads. Eigenvalue techniques in stability and dynamic analysis; direct and modal formulation of dynamical equations; treatment of constrained and partially constrained systems; sensitivity analysis and probabilistic structures. Design problems using commercially available CAD software.

606. Design of Models. (3-0). Credit 3. Analytical methods and analogue techniques used to design accurate system models. Classical methods of similitude and model design. Methods of performance from distorted models and dissimilar models. Prerequisites: A course in differential equations; graduate classification.

613. Engineering Dynamics. (3-0). Credit 3. Three dimensional study of dynamics of particles and rigid bodies and application to engineering problems. Introduction to Lagrange equations of motion and Hamilton's principle. Prerequisites: Math. 308, M.E. 213.

615. Advanced Engineering Thermodynamics. (3-0). Credit 3. Theories of thermodynamics and their application to the more involved problems in engineering practice and design. Equilibrium, Gibbs' function, nonideal gases and various equations of state. Second law analysis and statistical theory. Prerequisite: M.E. 328 or equivalent.

617. Mechanical Vibrations. (3-0). Credit 3. Linear theory of vibrations of finite number of degree of freedom systems via Lagrange equations. Engineering applications. Prerequisites: Math. 308, M.E. 213.

620. Experimental Stress Analysis. (2-3). Credit 3. Stress and strain at a point. Theory of photoelasticity and its application to stress analysis. Principles of birefringent coating, moire fringe patterns, stress coat, strain gages and their application. Basic techniques of experimental stress analysis and the related equipment.

621. Fluid Mechanics. (3-0). Credit 3. Dynamics of two-dimensional incompressible and compressible fluids. Viscous flow in laminar and turbulent layers, the Navier-Stokes equations, boundary layer theory, and applications to turbomachinery design.

622. Applications of Fluid Mechanics. (3-0). Credit 3. Applications of the principles of fluid mechanics to specific problems of interest to the mechanical engineer. Analyses of fluid networks and devices. Flow measurement techniques and control methods for unsteady flows. Prerequisite: M.E. 344.

624. Two-Phase Flow and Heat Transfer. (3-0). Credit 3. Current status of two-phase flow and heat transfer for application to design. Basic one dimensional treatment of two-phase flows and the current state of the art in liquid-vapor phase change heat transfer. Prerequisite: Undergraduate courses in fluid mechanics and heat transfer.

626. Lubrication Theory. (3-0). Credit 3. Development of Reynolds equation from Navier-Stokes equation for study of hydrodynamic lubrication theory as basis for bearing design. Application to simple thrust and journal bearings and pads of various geometries. Hydrostatic lubrication, floating ring bearing, compressible fluid (gas) lubrication, grease lubrication, dynamically loaded bearings, half speed whirl and stability. Prerequisites: Math. 308; M.E. 344 or equivalent.

627. Heat Transfer-Conduction. (3-0). Credit 3. Mathematical theory of steady-state and transient heat conduction. Solution of the governing differential equations by analytical and numerical methods; applications to various geometric configurations. Prerequisites: C.S. 458 or equivalent; Math. 601 or registration therein; M.E. 461.

628. Heat Transfer-Convection. (3-0). Credit 3. Mathematical theory of convection energy transport. Applications to the design of heat-transfer apparatus. Prerequisites: Math. 601 or registration therein; M.E. 461.

629. Heat Transfer-Radiation. (3-0). Credit 3. Mathematical theory of thermal radiation with design applications. Ideal and nonideal radiating surfaces, heat transfer in enclosures, solar radiation. Analytical, numerical, and analogical methods stressed in problem solving. Prerequisites: Math. 601 or registration therein; M.E. 461.

632. Field Computations in Engineering. (3-0). Credit 3. Application of numerical methods to design problems associated with flow of fluids, heat and stress. Application to physical design problems. Prerequisites: Math. 601; graduate classification.

639. Dynamics of Rotating Machinery. (3-0). Credit 3. Dynamic stability, critical speeds and unbalanced response of rotor-bearing systems. Special problems encountered in modern applications operating through and above critical speeds. Prerequisite: M.E. 459 or 613.

645. Advanced Gas Dynamics. (3-0). Credit 3. Continuous and discontinuous unsteady one-dimensional flow, hydraulic analogy for steady and unsteady gas dynamics, hypersonic viscous flows, hypersonic gas dynamics of slender and blunt bodies, and radiation gas dynamics encountered in design. Prerequisites: Math. 601 or approval of instructor; M.E. 472.

646. Aerothermodynamics of Turbomachines. (3-0). Credit 3. Fluid mechanics and thermodynamics as applied to the design of rotating systems. Development of turbomachinery equations. Detailed aerodynamic design of compressors and turbines. Prerequisites: Math. 601 or approval of instructor; M.E. 414, 472.

647. Vibrations of Plates and Shells. (3-0). Credit 3. Geometrics of the plate and the shell; concepts, formulation, and methods of solution associated with vibrational problems concerning plates and shells. Anisotropic media, variable thickness and implane forces. Prerequisite: M.E. 617 or equivalent.

649. Nonlinear Vibrations. (3-0). Credit 3. Exact and approximate solutions to nonlinear differential equations in mechanical vibrations; application of classical methods in nonlinear analysis such as the Method of Perturbations and Variation of Parameters. Virtual Work Technique and the Modified Galerkin Method. Applications to selected nonlinear problems. Prerequisites: A course in differential equations; graduate classification.

650. Random Vibration. (3-0). Credit 3. Vibrations of mechanical systems and structures excited by random loadings. Stationary and ergodic processes; probability, correlation and spectral density functions. Finite-degree-of-freedom and continuous systems; point and distributed loadings; first passage and fatigue failures. Data analysis techniques; typical excitation environments; environmental simulation testing; statistical energy method. Prerequisites: M.E. 459.

662. Energy Management in Industry. (3-0). Credit 3. Energy systems and components frequently encountered in industrial environments. Application of basic principles of thermodynamics, heat transfer, fluid mechanics and electrical machinery to the analysis and design of industrial system components and systems. Improved energy utilization. Prerequisites: M.E. 328 and 461 or approval of instructor.

664. Energy Management in Commercial Buildings. (3-0). Credit 3. Basic heating, ventilating and air conditioning system design/selection criteria for air conditioning and heat system and design/selection of central plant components and equipment. Prerequisite: M.E. 328 and 461 or approval of instructor.

665. Application of Energy Management. (3-0). Credit 3. Continuation of M.E. 662 and M.E. 664. Case studies by students of energy conservation opportunities using energy audits and building load computer simulation. Prerequisites: M.E. 662 and 664 or approval of instructor.

681. Seminar. (0-1). Credit 1. Current research in a wide range of fields, described by guest lecturers who are prominent in their fields. Discussion period at the end of each lecture will permit the students to learn more about the lecturer and his/her work. Prerequisite: Graduate classification in mechanical engineering.

684. Professional Internship. Credit 1 or more each semester. Supervised work in an area closely related to the specialized field of study undertaken by a master of engineering candidate. Prerequisite: Admission to a specialized master of engineering program in mechanical engineering.

685. Problems. Credit 1 to 4 each semester. Content will be adapted to interest and needs of group enrolled.

689. Special Topics in . . . Credit 1 to 4. The special topic selected each time will depend upon the interest of the student group involved. A poll of all concerned will be conducted during each semester preceding the one in which the course will be presented. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Methods and practice in mechanical engineering research for thesis or dissertation.

The following courses are described in the section entitled Mechanics and Materials and are prefixed with the letters M.M. They are part of the curriculum in mechanical engineering.

601. Theory of Elasticity. (3-0). Credit 3.

603. Foundations of Solid Mechanics. (3-0). Credit 3.

605. Energy Methods. (3-0). Credit 3.

607. Flow and Fracture of Solids. (3-0). Credit 3.

608. Elasticity of Structural Elements. (3-0). Credit 3.

609. Materials Science. (3-0). Credit 3.

613. Principles of Composite Materials. (3-0). Credit 3.

618. Designing with Composites. (2-3). Credit 3.

620. Processing and Testing of Composite Materials. (2-3). Credit 3.

632. Structural Stability. (3-0). Credit 3.

633. Theory of Plates and Shells. (3-0). Credit 3.

636. Theory of Thermal Stresses. (3-0). Credit 3.

640. Theory of Shells. (3-0). Credit 3.

641. Plasticity Theory. (3-0). Credit 3.

647. Theory of Finite Element Analysis. (3-0). Credit 3.

650. Dynamic Fluid-Solid Interactions. (3-0). Credit 3.

651. Viscoelasticity of Solids and Structures I. (3-0). Credit 3.

652. Viscoelasticity of Solids and Structures II. (3-0). Credit 3.

MECHANICS AND MATERIALS

(See Interdisciplinary Engineering)

DEPARTMENT OF METEOROLOGY

K. C. Brundidge*, P. Das, D. Djuric, D. M. Driscoll, G. A. Franceschini, J. F. Griffiths, W. K. Henry, G. L. Huebner, Jr., J. P. McGuirk, R. C. Runnels, J. R. Scoggins (Head), A. H. Thompson

*Graduate Advisor

Master of science and doctor of philosophy degrees are offered in meteorology as well as the bachelor of science degree. In addition to the Graduate College requirements, doctoral candidates may be required to pass (B average) up to 12 semester hours of course work in broadening subjects outside the major and minor fields. The student's graduate advisory committee shall determine whether one or more foreign languages shall be included in this work. All candidates for advanced degrees must pass a departmental qualifying examination as a condition for graduation.

Prerequisites for graduate work in meteorology are satisfied by the undergraduate program offered in the department. Anyone holding a bachelor's degree is eligible to enter the graduate program in meteorology. However, those entering the graduate program from another discipline will be required to complete a limited number of background courses. Most students can expect to complete a master's degree program in approximately two years. Students may emphasize marine, agricultural, radar, dynamical and numerical, physical, synoptic, mesoscale and air pollution meteorology, or climatology.

Meteorology. Meteorology is the science of planetary atmospheres and their phenomena. It concerns the study of internal and boundary layer atmospheric processes. The objective in meteorology is to determine the physical and chemical laws affecting atmospheres and to apply them in ways benefiting life and human endeavor. The greatest uses of weather information and forecasts have been in aviation, space exploration and travel, environmental quality and air pollution, and in the general public interest. Increasing rewards are being found in applications to agriculture, shipping, engineering, civil and industrial planning, health and travel, recreation, space exploration, air pollution and related sciences.

Persons with B.S. and M.S. degrees in meteorology typically obtain employment with the National Weather Service or other government agencies, industrial organizations and consulting firms, or they may enter the meteorological branch of one of the military services. Their responsibilities might be in the accumulation and analysis of weather data, weather forecasting including television, air pollution meteorology, or in a closely allied area such as computer programming or agriculture. Positions in teaching and research almost exclusively require a graduate degree.

Facilities and Participation in Research. Graduate students often take an active part in one or more of the research contracts sponsored in the department by industry and by state and federal agencies. In addition to campus facilities, which include dual wavelength weather radars, weather station with teletype and facsimile machines and satellite receiver, micrometeorological measurement facility, walk-in freezer room, and instrumentation and other special laboratories, others are available in the College of Geosciences for working at sea or a coastal location.

(Met.)

600. Survey of Meteorology. (3-0). Credit 3. Survey course in meteorology designed for teachers of secondary school science. Prerequisite: Approval of department head.

615. Instrument Theory and Design. (3-0). Credit 3. Modern methods of instrumentation as related to meteorology and allied geophysical fields; their basic concepts, design, use and inherent errors. Prerequisite: Bachelor of science degree in science or engineering.

616. Remote Sensing of the Atmosphere. (3-0). Credit 3. Advanced methods of measurement in geoscience; meteorological parameters. Prerequisite: Met. 615 or approval of instructor.

625. Applied Climatology. (3-0). Credit 3. Practical applications of climate to other disciplines; methods used for this coordination. Prerequisite: Met. 425 or approval of instructor.

635. Reading Seminar in Dynamic Meteorology. (3-0). Credit 3. Group examination of pertinent papers in current literature; designed to confront students with recent developments for critical evaluation. May be repeated once for credit. Prerequisite: Met. 435 or approval of instructor.

636. Dynamic Meteorology. (3-0). Credit 3. Baroclinic and barotropic instability; general circulation; tropical systems. Prerequisite: Met. 435. (Offered in 1981-82 and alternate years thereafter.)

637. Numerical Weather Prediction. (3-0). Credit 3. Numerical solution of meteorological equations, time and space differencing, non-linear stability, spectral approach. Prerequisite: Met. 435 or registration therein.

638. Dynamics of Convective Clouds. (3-0). Credit 3. Parcel, slice, and entrainment concepts; bubble and plume theories; spherical vortex; the starting plume; one-dimensional models; select topics of current interest. Prerequisite: Met. 336.

645. Cloud and Precipitation Physics. (3-0). Credit 3. Physics of atmospheric condensation nuclei, ice in the atmosphere; precipitation processes; artificial modification of clouds; precipitation. Prerequisite: Met. 446.

647. Meteorology of the Upper Atmosphere. (3-0). Credit 3. Effects of solar system astrophysical processes and properties on extratropospheric terrestrial atmosphere. Composition, structures and characteristic phenomena. Prerequisite: Bachelor of science degree in meteorology, science or engineering.

648. Cosmic Meteorology. (3-0). Credit 3. Continuation of Met. 647. Properties and processes of interplanetary medium, atmospheres of other planets; cosmological implications in planetary environments. Prerequisite: Met. 647.

655. Satellite Data in Meteorology. (3-0). Credit 3. Meteorological satellite programs of the U. S. and other countries; theory of meteorological measurements from artificial satellites; applications of satellite data in determinations of atmospheric structure and in forecasting; recent and current research studies; future programs. Prerequisite: Met. 451 or approval of instructor.

656. Tropical Meteorology. (3-0). Credit 3. Role of the tropics in global circulation; structure and dynamics of the tropical zone; local and diurnal phenomena; synoptic components; tropical cyclones; role of cumulus-scale convection; current topics. Prerequisite: Met. 451 or approval of instructor.

657. Mesometeorology. (3-0). Credit 3. Theory and structure of mesoscale weather systems and their relation to larger and smaller scale systems. Prerequisite: Met. 451 or approval of instructor.

658. Synoptic Meteorology. (3-0). Credit 3. Mechanism and energetics of general circulation. Structure of large-scale systems. Persons desiring practice in analysis techniques should enroll for one or more hours of Met. 685. Prerequisite: Met. 453 or approval of instructor.

661. Atmospheric Turbulence. (3-0). Credit 3. Theory of atmospheric turbulence; production and dissipation of eddy energy; eddy energy equation; similarity theory; structure of turbulence. Prerequisites: Math. 308; Met. 445 or approval of instructor.

666. Agricultural Meteorology. (3-0) Credit 3. Application of physical concepts of meteorology to problems arising in agriculture; meso- and micro-climates and their modification. Prerequisite: Met. 465 or approval of instructor.

667. Atmosphere-Ocean Interaction. (3-0). Credit 3. Physical aspects of processes of exchange across the air-sea interface and their effects on boundary layers; influence of ocean on weather and climate. Prerequisite: Met. 445 or equivalent or approval of instructor.

681. Seminar. (1-0). Credit 1. Presented by students and faculty based upon their research work and upon surveys of the literature.

685. Problems. Credit 1 or more each semester. Offered to enable majors in meteorology to undertake and complete, with credit, in their particular fields of specialization, limited investigations not covered by any other courses in established curriculum.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of meteorology. May be repeated for credit.

691. Research. Credit 1 or more each semester. For thesis or dissertation. Topic subject to approval of department head.

DEPARTMENT OF MODERN LANGUAGES

C. C. Christian, Jr.*, L. F. Costa, N. J. Dyer, A. M. Elmquist (Head), W. Koepke, O. L. Naudeau, H. W. Puppe, K. C. Richards, L. Stavenhagen

*Graduate Advisor

The Department of Modern Languages offers graduate courses leading to the degree of master of arts, with an option in Spanish, and courses in other languages preparing graduate students for the Ph.D. foreign language examinations. These latter courses (Fren. 601, 602 and 685; Germ. 603, 604 and 685; Russ. 685; and Span. 615, 616) are not normally approved for graduate degree credit.

The master of arts program offers courses in Peninsular Spanish literature, Spanish American literature and bilingualism. The thesis may be written in one of these areas. A minimum of six credit hours must be taken in a selected minor field. A non-thesis option is available.

Graduate work will directly prepare the student for professional careers concerned with Spanish and bilingualism, for teaching positions, and for further graduate studies. A high competence in the Spanish language is required. This competence also assists the student in pursuit of professional employment outside of traditional areas.

Prerequisites: Admission to the Graduate College and an undergraduate degree in Spanish or an equivalent competence in Spanish language and literature.

FRENCH
(Fren.)

601. Introduction to Scientific French. (3-0). Credit 3. Intensive course to prepare graduate students to read scientific material. Technical vocabulary and translation. Prerequisite: Graduate classification.

602. Readings in Scientific French. (3-0). Credit 3. Continuation of Fren. 601. Reading and translation of material relating to various disciplines. Designed to develop technical vocabulary and facility in reading scientific French. Prerequisite: Fren. 601 or approval of department head.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the field of French. Prerequisite: Approval of department head.

GERMAN
(Germ.)

603. Introduction to Scientific German. (3-0). Credit 3. Intensive course to prepare graduate students to read scientific material. Technical vocabulary and translation. Prerequisite: Graduate classification.

604. Readings in Scientific German. (3-0). Credit 3. Continuation of Germ. 603. Translation of material relating to various disciplines. Designed to develop technical vocabulary and facility in reading scientific German. Prerequisite: Germ. 603 or approval of department head.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the field of German. Prerequisite: Approval of department head.

RUSSIAN
(Russ.)

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the field of Russian. Prerequisite: Approval of department head.

SPANISH
(Span.)

605. Spanish and the Bilingual Movement. (3-0). Credit 3. Problems of bilingualism with special reference to the Spanish-speaking population of the Southwest.

606. Spanish Language in Texas. (3-0). Credit 3. Sociocultural variables relating to Spanish usage in Texas; linguistic analysis of texts in which such usage is represented, as in the works of contemporary Chicano writers. Prerequisite: Graduate classification. Some knowledge of Spanish is desirable.

615. Introduction to Spanish Reading and Translation. (3-0). Credit 3. Reading professional material in the areas of the humanities, social sciences and related disciplines. Translation and reading for comprehension with emphasis on grammar and vocabulary. Not for graduate students in languages. Prerequisite: Graduate classification.

616. Technical and Professional Readings in Spanish. (3-0). Credit 3. Reading professional material in the areas of the humanities, social sciences and related disciplines. Translation and readings for comprehension. Not for graduate students in languages. Prerequisite: Span. 615 or approval of department head.

635. Contemporary Spanish-American Prose. (3-0). Credit 3. Life and works of a selected Spanish-American novelist. Prerequisite: Twelve hours of advanced Spanish courses.

636. Contemporary Spanish Prose. (3-0). Credit 3. Life and works of a selected Spanish novelist. Prerequisite: Twelve hours of advanced Spanish courses.

646. Spanish Literature of the Golden Age. (3-0). Credit 3. Spanish drama and poetry from the Golden Age as well as selections from Don Quijote and the picaresque novel. Prerequisite: Twelve hours of advanced courses in Spanish.

647. Poetry of Spain and Spanish America. (3-0). Credit 3. Spanish and Spanish-American poetry; outstanding poets of the 20th century and analysis of contemporary techniques in writing poetry. Prerequisite: Twelve hours of advanced courses in Spanish.

648. Development of Spanish Literature and Culture. (3-0). Credit 3. Development of Spanish literature with selections from major authors interpreted in relation to the historical contexts. Prerequisites: Twelve hours of advanced courses in Spanish.

649. Literature, Society, and Culture in Latin America. (3-0). Credit 3. Society and culture of Latin American countries as represented in contemporary literature; the novel and the views of their societies expressed by Latin American writers in interviews, articles, essays and other forms. Prerequisite: Twelve hours of advanced courses in Spanish.

650. Structure of the Spanish Language. (3-0). Credit 3. Phonological and morphological structures of Spanish; regional and national variations. Prerequisite: Twelve hours of advanced courses in Spanish.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in the field of Spanish language or literature. Prerequisite: Twelve hours of advanced Spanish courses.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of Spanish. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Thesis research credit given only upon acceptance of completed thesis. Prerequisite: Twelve hours of advanced courses in Spanish.

DEPARTMENT OF NUCLEAR ENGINEERING

R. G. Cochran*, C. A. Erdman* (Head), R. R. Hart*, C. E. Lee*, R. D. Neff*, T. A. Parish*, J. D. Randall*, R. S. Wick*

*Graduate Advisor

The rapid development of nuclear power and related industries has created a great and growing demand for trained nuclear engineers. The nuclear engineer is concerned with the release, control and use of energy from nuclear sources. Nuclear engineering is based on the principles of nuclear physics which govern radioactivity, fission and fusion; the production of heat and radiation in those processes; and the interaction of radiation with matter. The function of the nuclear engineer is to apply these principles to a wide range of challenging technological problems.

The Department of Nuclear Engineering offers the master of engineering, master of science and doctor of philosophy degrees. The department also offers courses and faculty supervision for students pursuing the doctor of engineering degree. Admission to nuclear engineering requires a bachelor's degree in engineering, chemistry, mathematics or physics. Some nuclear physics background is highly desirable. Mathematics through differential equations is required.

Degree programs which include a minor field of study are encouraged. This minor field would normally include graduate study in the area of the student's baccalaureate degree. If the baccalaureate degree is nuclear engineering, the student with the advice of his or her committee will select a suitable minor area of study. The department does not have a foreign language requirement for the Ph.D. degree.

The facilities available for instructional and research purposes include a radiation measurements laboratory, a sub-critical reactor laboratory, AMDAHL 470 V/6 digital computer, a radiochemistry laboratory, a low power nuclear reactor, a Cockcroft-Walton pulsed accelerator, and a large research reactor located at the Texas A&M University Nuclear Science Center. An 88-inch cyclotron is available for research in nuclear physics and engineering.

PROFESSIONAL EDUCATIONAL PROGRAM IN HEALTH PHYSICS

This area of specialized study in the Department of Nuclear Engineering is based strongly on the fundamental aspects of radiation effects on matter. The curriculum is such that students are trained at a professional level in the field of radiation safety or health physics.

A student is required to spend the initial academic year taking formal course work in the Department of Nuclear Engineering and in other cooperating departments of the University. The summer is spent in special courses providing practical on-the-job training in health physics at the Cyclotron Institute, the Nuclear Science Center Reactor and at the Radiological Safety Office. At least one additional semester is normally required to finish course work and complete a research project for the master of science degree in nuclear engineering.

(N.E.)

601. Nuclear Reactor Analysis. (3-0). Credit 3. Neutron energy spectra in infinite homogeneous media. Boltzmann transport equation. Diffusion approximation. One-speed and multigroup diffusion theory calculations for bare homogeneous reactors. Reflected homogeneous reactors. Prerequisites: N.E. 404 or equivalent; Math. 601 or registration therein.

602. Nuclear Reactor Analysis. (3-0). Credit 3. Resonance absorption. Heterogeneous reactors. Reactor kinetics. Temperature coefficients. Perturbation theory. Prerequisite: N.E. 601.

603. Fast Reactor Analysis. (3-0). Credit 3. Fast neutron interactions, neutron spectra, criticality calculations, reactivity effects: void effects, Doppler effects, expansion effects. Kinetics and dynamics, comparison with thermal reactors, engineering safeguards. Breeding ratio, doubling time, fuel cycle economics. Comparison of coolants: Na, steam, gas. Existing fast reactor experiments. Prerequisite: Approval of instructor.

605. Nuclear Measurements Laboratory. Credit 3. Basic techniques of nuclear measurements. Behavior of neutrons in multiplying and nonmultiplying media observed. Extensive use of nuclear reactor. Prerequisite: N.E. 601 or registration therein.

606. Reactor Experimentation. (2-3). Credit 3. Extension of N.E. 605. Control rod and power calibrations are performed. Effects of scattering, absorption and moderation on the reactor are determined. Reactor core is disassembled and a critical experiment performed. Prerequisite: N.E. 605 or approval of graduate advisor.

607. Thermonuclear Engineering. (3-0). Credit 3. Fusion reactions, orbit theory in magnetic and electric fields. Coulomb interactions, formulation of Boltzmann equation, magnetohydrodynamics, plasma waves. Prerequisite: Math. 601 or registration therein, N.E. 417, or approval of instructor.

608. Thermonuclear Engineering. (3-0). Credit 3. Fundamentals relative to use of fusion reaction as energy source. Transport theory for ionized gases. Liouville and Boltzmann equations. Macroscopic conservation laws and magnetohydrodynamics. Instabilities. Confinement and heating problems. Diagnostics. Prerequisite: N.E. 607.

610. Design of Nuclear Reactors. (4-0). Credit 4. Application of fundamentals of nuclear physics and reactor theory with engineering fundamentals to design of nuclear reactors. Prerequisites: N.E. 602 or registration therein, N.E. 410 or approval of instructor.

612. Radiological Safety and Hazards Evaluation. (3-0). Credit 3. Rigorous mathematical and physical approach to various aspects of radiological safety. Derivation of equations involving radiation absorption, radiation dosimetry, and calculations of radiation dose due to internal emitters. Mathematical models developed for determination of maximum permissible body burdens and concentrations in air and water. Prerequisites: Math. 308, N.E. 613.

613. Principles of Radiological Safety. (3-0). Credit 3. State and federal regulations concerning radioactive materials. Radiation safety as applied to accelerators, nuclear reactors, and radioactive byproducts. Rigourous methods of analysis applied to computation of biological radiation dose and dose rates from various sources and geometries. Radiation effects on physical systems. Prerequisite: N.E. 409.

618. Nuclear Control Systems. (3-0). Credit 3. Reactor kinetics and fundamentals of servo-control developed and applied to nuclear reactors. Safety aspects of reactor control and operational problems. Prerequisite: N.E. 601 or registration therein.

622. Nuclear Power Plant Design and Analysis. (3-0). Credit 3. Application of nuclear reactor systems to field of power production, using general fields of thermodynamics and heat transfer, with special problems arising from nuclear system. Prerequisites: M.E. 323 or 327; N.E. 601 or registration therein.

623. Analytical Nuclear Engineering I. (3-0). Credit 3. Unified treatment of mass, momentum, and energy transport with applications to nuclear engineering sources. Velocity and temperature distributions in laminar and turbulent flow. Liquid metal heat transfer. Flow and thermal stability. Prerequisites: Math. 601 or registration therein; M.E. 344, 346 or 461; or approval of instructor.

624. Analytical Nuclear Engineering II. (3-0). Credit 3. Unified analytical treatment of heat conduction in solids and thermal stress phenomena with application to nuclear energy sources. Transient heat conduction in solids. Isothermal elasticity. Thermoelasticity. Viscoelasticity. Plasticity. Prerequisites: Math. 601 or registration therein; N.E. 623 or approval of instructor.

625. Nuclear Reactor Theory. (4-0). Credit 4. Advanced treatment of neutron transport theory. Methods of solution of integrodifferential and integral Boltzmann equations and their adjoints. Multigroup diffusion and transport theory. Prerequisites: Math. 602; N.E. 602.

626. Nuclear Reactor Theory. (4-0). Credit 4. Continuation of N.E. 625. Methods of singular eigenfunctions and energy dependent transport theory. Variational methods, thermalization, and resonance absorption theory. Double heterogeneous systems. Current advanced techniques in transport theory.

629. Numerical Methods in Reactor Analysis. (3-0). Credit 3. Solution of multidimensional multigroup problems, including S^n, P^n, and Monte Carlo techniques. Techniques in reactor kinetics, fuel cycle, and reactor life study approximations.

630. Analysis of Isotopic Enrichment. (3-0). Credit 3. Development of general cascade equations for isotopic enrichment; analysis of the ideal cascade, squared off cascade, close separation cascade approximations. Various processes used to achieve enrichment and application. Prerequisite: N.E. 404 or approval of instructor..

631. Reactor Fuel Reprocessing. (3-0). Credit 3. Engineering analysis of characteristics of fission products in irradiated reactor fuel; properties of reactor fuel materials; various methods used to reprocess spent fuels. Prerequisite: N.E. 404 or approval of instructor.

679. Practical Applications of Radiological Safety I. (1-6). Credit 3. Intensive and comprehensive lecture and practical training in radiological safety operations. Radioactive license application, review and compliance. Actual performance of radiation safety duties at isotope laboratories, counting laboratories, nuclear reactors and high energy accelerators. Prerequisites: N.E. 612, 613.

680. Practical Applications of Radiological Safety II. (1-6). Credit 3. Continuation of N.E. 679 reaching point where student can design and conduct radiation surveillance operations independently, with no immediate supervision. Prerequisite: N.E. 679.

681. Seminar. (1-0). Credit 1. Special topics in nuclear engineering not covered by formal course work. Whenever possible, guest lecturers will discuss topics which they have personally investigated. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 4 each semester. Offered to enable students to undertake and complete limited investigations not within their thesis research and not covered by any other courses in curriculum. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of nuclear engineering. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research toward thesis or dissertation.

DEPARTMENT OF OCEANOGRAPHY

L. D. Berner, Jr., D. C. Biggs, T. J. Bright, D. A. Brooks, J. M. Brooks, W. R. Bryant, J. D. Cochrane, R. Darnell*, S. Z. El-Sayed, D. A. Fahlquist, G. A. Fryxell, S. Gartner, C. S. Giam, T. W. C. Hilde, T. Ichiye, L. M. Jeffrey, D. W. McGrail*, W. J. Merrell, J. W. Morse, W. D. Nowlin, Jr.*, E. N. Powell, B. J. Presley, P. D. Rabinowitz, R. O. Reid (Head), R. Rezak, D. R. Schink, M. R. Scott*, G. F. Sharman, T. W. Spence, T. K. Treadwell, Jr., A. C. Vastano, J. H. Wormuth

*Graduate Advisor

Degrees. Degrees of master of science and doctor of philosophy are offered in oceanography.

Oceanography. Oceanography is the interdisciplinary science that focuses on the ocean, its contents and its boundaries. Whereas typical graduate programs lead to progressively greater amounts of specialization, oceanography as an interdisciplinary field, admits graduates of specialized areas such as biology, chemistry, geology, mathematics, physics or engineering and initially generalizes and broadens their education with a core of required courses. These core courses include the four specializations of the oceanography program — biological, chemical, geological/geophysical and physical oceanography — as well as a techniques course and a seminar covering the state of the science. After this exposure to the interdisciplinary nature of oceanography, the graduate student refocuses in his or her particular subject area to pursue research at the leading edge of the science.

Required prerequisites are the equivalent of a B.S. degree in one of the basic fields mentioned above and basic courses in each of the other areas. All students are expected to have had mathematics through integral calculus, at least one year each of physics and chemistry, and at least one survey course in biology and geology. These are in addition to the usual amount of course work in their major field of science or engineering.

To qualify for an advanced degree in oceanography, the student must demonstrate an ability to apply basic science to the marine environment. This capability requires a combination of principles and methods and a certain body of knowledge unique to oceanography; a student of oceanography must become conversant in all of the marine sciences.

Facilities and Participation in Research. Facilities include office, laboratory and classroom space in the 15-story Oceanography and Meteorology Building on the College Station campus; space at the Texas A&M University Research and Extension Center; office, shop and dock facilities on Pelican Island in Galveston, Texas; the R/V *Gyre,* a 179-foot oceangoing research vessel; the R/V *La Mer,* a 38-foot shelf and coastal research vessel; the DRV *Diaphus,* a 2-person, 1200-foot depth research submersible; and a large research equipment inventory. Graduate students usually take an active part in research grants and contracts awarded to individual professors and research teams by federal and state agencies, industry and private foundations.

Required Courses. Ocn. 602, 608, 620, 630 and 640 and two hours of oceanography seminar (Ocn. 681) are required of all graduate students who are candidates for M.S. and Ph.D. degrees. A reading knowledge of one modern foreign language is required of all Ph.D. candidates. Further information is available from the department.

(Ocn.)

600. Survey of Oceanography. (3-0). Credit 3. General survey of the scientific framework of oceanographic study. Applications of ocean research to social and economic problems; interrelations between the ocean disciplines and other fields of study. Prerequisite: Approval of instructor.

602. Ocean Research and Operational Techniques. (1-5). Credit 3. Technical, operational and legal aspects of sea-going research operations. Planning and executing ocean research operations. Practice in techniques and equipment regularly used aboard ships; familiarization with acquisition and processing of data. Prerequisite: Approval of instructor.

604. Biological Oceanography Cruise. Credit 2. Specialized experience in research methods and analysis in biological oceanography via preparation for and participation in a research cruise of at least two weeks duration under the supervision of a Texas A&M oceanography faculty member. May be taken for credit up to twice for M.S. candidates and four times for Ph.D. candidates. Prerequisite: Approval of instructor.

605. Chemical Oceanography Cruise. Credit 2. Specialized experience in research methods and analysis in chemical oceanography via preparation for and participation in a research cruise of at least two weeks duration under the supervision of a Texas A&M oceanography faculty member. May be taken for credit up to twice for M.S. candidates and four times for Ph.D. candidates. Prerequisite: Approval of instructor.

606. Geological Oceanography Cruise. Credit 2. Specialized experience in research methods and analysis in geological oceanography via preparation for and participation in a research cruise of at least two weeks duration under the supervision of a Texas A&M oceanography faculty member. May be taken for credit up to twice for M.S. candidates and four times for Ph.D. candidates. Prerequisite: Approval of instructor.

607. Physical Oceanography Cruise. Credit 2. Specialized experience in research methods and analysis in physical oceanography via preparation for and participation in a research cruise of at least two weeks duration under the supervision of a Texas A&M oceanography faculty member. May be taken for credit up to twice for M.S. candidates and four times for Ph.D. candidates. Prerequisite: Approval of instructor.

608. Physical Oceanography. (3-2). Credit 4. Observations, instruments; physical properties of seawater. Property distributions; characteristics of water masses; heat budget. Kinematics; gravity, pressure, hydrostatics, stability. Horizontal flow; Coriolis force, geostrophy; friction, wind drift; general circulation. Wave motions; tides. Prerequisites: Math. 122 or equivalent; Phys. 219.

609. Physical Oceanography. (3-0). Credit 3. Kinematics of fluids, systematic derivation of the equations of motion and continuity; general integral relations; thermodynamic considerations of seawater; non-equilibrium transfer processes and the second law of thermodynamics. Prerequisites: Math. 601; Met. 435 or Ocn. 608 (concurrently).

611. Theoretical Physical Oceanography. (3-0). Credit 3. Reynolds equations of motion; scaling analysis, Ekman layers; application of vorticity equation to ocean circulation; meanders and Rossby waves; inertio-gravity waves and other wave phenomena in the ocean including boundary waves. Prerequisites: Ocn. 608, 609.

612. Elements of Ocean Wave Theory. (3-0). Credit 3. Theories of simple harmonic surface gravity, capillary and internal waves. Wave propagation, dispersion and energy. Modifications due to rotation, variable depth and finite amplitude. Prerequisites: Math. 601; Ocn. 608; or approval of instructor.

614. Dynamics of the Ocean and Atmosphere. (3-0). Credit 3. Unified linear perturbation theory of rotating stratified fluids with application to waves in the ocean or atmosphere. Energy considerations, characteristic modes of motion, approximate methods of analysis. Offered in 1980-81 and alternate years thereafter. Prerequisites: Math. 602; Ocn. 611.

615. Long Waves and Tides. (3-0). Credit 3. Hydrostatic long wave model; Kelvin, Poincare, Rossby, edge and topographic waves. Quasi-geostrophic scaling analysis, potential vorticity equation, initial value problem. Equatorial modes. Oceanic tides; tide-generating forces, equilibrium and dynamical theory of tides; tidal prediction; co-oscillating tides. Prerequisites: Math. 602; Ocn. 611.

617. Theories of Ocean Circulation. (3-0). Credit 3. Theories of wind-driven circulation, Sverdrup solution, frictional and inertial boundary regimes; instabilities, meanders and mesoscale features. Role of stratification, topography, and time dependence. Thermohaline circulation. Offered in 1981-82 and alternate years thereafter. Prerequisite: Ocn. 611 or approval of instructor.

620. Biological Oceanography. (3-0). Credit 3. Critical analysis of contribution of biological science to our understanding of sea. Discernible interrelationships between organisms and physicochemical parameters. Prerequisite: General prerequisites for oceanography.

621. Open-Ocean Physiological Ecology. (2-3). Credit 3. Metabolic adaptations and biochemical responses exhibited by open-ocean plankton and benthos to high hydrostatic pressure, low temperature, and oxygen minima stresses. Nutritional ecology and ecological bioenergetics of oligotrophic oceanic systems. Prerequisite: Ocn. 620 or graduate classification in oceanography, biology, or wildlife and fisheries sciences.

622. Analysis of Benthic Communities. (2-3). Credit 3. Comprehensive study of marine benthos with principal emphasis upon Gulf of Mexico and Caribbean Sea. Offered in 1980-81 and alternate years thereafter. Prerequisite: Ocn. 620 or equivalent.

623. Marine Zooplankton. (2-3). Credit 3. Descriptive material on zooplankton populations of the world's oceans. Feeding, growth, reproduction and predator-prey interrelationships. Laboratory deals with organism morphology necessary for taxonomic identifications using mainly Gulf of Mexico material. Prerequisite: Ocn. 620 or equivalent.

624. Marine Phytoplankton. (2-3). Credit 3. Detailed studies of phytoplankton; physical and chemical factors which affect plankton production. Phytoplankton-zooplankton relationship, sampling problems. Prerequisite: Ocn. 620 or equivalent.

626. Organic Cycles of the Sea. (3-0). Credit 3. Nature, sources and kinetics of organic materials of the sea. Interrelationships of the physical, chemical and biological aspects presented to provide comprehensive picture of the marine ecosystem as a functional unit. Prerequisite: Approval of instructor.

627. Ecology of the Continental Shelf. (3-0). Credit 3. Environments, populations and communities of the continental shelf. Interactions of the shelf with the estuaries and the deep sea; man's impact on the shelf ecosystems. Prerequisite: Approval of instructor.

628. Biology of Coral Reefs. (2-2). Credit 3. Ecology, zonation, community structure and ethology of coral reefs with emphasis on those in the Atlantic and adjacent seas. Laboratory

familiarization with faunal components. Prerequisite: Graduate classification in oceanography, biology, or wildlife science or approval of instructor.

629. Field Studies on Atlantic Coral Reefs. Credit 2. Three-week field trip to living coral reef in the Gulf of Mexico or the Caribbean. Familiarization with reef zones and fauna. Skin diving ability required. May be repeated once for credit. Prerequisite: Ocn. 628 or approval of instructor.

630. Geological Oceanography. (3-0). Credit 3. Survey of marine geology, structure and composition of ocean basins and continental margins, properties of marine sediments. Prerequisite: General prerequisites for oceanography.

633. Carbonate Sediments I. (1-3). Credit 2. Detailed examination of skeletal microstructures of carbonate producing organisms and recognition of these organisms through practical identification in carbonate sediments. Offered in 1981-82 and alternate years thereafter. Prerequisite: Approval of instructor.

634. Carbonate Sediments II. (2-3). Credit 3. Composition, classification and distribution of carbonate sediments; processes of carbonate sedimentation and diagenesis. Laboratory work includes study of both recent and ancient carbonates. Offered in 1981-82 and alternate years thereafter. Prerequisite: Approval of instructor.

635. Techniques in Geological Oceanography. (2-2). Credit 3. Shipboard and laboratory techniques used in geological oceanography: sampling peels, impregnation, thin sectioning, imbedding, radiography, staining, geotechnical properties, photography, microscopy, photomicrography, granulometry, profiling, cruise preparation. Two field trips required for which departmental fee may be required to cover costs. Prerequisite: Approval of instructor.

636. Marine Biostratigraphy I. (2-3). Credit 3. Survey of all microfossil groups useful for the biostratigraphic study of marine sediments. Biostratigraphic concepts, systematics (including ecology and evolution), morphology and distribution of microfossil groups. Laboratory emphasis is on techniques and biostratigraphic use. Prerequisite: Invertebrate paleontology, stratigraphy, or approval of instructor.

637. Marine Biostratigraphy II. (2-3). Credit 3. Calcareous nannofossil biostratigraphy and zonal succession, correlation with stratotypes, the paleomagnetic record and absolute chronology of the Jurassic to Recent. Prerequisite: Ocn. 636 or approval of instructor.

638. Simulation Techniques. (2-6). Credit 4. Numerical simulation of geophysical fluid dynamic phenomena; barotropic and baroclinic fluids, inertio-gravitational and planetary waves; quasi-geostrophic circulation. Offered in 1980-81 and alternate years thereafter. Prerequisite: Approval of instructor.

639. Lithophycology. (2-3). Credit 3. Morphology, taxonomy, and ecology of calcareous algae and stromatolites and their role as builders of limestones. Laboratory work includes identification of both recent and fossil species. Offered in 1980-81 and alternate years thereafter. Prerequisite: Approval of instructor.

640. Chemical Oceanography. (3-0). Credit 3. Chemical composition and properties of seawater, evaluation of salinity, pH, excess base and carbon dioxide system in sea. Marine nutrients, oxygen and other dissolved gases, organic constituents. Prerequisite: General prerequisites for oceanography.

641. Chemical Oceanography. (3-0). Credit 3. Selected topics in chemical oceanography; thermodynamics of electrolyte solutions, absorption, diffusion and the carbonate system. Offered in 1981-82 and alternate years thereafter. Prerequisite: Degree in chemistry or approval of instructor.

642. Marine Chemistry of the Nutrient Elements. (2-3). Credit 3. Descriptions of the nutrient element cycles in the sea: inputs; biological interactions; use as tracers; removal processes. Silicon, phosphorus, nitrogen. Offered in 1980-81 and alternate years thereafter. Prerequisite: Ocn. 640 or approval of instructor.

643. Geochemistry of the Ocean. (3-0). Credit 3. Chemical behavior of naturally occurring materials at earth surface conditions and the processes which control the chemical composition of seawater and marine sediments. Prerequisite: Undergraduate major in geology or approval of instructor.

644. Isotope Geochemistry. (3-0). Credit 3. Stable and radioactive isotope variations in natural materials. Applications to geochronometric, geothermometric and paleoclimatologic studies of the marine environment. Prerequisite: Approval of the instructor.

645. Marine Organic Geochemistry. (3-0) Credit 3. Origins, fates and distribution of organic compounds in contemporary marine environments and in recent and ancient sediments. Specific analytical techniques. Prerequisite: Approval of instructor.

646. Techniques in Marine Geochemistry. (2-4) Credit 3. Practical techniques for collecting and preserving marine sediments, water and organisms and for determining their elemental and isotopic composition. Prerequisites: Quantitative and instrumental analysis, or approval of instructor.

647. Chemical Contamination of the Marine Environment. (3-0). Credit 3. Assessment of the inputs, transfers, effects and fates of heavy metals, radio-nuclides, petroleum hydrocarbons, chlorinated hydrocarbons and other chemicals in the ocean. Models developed to predict the future viability of the ocean with particular emphasis on the Gulf of Mexico. Prerequisite: Approval of instructor.

651. Meteorological Oceanography. (3-0) Credit 3. Interaction between the ocean and atmosphere. Major features of the two systems. Heat budget, teleconnections between ocean and atmosphere, El Nino and related phenomena. Prerequisites: Met. 445 or Ocn. 608.

652. Ocean Boundary Layer Problems. (3-0). Credit 3. Deterministic and statistical theory of turbulence. Turbulent transfer of momentum, heat and substances. Dynamics of the ocean mixed layer and benthic boundary layer. Offered in 1980-81 and alternate years thereafter. Prerequisites: Ocn. 608; Stat. 601; or approval of instructor.

653. Synoptic Physical Oceanography. (2-2) Credit 3. Methods of analysis and description of major water masses. Variations in ocean circulation, vertical motion and spreading of water masses, abyssal circulations. Formation of deep waters especially in the Norwegian-Greenland Seas. Prerequisite: Ocn. 608.

661. Plate Tectonics: History and Practice. (3-0) Credit 3. Discoveries, concepts and scientific environment that led to the theory of plate tectonics from readings of pioneering and fundamental papers. Focuses on geological case studies of regions that typify and elucicate tectonic plate processes, boundaries and interactions. Prerequisite: Math. 601 or approval of instructor.

662. Marine Sedimentary Processes I. (3-2). Credit 4. Geophysical fluid dynamics as it pertains to sedimentary processes. Erosion, transportation and deposition from shoreline to the middle of the continental shelf. Prerequisite: Undergraduate degree in geology or approval of instructor.

663. Marine Sedimentary Processes II. (3-0). Credit 3. Continuation of Ocn. 662. Sedimentary processes taking place in the sea from midshelf to deep ocean basin. Prerequisite: Ocn. 662.

664. Field Course in Marine Soft-Bottom Communities. (1-3). Credit 2. Field course stressing community composition, trophic structure, animal sediment interactions. Biological and physical factors controlling community structure in soft-bottom communities. Taught entirely at the coast and consists of 1-2 day-long trips with lecture and lab. Prerequisites: Ocn. 620 and 622 and approval of instructor. Usually taken concurrently with Ocn. 629.

665. Invertebrate Biochemistry and Biochemical Ecology. (3-0). Credit 3. Biochemistry of marine invertebrates; biochemical adaptations to life in the oceans and evolution of biochemical systems in invertebrates. Prerequisites: Bich. 603 and 604 or approval of instructor.

666. Principles of Geodynamics. (4-0). Credit 4. Cross-listed with Geol. 666 and Geop. 666. Prerequisite: Approval of instructor.

667. Seismic Stratigraphy of the Ocean Basins. (3-3). Credit 4. Geological interpretation of marine seismic reflection profiling data constrained by the physical and acoustic properties of marine sediments. Geological interpretation methods with several exercises on seismic reflection profiles. Prerequisites: Geop. 435, 436 or equivalent.

681. Seminar. (1-0). Credit 1. Presented by faculty, students, staff and visiting scientists. Based on recent scientific research.

685. Problems. Credit 1 to 4 each semester. Special topics to suit small group requirements. Problems not within thesis research and not covered by any other course in established curriculum. Prerequisite: General prerequisites for oceanography.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of oceanography. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. For thesis or dissertation. Topic subject to approval of department head.

DEPARTMENT OF PETROLEUM ENGINEERING

J. C. Calhoun, Jr., P. B. Crawford, S. A. Holditch, E. R. Hoskins, W. J. Lee*, R. A. Morse*, J. S. Osoba*, J. E. Russell*, R. F. Strickland, W. D. Von Gonten* (Head), R. L. Whiting*, C. H. Wu

*Graduate Advisor

Graduate work in petroleum engineering is offered at both the master's and doctoral levels. At the master's level, courses are offered with the primary aim of giving the student a fundamental understanding of the performance of petroleum reservoirs and their behavior under conditions imposed by pressure depletion, pressure maintenance, enhanced recovery operations and cycling. Courses are also given which deal with the problems encountered in drilling and producing wells, and research on these problems is encouraged.

At the doctoral level, curricula are offered to give the student a broad understanding of the various phases of the petroleum industry as well as the ability to investigate and solve technical problems arising in the industry by original research. Laboratory facilities are available for advanced studies on all phases of reservoir equilibrium and mechanics, including equipment for work on permeability-saturation relationships, core analysis and interpretation, secondary recovery and model reservoir studies. Equipment is also available for investigating problems arising in subsurface engineering and in handling and formulating drilling fluids. Much special equipment has been provided for the study of reservoir behavior at high pressures and temperatures.

A strong area of specialization is offered dealing with the development and use of numerical models for simulating field and/or well performance for a wide range of operating conditions.

Another important area of specialization is laboratory and field tests of *in situ* lignite gasification.

Students are encouraged to become proficient in the programming and use of the high-speed digital computer in engineering and research.

(Pet.E.)

601,602. Drilling and Completing Wells. (3-3). Credit 4 each semester. Problems encountered in drilling, completing and producing of oil and gas wells. Prerequisite: Approval of department head.

603,604. Advanced Reservoir Engineering. (3-3). Credit 4 each semester. Petroleum reservoir engineering; development and use of numerical models for simulating field and well performance. Prerequisite: Approval of department head.

605. Phase Behavior of Petroleum Reservoir Fluids. (3-0). Credit 3. Pressure, volume, temperature, composition relationships of petroleum reservoir fluids. Prerequisite: Approval of department head.

607. Recovery Methods. (3-0). Credit 3. Methods of increasing recovery of petroleum from petroleum reservoirs. Prerequisite: Approval of department head.

608. Well Logging Methods. (2-3). Credit 3. Well logging methods for determining nature and fluid content of formations penetrated by drill. Prerequisite: Approval of department head.

610. Numerical Simulation of Heat and Fluid Flow in Porous Media. (2-6). Credit 4. Various schemes available for the numerical simulation of heat and fluid flow in porous media. Application to hot water and steam flooding of heavy oil reservoirs and to various geothermal problems. Prerequisites: Pet.E. 603, 604.

611. Application of Petroleum Reservoir Simulation. (2-6). Credit 4. Use of simulators to solve reservoir engineering problems too complex for classical analytical techniques. Prerequisites: Pet.E. 428, 438.

648. Pressure Transient Testing. (4-0). Credit 4. Diffusivity equation and solutions for slightly compressible liquids. Gas pseudo-pressure. Dimensionless variables. Type curves. Applications of solutions to buildup, drawdown, multi-rate, interference, pulse and deliverability tests. Extensions to multiphase and non-Darcy flow. Analysis of hydraulically-fractured wells. Prerequisite: Pet.E. 448.

681. Seminar. (1-0). Credit 1 each semester. Study and presentation of papers on recent developments in reservoir mechanics. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 4 each semester. Offered to enable students to undertake and complete limited investigations not within their thesis research and not covered by any other courses in curriculum. Prerequisite: Graduate classification.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of petroleum engineering. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Advanced work on some special problem within field of petroleum engineering. Thesis course. Prerequisite: Approval of department head.

DEPARTMENT OF PHILOSOPHY AND HUMANITIES

R. Becka, R. W. Burch, M. M. Davenport, C. E. Harris, Jr., L. A. Hickman, H. J. McCann, Jr. (Head), J. J. McDermott

PHILOSOPHY
(Phil.)

601. Major Philosophical Issues. (3-0). Credit 3. Major philosophical theories as applied to selected problems and issues in such areas as art, education, politics and religion. Specific content and structure will be determined by interests and needs of students enrolled.

608. Philosophy of Education. (3-0). Credit 3. Major philosophical systems and their implications for the theory and practice of education.

671. Ethics for the Professional. (3-0). Credit 3. Basic concepts and theories underlying major contemporary ethical codes with application to ethical problems encountered in professions such as engineering, law, business, and teaching.

685. Problems. Credit 1 to 3. Directed studies in specific problem areas in philosophy.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of philosophy. May be repeated for credit. Prerequisite: Approval of instructor.

PHYSICAL EDUCATION
(See Health and Physical Education)

DEPARTMENT OF PHYSICS

T. W. Adair III, R. E. Allen, W. H. Bassichis, R. A. Bryan, D. A. Church, R. B. Clark, N. M. Duller, Jr., D. J. Ernst, A. L. Ford, Jr.*, E. S. Fry, A. V. Gibson, P. J. Green II, J. S. Ham, J. C. Hiebert, C.-R. Hu, G. W. Kattawar, R. A. Kenefick, W. P. Kirk, C.-M. Ko, J. A. McIntyre, P. M. McIntyre, K. Nagatani, D. G. Naugle*, L. C. Northcliffe, J. M. Parpia, G. N. Plass, J. F. Reading, W. M. Saslow, H. A. Schuessler, P. J. Siemens, R. E. Tribble (Head), B. J. VerWest, R. C. Webb, D. H. Youngblood

*Graduate Advisor

The physics curriculum provides classroom and research experience that prepares a graduate student for a career of either research and teaching at a university, or research and development at an industrial or government laboratory. The courses are well suited to graduate students in chemistry, mathematics, geosciences or engineering, as well as those seeking a graduate degree in physics.

Phys. 601, 603, 606, 607, 615 and 616 and/or courses in mathematics and research in the field of the thesis will normally comprise the program of a candidate for the degree of master of science. A non-thesis option is also offered. The six courses mentioned together with Phys. 611, 617, 624 and 625, provide a comprehensive, integrated coverage of the fields of classical and modern physics at the graduate level and constitute the basic courses normally required for the degree of doctor of philosophy. More advanced courses in a number of specialized fields are available for candidates for the Ph.D. degree. There is no language requirement for the Ph.D. degree. Satisfactory completion of a departmental qualification exam covering material from the first four M.S. courses is required for the continuation of the Ph.D. and is also part of the examination for the non-thesis M.S. degree.

As part of the training of the graduate student pursuing the M.S. or Ph.D. in physics, the Department of Physics requires all students to teach at least two semesters for the M.S. degree and at least four semesters for the Ph.D. degree.

The current research areas of members of the department include experimental and theoretical research in atomic, nuclear and low temperature/solid state physics. Other research areas within the department include the theory of elementary particle interactions, astronomy, atmospheric physics, experimental high energy physics and cosmic ray physics. Research laboratories supporting the experimental programs are well-equipped with modern research apparatus. Special support facilities include a helium liquefier, a present generation high-speed Amdahl computer, and a variable energy cyclotron.

(Phys.)

601. Analytical Mechanics. (4-0). Credit 4. Lagrange, Hamilton and Hamilton-Jacobi equational approaches to dynamics; canonical transformation and variational techniques; central force and rigid body motions; the mechanics of small oscillations and continuous systems. Prerequisites: Math. 311 or 601, Phys. 405 or equivalents.

603. Electromagnetic Theory. (4-0). Credit 4. Boundary-value problems in electrostatics; basic magnetostatics; multipoles; elementary treatment of ponderable media; Maxwell's equations for time-varying fields; energy and momentum of electromagnetic field; Poynting's theorem; gauge transformations. Prerequisites: Math. 311 or 601, Phys. 416, or equivalents.

606. Quantum Mechanics. (4-0). Credit 4. Schrodinger wave equation, bound states of simple systems, collision theory, representation and expansion theory, matrix formulation, perturbation theory. Prerequisites: Math. 601, Phys. 412 or equivalents.

607. Statistical Mechanics. (4-0). Credit 4. Classical statistical mechanics, Maxwell-Boltzmann distribution, and equipartition theorem; quantum statistical mechanics, Bose-Einstein distribution, and Fermi-Dirac distribution; applications such as polyatomic gases, blackbody radiation, free electron model for metals, Debye model of vibrations in solids, ideal quantum mechanical gases, and Bose-Einstein condensation; if time permits, phase transitions and nonequilibrium statistical mechanics. Prerequisites: Phys. 408 and 412, or equivalents.

611. Electromagnetic Theory. (4-0). Credit 4. Continuation of Phys. 603. Propagation, reflection and refraction of electromagnetic waves; wave guides and cavities; interference and diffraction; simple radiating systems; dynamics of relativistic particles and fields; radiation by moving charges. Prerequisites: Phys. 603, Math. 602, or equivalents.

615. Methods of Theoretical Physics I. (3-0). Credit 3. Orthogonal eigenfunctions with operator and matrix methods applied to solutions of the differential and integral equations of mathematical physics. Contour integration, asymptotic expansions of Fourier transforms, the method of stationary phase, and generalized functions applied to problems in quantum mechanics. Prerequisites: Phys. 412, 416; Math. 311, 312; or equivalents.

616. Methods of Theoretical Physics II. (3-0). Credit 3. Green's Functions and Sturm-Liouville theory applied to the differential equations of wave theory. Special functions of mathematical physics. Numerical techniques are introduced. Conformal mapping and the Schwarz-Christoffel transformation applied to two-dimensional electrostatics and hydrodynamics. Prerequisites: Phys. 412, 416; Math. 311, 312; or equivalents.

617. Physics of the Solid State. (3-0). Credit 3. Crystalline structure and symmetry operations; electronic properties in the free electron model and band effects included; lattice vibrations and phonons; thermal properties; additional topics selected by the instructor from: scattering of X-rays, electrons, and neutrons, electrical and thermal transport, magnetism, superconductivity, defects, semiconductor devices, dielectrics, optical properties. Prerequisites: Phys. 408 or 607 and 412 or 606 or equivalents.

624. Quantum Mechanics. (4-0) Credit 4. Continuation of Phys. 606. Scattering theory, second quantization, angular momentum theory, approximation methods, application to atomic and nuclear systems, semi-classical radiation theory. Prerequisite: Phys. 606 or equivalent.

625. Nuclear Physics. (3-0). Credit 3. Nuclear models, nuclear spectroscopy, nuclear reactions, electromagnetic properties of nuclei; topics of current interest. Prerequisite: Phys. 428 and 606 or equivalents.

627. Elementary Particle Physics I. (3-0). Credit 3. Fundamentals of elementary particle physics. Particle classification, symmetry principles, relativistic kinematics and quark models. Basics of strong, electromagnetic and weak interactions. Prerequisite: Phys. 606.

631. Quantum Theory of Solids. (3-0) Credit 3. Second quantization, and topics such as plasmons; many-body effects for electrons; electron-phonon interaction; magnetism and magnons; other elementary excitations in solids; BCS theory of superconductivity; interactions of radiation with matter; transport theory in solids. Prerequisites: Phys. 424 or 617, 624 or equivalents.

634. Relativistic Quantum Field Theory. (3-0) Credit 3. Classical scalar, vector, and Dirac fields. Second quantization. Scattering matrix and perturbation theory. Dispersion relations. Renormalization. Prerequisite: Phys. 624 or equivalent.

635. Scattering Theory. (3-0). Credit 3. General time-dependent integral scattering solutions. Feynman diagrams. Optical theorem. Non-local potentials. Partial-wave scattering solutions. Unitarity. Effective range theory. Polarization phenomena. Prerequisite: Phys. 624 or equivalent.

636. The Many-Body Problem. (3-0). Credit 3. Second quantization; Green's functions; Feynman diagrams; Dyson's equations; Bethe-Salpeter equation; Hartree-Fock and random phase approximations; linear response theory, screening and correlation energy for the electron gas; nuclear matter; superconductivity; liquid ^{3}He and ^{4}He; the finite nucleus. Prerequisite: Phys. 624 or approval of instructor.

642. Atomic and Electron Physics. (3-0). Credit 3. Theory of hyperfine structure; atomic and nuclear moments; isotope shift; core polarization atomic beam resonance methods; optical pumping and level crossing; quantum electronics; topics from current literature involving recent theories and experimental methods on stored ions, dilute plasmas and polarized beams. Prerequisite: Phys. 412 or approval of instructor.

643. Topics in Astrophysics. (3-0). Credit 3. States of matter, interaction of radiation and matter, statistical equilibrium, local thermodynamic equilibrium, spectral line formation, particle and gas dynamics, relativistic astrophysics, nucleosynthesis. Prerequisites: Phys. 420, 603, 606 and 607 or equivalents.

644. Low Temperature Physics. (3-0). Credit 3. Quantum behavior of matter at extremely low temperatures; production of low temperatures in the laboratory, superfluidity in ^{3}He and ^{4}He and magnetic properties. Prerequisites: Phys. 606, 607 and 424 or 617 or equivalents.

645. Nuclear Theory. (3-0). Credit 3. Topics of current interest; multipole theory of electromagnetic interaction, shell model and collective model of nucleus, and models of nuclear reactions. Prerequisites: Phys. 606 and 625 or equivalents.

646. Intermediate Energy Nuclear Physics. (3-0). Credit 3. Topics of current theoretical and experimental interest; particle-particle scattering, particle-nucleus scattering, symmetries, polarization analysis; multiple scattering, nuclear structure studies and dynamical models. Prerequisite: Phys. 624 or equivalent.

648. Cosmic Rays. (3-0). Credit 3. Phenomenology and theory of contemporary cosmic ray physics; subjects of current research interest. Prerequisites: Phys. 603, 606; approval of instructor.

654. Low Temperature Physics. (3-0). Credit 3. Quantum behavior of matter at extremely low temperatures; thermal and electronic properties of solids; superconductivity. Prerequisites: Phys. 606, 607 and 617 or 424, or equivalents.

659. The Evolution of Physics. (2-2). Credit 3. Traces the evolution of classical physics from early Greek times through the end of the 19th century; feedback between ideas in physics and the surrounding culture. Laboratory techniques for teaching classical physical concepts.

660. Evolution of Physics. (2-2). Credit 3. Continuation of Phys. 659. Evolution of physics in the 20th century; birth and development of quantum physics, relativity and nuclear physics. Laboratory techniques for teaching modern physical concepts.

665. Concepts of Modern Physics. (3-0). Credit 3. Physical phenomena of contemporary interest; physical concepts. Cosmology and astrophysics, elementary particles, lasers and their applications, atomic and nuclear phenomena, and the application of physical principles in recent technology. Laboratory techniques for presenting the concepts in inquiry-oriented physical science courses.

681. Seminar. (1-0). Credit 1. Subjects of current importance. Normally required of all graduate students in physics.

685. Problems. Credit 1 to 4 each semester. Individual problems not related to thesis. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of physics. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Physical Research. (3-0). Credit 3. Problems in the various specialized research areas of the department are presented and discussed in detail. Methods of solution together with applicable experimental design and theoretical techniques are discussed in detail. May be repeated for credit. Prerequisite: Baccalaureate degree in physics or approval of instructor.

691. Research. Credit 1 or more each semester. Research toward thesis or dissertation. Prerequisite: Baccalaureate degree in physics or equivalent.

DEPARTMENT OF PLANT SCIENCES

A. A. Bell, C. R. Benedict*, L. S. Bird, T. E. Boswell, J. A. Browning (Head), J. Craig, J. W. Dieckert, K. M. El-Zik, F. Fong, R. A. Frederiksen, E. A. Funkhouser, A. S. Garay, C. E. Gates, J. R. Gold, M. P. Grisham, R. S. Halliwell*, J. M. Halloin, G. E. Hart, C. W. Horne, J. S. Johnston, D. E. Koehler, S. D. Lyda, C. W. Magill, R. D. Martyn, Jr., R. E. Meyer, P. W. Morgan*, R. J. Newton, R. E. Pettit, R. D. Powell, H. J. Price, D. H. Smith, J. D. Smith, L. R. Smith, R. H. Smith, R. A. Taber, R. W. Toler, B. Villalon, N. G. Whitney

*Graduate Advisor

The Department of Plant Sciences offers the master of science and doctor of philosophy degrees in genetics, plant breeding, plant pathology and plant physiology. In their thesis and dissertation research, students carry out research using facilities located on campus and/or at one of the research centers.

In addition to possessing a competent command of English, Ph.D. candidates must complete the foreign language requirement in one or two approved languages. For complete information on the options available, prospective students should contact the Department of Plant Sciences.

The department offers two options in its master of agriculture degree program: plant protection and plant sciences. The M.Agr. is a non-research degree which requires more formal course work in lieu of the thesis. This program emphasizes excellence in academic training and development of professional competence for students interested in careers in the agricultural industry, related biological-environmental agencies and industries and teaching.

Professional internship opportunities are an integral part of the M.Agr. degree program.

GENETICS SECTION

Genetics occupies a central position in biology, and many of the most significant research developments in the life sciences have occurred in this dynamic discipline. Facilities are available to support graduate students in the fields of bacterial genetics, biochemical genetics, cytogenetics, forest genetics, fungal genetics, developmental genetics and population genetics.

An unusual opportunity exists for graduate students to develop multidisciplinary approaches involving genetics, plant pathology and plant physiology within the department.

Programs in genetics are supervised by members of the genetics faculty. For a listing of all genetics courses and of the interdepartmental genetics faculty, please refer to the catalog listing under Genetics.

(Gen.)

603. Genetics. (4-0). Credit 4. Development of fundamental concepts related to the structure, function, organization, transmission and distribution of genetic material. Prerequisite: Gen. 301.

604. Genetics Laboratory. (0-3). Credit 1. Laboratory techniques and methods. Required for genetics majors. Prerequisite: Gen. 301.

607. Genetics of Differentiation. (3-0). Credit 3. Genetics of eukaryotic differentiation from a conceptual viewpoint. The underlying theme is that development is under genetic control and results from differential gene activity. Developmental processes which determine phenotypic expression, using plant and animal examples. Prerequisite: Gen. 603 or approval of instructor.

608. Genetics of Microorganisms. (3-0). Credit 3. Contributions to the understanding of genetics which have come from studies of microorganisms: bacteria, viruses, fungi, protozoa and lower algae. Areas of special interest to the students enrolled. Prerequisite: Gen. 301 or equivalent.

612. Population Genetics. (3-0). Credit 3. Biological approach to genetic characteristics of populations dealing with genetic equilibrium, allelic variation, determination of genetic variation in populations, effects of mating systems, selection, mutation and ploidy on population parameters. Prerequisites: Gen. 603, Stat. 651.

613. Quantitative Genetics I. (3-0). Credit 3. Quantitative genetics concepts particularly dealing with partition of phenotypic variance into genetic and environmental components, selection response, effects of systems of mating, genetic covariance and threshold effects. Prerequisites: Gen. 612; Stat. 652.

620. Cytogenetics. (3-0). Credit 3. Examination and analysis of variation in chromosome structure, behavior, and number; developmental and evolutionary effects of this variation. Prerequisite: Gen. 603.

625. Speciation. (3-0). Credit 3. Processes of organic evolution, particularly as they operate in the differentiation of populations and the origin of species. Prerequisite: Gen. 603 or approval of instructor.

631. Biochemical Genetics. (3-0). Credit 3. Genetic control of cellular metabolism. Mechanism of gene action. Gene-enzyme relationships; regulation of gene expression; structure and organization of genomes; biochemical manipulation and characterization of genetic molecules. Prerequisites: Bich. 410/411 or 603/604 and Gen. 431 or 603.

633. Forest Genetics. (3-0). Credit 3. Specialized study of genetics as applied to forest trees; forest tree improvement and forest tree breeding; genetics of conifers and hardwoods. Prerequisite: Gen. 603. Cross-listed with F.S. 633. (Offered in 1981-82 and in alternate years thereafter.)

634. Forest Genetics Laboratory. (0-3). Credit 1. Methods and techniques in forest genetics, forest tree breeding; crossing, grafting, air layering, field layouts, seed handling, greenhouse techniques. Prerequisite: Gen. 633. Cross-listed with F.S. 634. (Offered in 1981-82 and in alternate years thereafter.)

681. Seminar. (1-0). Credit 1. Reports and discussions of topics of current importance in genetics. Reports to be prepared and presented by graduate students enrolled in course.

685. Problems. Credit 1 to 4 each semester. Individual problems or research not pertaining to thesis or dissertation. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of genetics. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research in Genetics. (3-0). Credit 3. Design of research experiments in various subfields of genetics and evaluation of research results using examples taken from current scientific literature. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Prerequisite: Gen. 603.

PLANT PATHOLOGY SECTION

Plant pathology is the science of plant diseases, their nature, causal agents and interrelated phenomena. The major objectives concern the scientific training of professional phytopathologists. Emphasis is placed on the fundamental and practical concepts associated with pathology and the conceptual schemes of fungal, bacterial, viral, nematological, mycoplasmal and physiogenic diseases. In addition, superior facilities are available for research in most phases including physiology of parasitism, host-parasite relationships, genetics of host resistance, genetics of pathogen variation and variability, ecology of soil-borne pathogens, etiology and epidemiology of plant diseases, nematology, virology, phytotherapeutics and clinical phytopathology.

(Pl.Pa.)

610. Host Plant Resistance. (3-0). Credit 3. Host plant resistance programs from the standpoint of plant breeder, plant pathologist and entomologist. Team taught with each discipline represented. Roundtable discussions of assigned readings and lectures. Prerequisite: Approval of instructors.

616. Methods in Plant Pathology. (2-6). Credit 4. Standard principles, techniques and equipment used in investigation of plant disease and plant pathogens. Prerequisite: Pl.Pa. 301 and 303 or equivalent.

617. Parasitism in Plant Disease. (3-3). Credit 4. Critical review of literature on parasitism, specificity, mechanisms of host defenses and host-parasite interactions. Theoretical aspects of parasitism. Prerequisites: Pl.Pa. 616, undergraduate biochemistry and approval of instructor.

618. Bacterial Plant Diseases. (2-3). Credit 3. Bacterial diseases of fruit and vegetable crops, field crops and ornamental plants; nature of the disease, dissemination of the pathogen and methods of control. Prerequisite: Pl.Pa. 301 and 303 or equivalent.

620. Plant Viruses. (2-3). Credit 3. Nature and properties of plant viruses and plant virus diseases. Prerequisite: Pl.Pa. 301 and 303 or equivalent.

621. Plant Parasitic Nematodes. (2-3). Credit 3. Morphology, identification and biology of plant parasitic and soil-borne nematodes; damage they cause; methods of control. Prerequisite: Approval of instructor.

623. Diseases of Field Crops. (2-3). Credit 3. Fundamental and practical aspects of more important and representative diseases of field crops. Plant disease problems peculiar to extensive cultivation methods. Prerequisites: Pl.Pa. 301, 303.*

624. Diseases of Fruits, Vegetables and Ornamentals. (2-3). Credit 3. Important fruit, vegetable and ornamental diseases. Relationships between signs and symptoms used in identification of specific plant diseases. Prerequisites: Pl.Pa. 301 and 303 or equivalent.*

625. Plant Pathogenic Fungi. (2-4). Credit 4. Identification of fungi responsible for plant diseases. Representative pathogens used to illustrate principles used in differentiating species. Prerequisite: Biol. 353, Pl.Pa. 301 and 303 or equivalent.

626. Diagnosis of Plant Diseases. (1-3). Credit 2. Techniques employed in diagnosis of symptoms of plant diseases. Histological and microbiological studies to verify initial diagnosis and to identify the etiology. Prerequisites: Pl.Pa. 301, 303.

681. Seminar. (1-0). Credit 1 each semester. Reports and discussions of topics of current interest in plant pathology; reviews of literature on selected subjects.

684. Professional Internship. Credit 1 to 4. Work-study program for on-the-job training. The student's major professor and job training supervisor will grade the individual. Prerequisite: Graduate classification in Department of Plant Sciences.

685. Problems. Credit 1 to 4 each semester. Individual problems or research not pertaining to thesis or dissertation. Prerequisite: Pl.Pa. 301 and 303 or equivalent.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of plant pathology. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research in Plant Pathology. (3-0). Credit 3. Research inquiry and discussion of experimental design, theoretical techniques and scientific methodology in conducting scientific research. Recording, evaluating, interpretation and presentation of data. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Original investigations in support of thesis or dissertation.

*Field trip required for which departmental fee may be assessed to cover costs.

PLANT PHYSIOLOGY SECTION

Plant physiology is a key discipline in man's efforts to understand and use plants. It is a basic science with great applied value. Perhaps the most significant role for plant physiology is in joint efforts with plant breeders and pathologists to improve the productivity of crop plants. Awareness of both interdisciplinary and independent roles is incorporated into the section's training areas. Modern, well equipped laboratories and greenhouses are available to students. Active research programs in phytohormones and bioregulating systems; mineral nutrition; productive efficiency including carbon metabolism and transport; environmental and stress physiology; air pollution; crop growth simulation modeling; plant cell and tissue culture; harvest-aid chemicals and growth regulators; intergrated pest management; and the physiology of disease, insect, pollutant and stress resistance. Excellent support is available from chemistry, biochemistry, genetics, plant pathology, statistics, biology, soils and other related disciplines.

(P.Phy.)

602. Physiology of Plants. (3-0). Credit 3. Major areas of general plant physiology. Plant functions in terms of current hypotheses. Provides necessary background for more advanced courses in plant physiology. Prerequisite: P.Phy. 313 or equivalent.

605. Plant Metabolism I. (3-0). Credit 3. Fundamental process of autotrophy; Photosynthesis and nitrogen fixation in relation to plant physiology and crop productivity. Prerequisites: Chem. 228; P.Phy. 314 or 602.

606. Plant Metabolism II. (3-0). Credit 3. Regulation of plant metabolism, protein synthesis, organelle structure and function, storage molecules and secondary plant metabolites. Prerequisites: Bich. 410, 411; P.Phy. 605.

607. Physiology of the Fungi. (3-3). Credit 4. Physiological activities of fungi; growth and development, nutrition, intermediary metabolism, reproduction and physiology of parasitism. Prerequisite: Biol. 353 or approval of instructor. (Offered 1981-82 and alternate years thereafter.)

609. Quantitative Plant Physiology. (2-6). Credit 4. Methods employed in various types of physiological investigations and interpretation of results obtained by them. Prerequisite: P.Phy. 314 or 602.

611. Plant Nutrition. (3-0). Credit 3. Inorganic nutrition of plants; solute absorption, accumulation and translocation, growth in artificial media, physiological roles of various elements, and biochemical problems associated with salt absorption. Prerequisite: P.Phy. 314 or 602.

612. Phytohormones and Plant Growth Regulators. (3-0). Credit 3. Classification, properties, and action of naturally occurring plant hormones as well as synthetic growth regulators and their practical application. Prerequisite: P.Phy. 314 or 602.

613. Plant Growth and Development. (3-0). Credit 3. Mechanisms of the induction of nuclear and organelle genes by light, photoperiod, temperature and stress. Control of the growth and differentiation of plants. Prerequisite: P.Phy. 314 or 602.

620. Experimental Techniques in Plant Physiology. (2-6). Credit 4. Instrumentation and techniques used in research on various physiological processes in plants, such as photosynthesis, carbon metabolism, metabolic enzymes, respiration and plant growth and development. Prerequisites: P.Phy. 314 or 602; Bich. 410, 411 and a biochemistry laboratory course.

681. Seminar. (1-0). Credit 1 each semester. Reports and discussions of topics of current interest in plant physiology; reviews of literature on selected subjects.

685. Problems. Credit 1 to 4 each semester. Individual problems or research not pertaining to thesis or dissertation. Prerequisite: P.Phy. 314 or 602.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of plant physiology. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research in Plant Physiology. (3-0). Credit 3. Research inquiry and discussion of experimental design, theoretical techniques and scientific methodology in conducting scientific research. Recording, evaluation, interpretation and presentation of data. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Original investigations in support of thesis or dissertation.

DEPARTMENT OF POLITICAL SCIENCE

R. E. Bensel, W. E. Benton, R. A. Bernstein, J. R. Bond, B. E. Browne, S. S. T. Chan, D. F. Davis, W. A. Dixon, J. A. Dyer, G. C. Edwards III, G. M. Halter, K. E. Hamm, R. E. Harmel, C. A. Johnson, S. A. Kirkpatrick (Head), J. P. Lester, N. R. Luttbeg, K. R. Mladenka, J. L. Payne, H. L. Perry, E. B. Portis, K. H. Ro, B. W. Robeck*, J. D. Robertson, R. D. Robertson, W. P. Snyder, H. J. Tucker, A. Vedlitz*, C. W. Wiggins**

*Graduate Advisor
**M.P.A. Program Coordinator

Graduate study in political science is offered leading to the degrees of master of arts and master of public administration. The curriculum is appropriate (1) for those interested in commencing preparation for teaching and research at the collegiate level, (2) as preparation for a career in the public service, either political or administrative, (3) for teaching at the secondary level, (4) or as preparation for still more advanced work in the discipline. The M.P.A. degree is based upon an interdisciplinary professional curriculum designed to provide broad preparation in public policy and administration for managerial careers in government.

The following paragraphs describe the M.A. degree program in political science. The M.P.A. degree program is described in another section of this catalog.

The courses offered in this degree program permit in-depth study of American politics and political behavior, international and comparative politics, political theory and methodology, public policy and administration, and law and judicial institutions. For still further breadth, or for support in depth of a special interest, a minor outside the department may be undertaken. While not required, such minors are often encouraged.

Requirements for an M.A. in political science may be satisfied by completing one of two options. Option I — the thesis plan — requires a minimum of 30 semester hours of credit, at least 24 of which must be for other than thesis research (691); a final oral examination is required unless the student has a 3.5 average or better. Option II — the non-thesis plan — requires at least 36 semester hours of course work, 24 of which must be in political science plus a minimum of six hours in a supporting field; here a comprehensive examination is mandatory.

A minor in political science requires at least nine semester hours; these may be within one area of specialization but must include at least six hours at the 600 level. Minors in other disciplines are subject to the regulations of those disciplines as outlined elsewhere in this announcement. But, whether or not a student undertakes a formal minor, one may, with the concurrence of one's graduate committee, take relevant supporting work outside political science.

In program formulation there is unusual flexibility within the minimal constraints outlined above. The initiative for selection of a student's graduate committee lies with the student. The committee and the student together design a suitable program.

Prerequisites: While there are no precise course prerequisites for entry into the M.A. degree program in political science, prior work in political science or in one of the following or a combination of them is especially helpful: any of the social sciences, history, philosophy, law or mathematics. In some cases other work may be appropriate. Students without adequate preparation for the graduate program they propose may be required to take prerequisite work in addition to the 30 hours required for a master's degree.

Prospective students uncertain as to prerequisites or opportunities are encouraged to correspond with the graduate advisor prior to entering into the admissions process. On language requirements and other relevant matters see especially the general discussions of the M.A. degree and of financial assistance elsewhere in this announcement.

(Pol.S.)

601. Components of Political Inquiry. (2-2). Credit 3. Research designs, data collection, models and conceptual frameworks as used in the social sciences, especially political science. Required for political science majors.

602. Quantitative Political Analysis. (2-2). Credit 3. Theory, techniques and applications of quantitative analysis in political science. Prerequisite: Six hours of advanced social science or approval of instructor. Required for political science majors.

606. American Government and Politics. (3-0). Credit 3. For non-political science majors. American national, state and local government; U.S. and Texas constitutions, democratic theory, problems of political power and the needs of those who must work in a political environment. Satisfies teacher certification requirements.

610. Parties and Group Politics. (3-0). Credit 3. American political process; party system, structure and organization; interest groups, influence and regulation; nominations, campaigns and elections; comparative party systems; the political environment.

614. The American Presidency. (3-0). Credit 3. Office of President of the U. S.; its place in the constitutional and political system. Modern experience and current problems of the office.

615. Legislative Process and Behavior. (3-0). Credit 3. Congress and state legislatures; recent research findings and relevant theoretical frameworks.

618. Urban Political Systems. (3-0). Credit 3. Urban politics, party structure and activities, voting behavior, power structures and current political problems.

619. Urban Government and Administration. (3-0). Credit 3. Selected problems in urban government, organization and administration.

620. Comparative Political Systems. (3-0). Credit 3. Comparative study of national political systems; cross-national relationships and comparative analysis.

621. Comparative Foreign Policies. (3-0). Credit 3. Major theoretical approaches to the study of foreign policy. Examines and compares the policies of several different types of states with the U. S.; internal and external factors which influence policies.

622. Government and Politics of Asia. (3-0). Credit 3. Comparative analysis of governments and politics in China, India and Japan. Traditional and modern patterns as they affect political behavior, modernization and foreign and economic policies of each nation. Prerequisite: Six hours of advanced social science or approval of instructor.

625. Politics of the Soviet Union. (3-0). Credit 3. Politics, ideology and political development in the Soviet Union and its relations with communist satellite countries, major Western democracies and non-aligned nations.

630. International Politics. (3-0). Credit 3. Survey of international politics; security politics, the development of nations, international law, organization and integration.

634. National Security Policies. (3-0). Credit 3. Causes of war; arms control, national security, defense policies and related issues involved in war and peace among nations and political systems.

636. Politics and Development of the Non-aligned Nations. (3-0). Credit 3. Political issues involved in development and modernization of non-aligned nations.

643. Theory and Practice of Public Administration. (3-0). Credit 3. Theory, process and structure of management in the public sector. Internal management and behavior in federal, state, or local agencies in a political setting.

645. Politics, Policy and Administration. (3-0). Credit 3. Relationship of politics and administration with reference to the influence of administration and bureaucracy, legislative bodies, parties, interest groups and other forces in the formation and execution of public policy in various levels of, primarily, American government.

646. Public Policy Theory. (3-0). Credit 3. Major theories and classifications of public policies, and general explanations of policy formation and impact; recent research testing major theories.

647. Public Policy Design and Evaluation. (3-0). Credit 3. Problems and methods in the design and evaluation of public policies and programs. Quantitative and qualitative approaches.

648. Public Personnel Administration. (3-0). Credit 3. Organization and operation of civil service personnel systems in American governments. Prerequisite: 6 hours of advanced social science or management or approval of instructor.

649. Politics of the Budgetary Process. (3-0). Credit 3. Nature of public budgeting through focus on development of political and analytic theory and practice on budgetary processes, cycles, and techniques at both national and sub-national levels of government. Prerequisite: Six hours of advanced social science or approval of instructor.

651. Reading Seminar in Political Theory. (3-0). Credit 3. Directed work on selected problems in political theory. May be repeated for credit.

655. Law and Society. (3-0). Credit 3. The meaning of law, its purpose, functions, and history; impact of law on society. Law as a system and a social device central to the governing of society.

656. Due Process of Law and Administrative Procedures. (3-0). Credit 3. Due process in a constitutional context as applied to administrative discretion and the theory and practice of public policy implementation. Administrative procedures are measured against the requirements of due process of law. Cross-listed with Mgmt. 656.

657. Judicial Process. (3-0). Credit 3. Power, process and outputs of state and federal courts; behavior of actors in the process.

659. Policy and Administration in Law Enforcement Systems. (3-0). Credit 3. Major law enforcement and judicial process systems in the U. S.; management of police, prosecution and defense functions; court administration.

660. Political Behavior. (3-0). Credit 3. Major approaches to the study of political behavior, personality and politics, political socialization and the social, cultural and economic characteristics of political activists.

662. Political Leadership and Elites. (3-0). Credit 3. Political behavior and motivations of leaders and elites in modern societies.

681. Seminar. (1-0). Credit 1. Topics of current research interest in political science with emphasis on promising areas of research opportunity. Prerequisite: Approval of graduate advisor.

684. Professional Internship. Credit 1 to 6. Directed internship in a public organization to provide on-the-job training with professionals in organizational settings appropriate to the student's professional objectives. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 6 each semester. Individual instruction in selected fields of political science. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of political science or public policy. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research in Political Science. (3-0). Credit 3. Theory and design of research problems, studies and experiments in political science and evaluation of research methodologies using examples from current literature. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Thesis research. Credit will be given only upon acceptance of completed thesis. Prerequisite: Approval of graduate advisor.

DEPARTMENT OF POULTRY SCIENCE

J. R. Cain*, C. R. Creger*, J. H. Denton, R. C. Fanguy*, F. A. Gardner*, W. F. Krueger* (Head), B. J. Marquez*, D. B. Mellor*

*Graduate Advisor

Growth of the poultry industry and the need for a rapid expansion of scientific and technical knowledge in the various fields of science basic to a successful poultry business have supplied the motivation for the development of graduate courses in this phase of agriculture. In no field of agriculture is an understanding of the science and practice of nutrition, breeding, physiology, pathology, environmental physiology, processing, product development and marketing more necessary or more rewarding than in the modern intensive methods of producing poultry meat and eggs.

In offering graduate courses, the major objectives of the department are to offer training for work in teaching, research or extension; to bridge the gap in both directions between courses in fundamental biochemistry, genetics, physiology and economics and their practical application to the production of poultry and poultry products; and to give students planning to go into some productive phase of poultry science a more thorough scientific background of knowledge and approach to problems than is possible in an average four-year undergraduate curriculum.

The department offers graduate work leading to the master of agriculture, master of science and doctor of philosophy degrees. Faculty expertise exists for study in poultry genetics and breeding, poultry nutrition and feeding, avian physiology, environmental physiology, reproduction, game bird management, incubation, production and management, poultry processing and marketing, and poultry product development.

(P.S.)

603. Avian Incubation and Embryology. (3-3). Credit 4. Embryonic development of bird eggs under both commercial and experimental incubation conditions. Developmental processes are evaluated relative to various environmental and genetic parameters. Prerequisite: P.S. 308 or equivalent.

604. Trends in Poultry Technology and Management. (3-2). Credit 4. Intensive literature review and in-depth analysis of special topics in poultry science; may include advanced environmental physiology, endocrinology and reproduction, birds as models for biomedical research, efficiency economics, management innovations, etc. Summer topics include effective use of poultry in teaching, poultry projects and demonstrations, poultry oriented youth programs, recent advances in the industry, etc. Prerequisites: P.S. 201, 425, or equivalent.

609. Avian Physiology. (3-3). Credit 4. Basic physiological principles pertaining specifically to avian species. Cardiovascular, neural, respiratory, digestive, endocrine and reproductive systems. Physiological experiments use various avian species as laboratory animals. Prerequisite: Approval of instructor.

611. Poultry Processing and Distribution Technology. (3-2). Credit 4. Poultry and egg composition, mechanisms of poultry and egg quality preservation effects of storage environments, time and product treatment. Evaluation of commercial methods of product assembly, processing, distribution and quality control. Evaluation of physical, microbiological, functional and chemical methods of quality determination. Cross-listed with F.S.T. 611.

613. Concepts of Breeding Systems. (3-0). Credit 3. Relating avian breeding system concepts to population dynamics. Measuring selection accuracy and efficiency as reflected in genetic improvement of quantitative traits using various breeding systems, general and specific combinability, diallel crossing and synthesizing new special purpose lines. Prerequisite: Approval of instructor.

615. Avian Nutrition. (3-0). Credit 3. Metabolism and nutritional requirements of domestic fowl including proteins, carbohydrates, fats, minerals, vitamins and related feed additives. Prerequisites: Chem. 228 or 232; P.S. 411 or approval of instructor.

625. Least-Cost Feed Formulation. (1-2). Credit 2. Theoretical and applied principles associated with "least-cost" feed formulation for poultry, livestock and laboratory animals. Computer optimization of feed resources for most efficient animal performance. Methods of reducing feed mill ingredient costs. Prerequisites: P.S. 411 or An.Sc. 309; Stat. 651 or equivalent. Cross-listed with An.Sc. 625.

681. Seminar. (1-0). Credit 1 each semester. Intensive review of literature on feeding, breeding, incubation, marketing, and management. Development of familiarity with journals, organizations, agencies and personnel working on poultry problems. May be repeated as many semesters as desired. Prerequisite: Graduate classification.

684. Professional Internship. Credit 1 to 4. Work-study program, for students interested in a Master of Agriculture degree in avian science. Students expected to prepare a scholarly report acceptable to graduate committee.

685. Problems. Credit 1 to 6 each semester. Individual problems involving application of theory and practice in the various disciplines of poultry science. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of poultry science. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. Research methods and techniques in breeding, nutrition, physiology, marketing, management and products technology. Students must conduct experiments in one of these fields. Design of experiments, collection, analysis, and presentation of experimental data. Designed for thesis or dissertation credit.

DEPARTMENT OF PSYCHOLOGY

L. T. Benjamin, Jr., B. O. Bergum, A. E. Bourgeois, A. J. Casey, L. B. Christensen, R. B. Evans (Head), J. M. Kern, A. D. LeUnes, C. J. Lutes, M. G. McGee, C. L. Muehlenhard, J. R. Nation, W. S. Rholes, J. B. Shaw, L. C. Shine II, S. M. Smith, P. J. Wellman, D. W. Wilson

The Department of Psychology offers graduate studies leading to the master of science degree. The graduate program may emphasize general-experimental, industrial or pre-clinical psychology. The programs are designed to train students for Ph.D. work at other institutions or for employment in the field of psychology upon completion of the M.S. degree. Students majoring in psychology receive field experiences in local and state mental health and mental retardation centers as well as research assistantships within the department. Graduate training in psychology offers a balance between theoretical and applied psychology. Objectives of the individual student will guide the selection of a committee and the choice of courses within the department

and in his or her minor area. Although Texas A&M University requires a minimum of 32 semester hours for the M.S. degree (thesis option), the Department of Psychology requires additional hours beyond this minimal requirement, depending upon the student's background and professional goals.

(Psy.)

601. Proseminar in Psychology. (5-0). Credit 5. Current status of the physiological psychology, sensation-perception and learning areas of psychology. Prerequisite: Graduate major or minor in psychology.

602. Proseminar in Psychology. (5-0). Credit 5. Current status of the abnormal, personality and social areas of psychology. Prerequisite: Graduate major or minor in psychology.

603. Motivation and Cognitive Processes. (3-0). Credit 3. Selected topics in areas of motivation and higher mental processes; symbolic processes in perceptual organization; learning and remembering, reasoning and creativity.

604. Personality and Social Behavior. (3-0). Credit 3. Advanced seminar focusing on special topics; interaction of personality and situational determinants of behavior. Prerequisite: Psy. 412.

605. Clinical Psychology. (3-0). Credit 3. Survey of clinical psychology; therapeutic modalities; experimental study of disordered behavior; diagnostic constructs and the assessment process; social, political and ethical contexts of mental health service delivery. Prerequisite: Psy. 306 and approval of instructor.

606. Classical Conditioning and Instrumental Learning. (3-0). Credit 3. Procedural and theoretical issues in Pavlovian and discrete trials conditioning; methods by which basic principles identified in these areas may be applied to contemporary social problems. Prerequisite: Psy. 406 or approval of department head.

607. Experimental Psychology. (2-3). Credit 3. Experimental methods; developing a general frame of reference for approaching experimental research problems.

609. Psychophysiology. (2-3). Credit 3. Current research and methodological procedures on physiological bases of sensation-perception, memory and learning, arousal-sleep-attention, emotions and motivation. Prerequisite: Psy. 409.

610. Industrial Psychology. (3-0). Credit 3. Current research and literature in industrial psychology; personnel selection, training of skilled and managerial personnel, employee motivation, job satisfaction, leadership, communication and decision-making.

611. Personnel Psychology. (3-0). Credit 3. Application of psychological principles and research methods to the areas of selection, placement, job analysis, performance appraisal and training. Prerequisites: Graduate classification; Psy. 401 or equivalent or approval of instructor.

612. Behavior Modification. (3-0). Credit 3. Principles of behavior theory and techniques of application to pathological and deviant behaviors. Prerequisite: Psy. 406 or approval of department head.

614. Practicum in Psychology. Credit 1 to 4 each semester. Practical on-the-job experience for graduate students. Activities will be guided by psychologists in the following areas: behavior modification, social, clinical, experimental and industrial. Supervision will be provided by members of University staff. Prerequisite: Approval of department head.

615. Perceptual Processes. (3-0). Credit 3. Complex sensory and perceptual phenomena with emphasis on the relationship between perception and motivation, cognition, creativity and instinctive/ethological; learning/experiential factors in higher level perceptual processes.

616. Modifying Problem Behavior. (3-0). Credit 3. Principles and techniques of modifying aggressive, disruptive, hyperactive, underachieving and other problem behaviors in natural settings; behavior of children and adolescents at home, school and at play. Prerequisite: Course in psychology of learning or behavior principles or approval of department head.

620. Theories of Social Psychology. (3-0). Credit 3. Current theories of social psychology and a review of studies to these theories. Theories of attitude change, prosocial behavior, aggression, equity, coalition formation, social learning and S-R theory applied to social behavior. Prerequisites: Psy. 315; Soc. 411.

623. Standardized Tests and Measurements. (3-0). Credit 3. Principles of psychological testing. Uses and critical evaluation of tests of achievement, intelligence, aptitude and personality.

624. Individual Testing. (2-3). Credit 3. Practicum in administration and interpretation of Stanford-Binet and Wechsler-Bellevue intelligence tests. Introduction to individual tests of personality. Prerequisite: Psy. 623 or registration therein.

625. Introduction to Projective Methods. (2-3). Credit 3. Theory and application of projective methods. Historical background of projective theory and applications. Practical application of Rorschach and other tests. Prerequisites: Psy. 623, E.Psy. 622 or approval of instructor.

626. Psychopathology. (3-0). Credit 3. Various symptom categories in psychopathology including differing theoretical conceptualizations of these symptom categories, and theories and research concerning etiology and treatment.

628. Behavior Disorders in Children. (3-0). Credit 3. Different systems of classification, including research and theory about the origins and anticipated outcomes of various emotional disorders. Families of disturbed children. Major treatment approaches and community resources for intervention. Prerequisites: Graduate classification; Psy. 407 or equivalent or approval of instructor.

634. Principles of Human Development. (3-0). Credit 3. Biological, psychological and cultural interrelationships in human development. Principles and methods as illustrated in research and theoretical contributions. Experiences in procedures of child study. Prerequisite: Graduate classification.

635. The Psychology of Aging. (3-0). Credit 3. Personality, cognitive, social and biological factors relevant to human aging; investigation of the validity of various sterotypes of the aged. Psychological impact of various social policies. Prerequisite: Approval of instructor.

671. Experimental Design for Behavioral Scientists. (2-3). Credit 3. Intensive practical study of designs of special interest to behavioral scientists. Repeated measures designs. Prerequisites: Stat. 652 or equivalent.

672. Factor Analysis for Behavioral Scientists. (2-3). Credit 3. Principles and uses of Factor Analysis in behavioral research. Implementation, alternate factor models and interpretation with heavy use of numerical examples. Prerequisite: Psy. 671 or approval of instructor.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problem in psychology or special topics to fit small group requirements. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of psychology. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Research for thesis.

DEPARTMENT OF RANGE SCIENCE

W. H. Blackburn, R. W. Bovey, D. D. Briske, J. D. Dodd, W. T. Hamilton, S. L. Hatch, R. Heitschmidt, J. E. Huston, R. W. Knight, M. M. Kothmann, L. B. Merrill, R. E. Meyer, B. J. Ragsdale, L. R. Roath, E. J. Rykiel, Jr., J. L. Schuster* (Head), C. J. Scifres, F. E. Smeins, J. W. Stuth, D. N. Ueckert, L. W. Varner, L. D. White

*Graduate Advisor

Graduate studies lead to the M.Agr., M.S. and Ph.D. degrees in range science. The M.Agr. degree is a professional (non-research) program directed to advanced training in management of rangeland resources, while the M.S. and Ph.D. degrees place emphasis upon a fundamental background in rangeland resources and supporting disciplines, and upon the ability to perform research of high quality.

The M.Agr. degree program is designed to give students broad academic training combined with practical experience to develop management skills. The program includes an internship of work on a rangeland resource or in the range-livestock industry, and emphasizes a diversified, multidisciplinary set of courses involving faculty with both scientific and industry experience.

Facilities and equipment are available for advanced instruction and student research in all phases of range science. Rangeland areas are available for field study of biosystematics, range animal and plant nutrition, watershed management, range ecology, remote sensing, resource management, and range weed and woody plant control.

Graduate courses are designed to develop the academic skills of individuals and to advance their knowledge in the professional field of range science. Departmental seminars supplement the individual counseling of graduate students and serve to relate the most recent research findings applicable to the discipline. Individually planned graduate programs assure a sound education for each candidate.

Students in the Department of Range Science are required to have adequate preparation in rangeland resource management as well as in the fundamentals of such supporting fields as animal science, economics, soil science, and wildlife science. There is no foreign language requirement for the Ph.D. degree in range science.

(R.S.)

601. Rangeland Resource Management. (3-0). Credit 3. Basic concepts and theories of rangeland resource management. Trends in range classification, grazing management and improvement practices. Prerequisite: Graduate classification in agriculture or related subject matter areas.

602. Ecology and Land Uses. (3-0). Credit 3. Ecological foundations for sustained use of natural resources. Climatic, edaphic, biotic and cultural factors in land resource allocation. Land and cover viewed with respect to population dynamics, succession and climax, gradients and graduation, equilibria and imbalance. Prerequisite: Graduation classification in agriculture or in allied subject.*

603. Range and Forest Watershed Management. (3-0). Credit 3. Management of range and forest watersheds; influence of range and forest practices on runoff, interception, infiltration, erosion and water quality. Current literature and research advances.*

604. Grazing Management and Range Nutrition. (3-0). Credit 3. Relationships between vegetation and grazing animals (domestic and wild) including the response of vegetation to grazing and the grazing process. Animal response to various grazing management practices and factors affecting diet selection, quality and intake on rangelands. Prerequisite: R.S. 314 or 601.*

605. Range Research Methods. (3-0). Credit 3. Methods applicable to research on rangeland and related resources. Development of field research projects, study design and implementation techniques for vegetation evaluation, research project management and publication. Prerequisite: Graduate classification.

606. Range Economics. (3-0). Credit 3. The application of economic and financial tools for improved managerial decision-making in the range-livestock industry. Prerequisite: Graduate majors and minors in range science.

607. Range Plant Ecophysiology. (3-0). Credit 3. Influence of environmental parameters on plant growth and function and the morphological and physiological adaptations of plants to these parameters under rangeland conditions. Radiation budgets, carbon assimilation, water relations, temperature, mineral nutrition and selected biotic interactions. Prerequisite: R.N.R. 205 or equivalent.

608. Remote Sensing for Wildland Resource Management. (3-0). Credit 3. Remote sensing for the management of renewable natural resources; state-of-the-art applications to rangeland management, resource assessment and systems analysis in renewable natural resources. Aerial photography, satellite imagery and other remote sensing data products. Prerequisite: Graduate classification.

609. Plant and Range Ecology. (3-0). Credit 3. Plant communities, successions, and effect of various degrees of use in vegetation types and edaphic factors. Prerequisite: R.N.R. 205, 215 or equivalent.*

610. Range Grasses and Grasslands. (2-3). Credit 3. Basic concepts of grass structure and classification, recent advances in agrostological research, genetical and ecological basis for patterns of variation and evolution in grasses.*

613. Analysis of Natural Resource Systems. (3-2). Credit 4. Structure and function of general systems with emphasis on ecosystems. Application of matrix manipulation and computer techniques in the analyses and simulation of ecosystems. Prerequisite: Math. 230, R.S. 417, Stat. 652 or equivalents.

614. Advances in Range Improvement Practices. (3-0). Credit 3. Brush and weed control, revegetation, fertilization, burning, and special treatments. Principles and recent advances in improvement practices.*

615. Rangeland Managerial Analysis. (3-0). Credit 3. Ranch management processes in planning, application and control of alternative land use schemes and multiple resource uses. Rangeland inventory and analysis, land use conversions, integrated resource uses and grazing management, economic analysis and decision-making. Prerequisite: R.S. 314 or approval of department head.*

681. Seminar. (1-0). Credit 1 each semester. Current scientific work in range management and related subjects in American and foreign fields. Prerequisite: Majors and minors in range science.

684. Professional Internship. Credit 1 to 4. Work study program for on-the-job training in master of agriculture program in range science. Prerequisite: Master of agriculture candidate in range science.

685. Problems. Credit 1 to 4 each semester. Investigations not included in student's research for thesis or dissertation. Lectures, conferences, field work, reports. Prerequisite: Graduate majors or minors in range science.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of range science. May be repeated for credit. Prerequisite: Graduate classification in range science or allied field.

691. Research. Credit 1 or more each semester. Research for thesis or dissertation. Prerequisite: Graduate majors in range science.

*Field trips required for which departmental fees may be assessed to cover costs.

DEPARTMENT OF RECREATION AND PARKS

R. L. Bury, E. G. Carls, J. L. Crompton, R. B. Ditton, C. A. Gunn*, J. W. Hanna, E. H. Heath, L. Hodges, B. D. Kamp, A. S. Mills, L. M. Reid (Head), C. S. Van Doren

*Graduate Advisor

Graduate course offerings in the Department of Recreation and Parks are designed to identify and provide scientific solutions to current and possible future problems encountered by administrators, educators and professional practitioners. The focus is upon the total leisure environment and its resource base, employing the most current valid and reliable techniques and methods of research and evaluation. This encompasses fundamental and practical concepts associated with the planning and administration of recreation and park areas and systems, including studies in comprehensive recreation resource planning, quality and carrying capacity, user preferences and demand, agency administration, and alternative methods for meeting leisure needs.

Graduate study in recreation and parks is by nature highly interdisciplinary. Close cooperative relations exist with a large number of the outstanding graduate-level programs in the University. This affords the student unusual opportunity to structure an individualized and highly relevant degree program in the field of his or her choice. Faculty expertise exists for study in recreational land use planning; travel, tourism, and commercial recreation; marine recreation management/development; recreation and park administration; social and behavioral studies; or environmental and cultural interpretation.

The Department of Recreation and Parks offers courses of study leading to the master of agriculture, master of science and doctor of philosophy degrees in recreation and resources development, and an interdisciplinary master of agriculture degree in natural resources development. The M.Agr. program is designed to emphasize professional involvement. Though equally as rigorous, this program differs significantly from the traditional M.S. degree. Additional courses in the student's selected field are included instead of a thesis. In addition, completion of a professional internship of at least six months duration in an organization or agency related to the degree emphasis, and submission of two professional papers on aspects of the internship experience, are required. Agency response to this program has been overwhelming, both in cooperating in the creation of internships, and in employment of graduates having this professional orientation.

The Department of Recreation and Parks no longer requires one or more modern foreign languages as an integral part of all Ph.D. degree programs. The decision regarding the appropriateness of competence in a modern foreign language is determined by each student's graduate advisory committee within guidelines adopted by the department. Information on this subject is available on request from the department.

Courses selected within the department and in supporting fields are designed to serve the individual needs of persons interested in teaching, public service, research or the administration of recreational developments. These courses stress the study of spatial relationships between humans and the natural environment in various recreational settings in which the primary concern is managerial response to urbanization, to patterns of leisure-time use, and to man's critical need of open space.

(R.P.)

601. Recreation and Leisure Concepts. (3-0). Credit 3. History and philosophy of the field of recreation and parks; fundamentals of planning, development, and management of resources allocated for recreation, parks and tourism purposes. Development of the recreation movement with broad treatment of the role of recreation and parks in contemporary society.

602. Conceptual Foundations of Recreation and Resource Development. (3-0). Credit 3. Development of contrasting concepts of leisure and recreation in relation to current recreational trends and needs. Contemporary role of recreation in society; implications of leisure-time use and necessary managerial responses. Prerequisite: R.P. 601 or approval of department head.

603. Recreational Organization and Policy. (3-0). Credit 3. Executive leadership in park departments and recreation agencies; administration of recreation resources to meet human needs, decision-making and the structure of organizational goals. Prerequisite: Approval of department head.

605. Decision-Making in Recreation Administration. (3-0). Credit 3. Political and economic realities associated with policy and decision-making in resource allocation. Using game-simulation techniques as a predictive tool, specific problems are examined and alternative decisions evaluated.

607. Recreation and Park Design. (2-3). Credit 3. Fundamentals of the recreation planning process; historical perspective and objectives of planning; planning models; major component analysis including public involvement, resource evaluation, demand analysis, classification systems and standards, integral implementation and planning research needs.

609. Socio-Economic Issues in Outdoor Recreation. (3-0). Credit 3. Socio-economic characteristics impinging on provision of outdoor recreation opportunities in urban and nonurban settings. Implications of economic factors to demand estimation, valuation, costs and repayment, financing, natural resource allocation, public-private sector interactions and policy issues. Prerequisite: Approval of department head.

611. Recreation Systems Planning. (2-3). Credit 3. Components of the tourism-park-recreation development system and the concepts of planning resource use at the larger-than-site scale. Physical and program factors important to development for visitor use. Computer techniques for land assessment. Prerequisite: Approval of department head.

615. Analytical Techniques in Recreation. (3-0). Credit 3. Analysis of current research; instruments and adaptive techniques used in the selection and formulation of research problems. Prerequisite: Approval of department head.

622. Recreational Resource Communication. (2-3). Credit 3. Philosophies, concepts and techniques associated with communication and dissemination of information pertaining to use of natural resources for recreation.*

636. Travel and Tourism. (3-0). Credit 3. Tourism and recreational travel; origins, present characteristics and societal impacts; implication of non-business travel in the U. S. and the emerging importance of international recreation. Prerequisite: Approval of department head.

650. Recreation Resource Development. (3-0). Credit 3. Theory of resource planning and development and of the role and significance of recreation and tourism in the broader environmental context; evaluation of relevant current and previous action programs in this country and elsewhere. Prerequisite: R.P. 603 or approval of department head.*

660. Environmental Impact Analysis for Parks and Recreation. (3-0). Credit 3. Analysis and critique of contemporary environmental analysis methods in current use; environmental impact statements. National policies; political, social and legal ramifications as related to recreation development.

666. Recreation Development in the Coastal Zone. (3-0). Credit 3. Specific recreational problems associated with coastal zone management. Nature, extent, location and value of coastal recreation behavior and relationship to the overall coastal framework. Implications for other areas of outdoor recreation resources management.

681. Seminar. (1-0). Credit 1. Preparation and discussion by students of special reports, topics, and research data in recreation and parks. Presentation of subjects of professional significance by staff members and invited speakers.

684. Professional Internship. Credit 1 to 4. Survey and application of principles of recreation and resources development. Studies of selected aspects of park and recreation management in professional setting within an approved recreation/park agency under the supervision of a member of the graduate faculty. Required of all students in the master of agriculture degree program. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 4 each semester. Investigations not included in student's research for thesis or dissertation. Problems selected in administration or management, recreation, or planning.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of recreation and resources development. May be repeated for credit. Prerequisite: Approval of department head.

690. Theory of Research in Recreation and Resources Development. (3-0). Credit 3. Theory and design of problems and experiments in various subfields of recreation and resources development. Communication of research proposals and results. Evaluation of current research of faculty and students and review of current literature. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Research in recreation and resources development for thesis or dissertation.

*Field trip required for which departmental fee may be assessed to cover costs.

SAFETY EDUCATION
(See Industrial Education)

SAFETY ENGINEERING
(See Industrial Engineering)

DEPARTMENT OF SOCIOLOGY AND ANTHROPOLOGY

ANTHROPOLOGY: G. F. Bass, V. M. Bryant, Jr. (Program Head), D. B. Dickson, D. L. Hamilton, H. J. Shafer, D. G. Steele*, J. R. Steffy, N. D. Thomas, F. H. van Doorninck, Jr., G. H. Weir.

SOCIOLOGY: B. E. Aguirre, J. P. Alston, J. H. Copp, B. M. Crouch, J. Gaston (Head), P. K. Guseman, W. P. Kuvlesky, W. A. McIntosh, E. Maret, S. H. Murdock, B. H. Nelson, J. S. Picou*, A. Schaffer, R. Schaffer, J. A. Sell, R. L. Skrabanek.

*Graduate Advisor

Graduates from accredited universities who meet the requirements of the Department of Sociology and Anthropology and the Graduate College may work toward the following advanced degrees: master of agriculture in rural sociology, master of science in sociology, master of arts in anthropology and doctor of philosophy in sociology.

Students with degrees in fields other than sociology or anthropology may be admitted provisionally at the master's degree level but will normally be required to make up deficiencies. Students at the Ph.D. level will normally be expected to have an advanced degree in sociology.

Course work in sociology currently stresses community and social organization; demography; sociological theory; social psychology; rural sociology, urban sociology, and research methodology. Special areas of course work in anthropology include nautical archeology; cultural resource management; method and theory in archeology; cultural and physical anthropology; and zooarcheology.

A wide variety of research programs in the department affords the student wide choice in research for a thesis or dissertation. To aid in financing graduate education, teaching and research assistantships and fellowships are available.

ANTHROPOLOGY
(Anth.)

601. Evolutionary Anthropology. (3-0). Credit 3. Analysis and application of evolutionary theory in the study of human development.

602. Archeological Methods and Theory. (3-0). Credit 3. Development of archeology as a discipline. Methods and theories used in archeology for reconstructing cultural history and culture process.

604. Cultural Method and Theory. (3-0). Credit 3. Survey of the theoretical concepts used in anthropology and how to construct models used in cultural and social anthropology.

605. Conservation of Archeological Resources I. (3-3). Credit 4. Fundamentals and applications of artifact conservation techniques in archeology. Prerequisite: Knowledge of basic chemistry and physics recommended.

606. Conservation of Archeological Resources II. (3-3). Credit 4. Comprehensive study of techniques used in the identification and conservation of metal and wooden artifacts. Prerequisite: Anth. 605.

607. Historical Archeology. (3-0). Credit 3. Past and present theoretical positions and research strategies in historical archeology. Prerequisite: Anth. 313 recommended.

612. Preclassical Seafaring. (3-0). Credit 3. Seafarers and watercraft of the ancient Near East and Mediterranean until ca. 700 B.C. Types of watercraft used, routes, cargoes, voyages of exploration and economics of maritime trade. Cross-listed with Geog. 612.

613. Classical Seafaring. (3-0). Credit 3. Culture history of Mediterranean seafarers between ca. 700 B.C. and end of Byzantine Empire. Types of ships and boats, sea law, naval tactics, harbor-works, routes, cargoes and economics of trade. Cross-listed with Geog. 613.

614. Eastern Seafaring. (3-0). Credit 3. Culture history of people and watercraft of China, Southeast Asia, and Oceania. Types, characteristics, origins and spread of Chinese junks and Oceanic canoes. Cross-listed with Geog. 614.

615. History of Wooden Ships. (3-0). Credit 3. Design and construction of preserved and excavated sailing ships, the expertise of their builders, and technology involved in ancient and early shipbuilding. Cross-listed with Geog. 615.

616. Research and Reconstruction of Ships. (2-2). Credit 3. Techniques of recording and interpreting excavated ships; preservation of hulls; ship drafting, modeling, lofting, testing and other methods used in the research and/or reconstruction of ships. Cross-listed with Geog. 616.

618. Medieval Seafaring. (3-0). Credit 3. Cultural history of seafaring in the Islamic world, Mediterranean region, and northern Europe during medieval and early modern times. Types of ships and boats, sea law, naval tactics, harborworks, routes, cargoes and economics of trade.

620. Texas Prehistory. (3-0). Credit 3. Archeological evidence for Texas prehistory is traced from the period of earliest occupation to the time of Spanish contact.

621. Prehistoric Technology. (3-0). Credit 3. Role of technology in meeting the cultural needs of human populations from prehistoric times to the Middle Ages.

625. Zooarcheology. (3-3). Credit 4. Analysis of animal bones from archeological sites. Inference of how prehistoric peoples hunted, domesticated and used animals. Prerequisite: Basic knowledge of zoology and archeology.

631. Cultural Dynamics and Archeological Reconstruction. (3-0). Credit 3. Comprehensive overview of current archeological methods used in the reconstruction of cultural systems.

640. Mesoamerican Ethnology. (3-0). Credit 3. Topically organized examination of Indian and peasant societies in Mexico, Guatemala and adjacent regions.

641. Applied Anthropology. (3-0). Credit 3. Theory, ethics, and practical applications of anthropological methods and concepts as they relate to planned programs of socio-cultural change.

650. Ethnographic Field Methods. (3-0). Credit 3. Methods common to anthropology for the field collection of data on cultural behavior. Prerequisites: Graduate status and approval of instructor.

681. Seminar. (1-0). Credit 1. Reports and discussion of current research, selected published technical reports and other issues relevant to anthropology.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problems in anthropology. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of anthropology. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more. Research for thesis. Prerequisite: Approval of graduate advisor.

SOCIOLOGY
(Soc.)

601. Urban Sociology. (3-0). Credit 3. Patterns of organization and the dynamics of change in the contemporary city. Internal and external structure of the city; processes of growth and decline. Prerequisite: Soc. 321 or approval of instructor.

602. Rural Sociology. (3-0). Credit 3. Application of sociological concepts to the rural environment. Social change and its effect on rural social structures. Prerequisite: Approval of instructor.

603. The Contemporary Family. (3-0). Credit 3. Review and criticism of theories developed for study of the family. Family formation, dynamics, conflicts, power, dissolution; subcultural family forms and responses to social change.

604. Social Gerontology. (3-0). Credit 3. Special phenomena of old age; social roles and adjustment to problems of aging and the aged in American society.

608. Social Organization. (3-0). Credit 3. Theoretical and conceptual bases of patterned human behavior. Structural, processual, and functional aspects of human groups from simplest informal to the most complex formal types: small groups, associations, institutions, complex organizations, bureaucracies, societies.

609. Social Change. (3-0). Credit 3. Concepts, theories and methodological approaches to studying social change. Evolutionary, conflict, equilibrium and modernization approaches. Prerequisite: Approval of instructor.

610. Sociological Theory. (3-0). Credit 3. Trends in theory-development in sociology; comparative study of general sociological frameworks and application of these systems to particular substantive areas of sociology. Prerequisite: Soc. 611.

611. Classical Sociological Theory. (3-0). Credit 3. Critical analysis of the writings of the principal founders of modern sociology; Marx, Durkheim and Weber and their influence on current theoretical issues. Prerequisite: Soc. 430, the equivalent, or approval of instructor.

612. The Community. (3-0). Credit 3. Problems, processes and techniques of community development. Effective methods through community development for improving the general well-being of community residents. Prerequisite: Twelve hours of social science.

613. Seminar in Sociological Theory I. (3-0). Credit 3. Contemporary theory. Structural-functionalism, system theory and symbolic interactionism; domain of each for sociological research; issues raised by respective partisans and critics. Prerequisite: Soc. 611 or equivalent.

614. Seminar in Sociological Theory II. (3-0). Credit 3. Contemporary theory. Critical analysis of theoretical systems and models used in sociology. Major metatheoretical approaches in sociology and more limited models and schema. Prerequisite: Soc. 613.

617. Comparative Ethnic Relations. (3-0). Credit 3. Cross-cultural variations in ethnic relations and structures of inequality; assessment of systems and power-conflict theoretical frameworks in diverse settings such as South America, Mexico, South Africa, Caribbean Regions and United States. Prerequisite: Approval of instructor.

618. Sociology of Education. (3-0). Credit 3. The school system and the democratic way of life. Relationship of education to social organization, social change and social control. Role of education in society. Prerequisite: Soc. 205 or Ed.C.I. 215.

620. Human Ecology. (3-0). Credit 3. Interrelationships between humans and their social and natural environments; human aggregations and their forms of settlement and organization. Prerequisites: Soc. 205, 206, or 613; six additional hours of social science.

621. Social Psychology. (3-0). Credit 3. Personality, social and cultural systems; development and interrelationships. Cognitive activities, motivational determinants and selectivity. Goals, structures, coordination, and related factors influencing complex social groupings. Prerequisites: Soc. 205; 12 additional hours of social science.

622. Social Demography. (3-0). Credit 3. Survey of methods, theories and problems of contemporary demographic phenomena. Prerequisite: Approval of department head.

623. Measurement of Sociological Parameters. (3-0). Credit 3. Sociological research including scaling, scale analysis and experimental design. Prerequisites: Graduate classification; three hours of statistics.

625. Attitude Theory and Measurement. (3-0). Credit 3. Attitudinal and behavioral theory. Attitude measurement, scale development and evaluation. Prerequisite: Twelve hours advanced sociology and/or psychology.

626. Sociology of Power. (3-0). Credit 3. Power structures; models and theories of power; techniques for identifying power wielders; sociological presentation of interest groups, elites, and pluralism. Prerequisite: Soc. 404 or 612 or equivalent.

628. Deviant Behavior. (3-0). Credit 3. Contemporary sociological approaches to deviance. Theoretical and empirical studies of major types of deviant behavior.

631. Seminar in Sociological Research. (3-0). Credit 3. Critical analysis of research procedures used by sociologists. Prerequisite: Soc. 623.

632. Migration. (3-0). Credit 3. Causes and effects of international and internal migration; migration models and theories; data sources and methods of measurement; and policy implications of migration. Prerequisite: Soc. 622.

633. Demographic Methods. (3-0). Credit 3. Procedures and techniques for the collection, evaluation, and analysis of demographic data; measures of population growth, composition, fertility, mortality and migration. Prerequisite: Soc. 622.

685. Problems. Credit 1 to 4 each semester. Directed individual study of selected problem in field of sociology. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Seminar approach to various specialized fields of sociology.

691. Research. Credit 1 or more each semester. Initiation and completion of research project of approved scope for an advanced degree. Prerequisite: Approval of instructor.

DEPARTMENT OF SOIL AND CROP SCIENCES

J. R. Abernathy, W. B. Anderson, E. C. Bashaw, J. B. Beard, M. E. Bloodworth, A. J. Bockholt, R. D. Brigham, K. W. Brown, E. Burnett, F. G. Calhoun, L. E. Clark, B. E. Conrad, J. P. Craigmiles, L. E. Deuel, Jr., J. B. Dixon, E. F. Eastin, G. W. Evers, J. M. Faubion, P. A. Fryxell, C. J. Gerard, E. C. Gilmore, Jr., C. T. Hallmark, E. C. Holt, W. L. Hoover, G. L. Horst, L. R. Hossner, L. A. Johnson, R. J. Kohel, G. W. Kunze, R. H. Loeppert, Jr., E. W. Lusas, G. G. McBee, K. J. McCree, M. E. McDaniel, J. E. Matocha, J. R. Melton, M. G. Merkle, M. H. Milford*, F. R. Miller, J. F. Mills, L. R. Nelson, G. A. Niles, A. B. Onken, R. D. Palmer, F. C. Petr, K. B. Porter, J. D. Price, J. C. Read, K. C. Rhee, J. T. Ritchie, L. W. Rooney, D. T.Rosenow, F. M. Rouquette, Jr., E. C. A. Runge (Head), J. R. Runkles, K. F. Schertz, J. W. Sij, Jr., C. E. Simpson, D. T. Smith, O. D. Smith, J. W. Stansel, R. D. Staten, N. A. Tuleen, F. T. Turner, C. H. M. van Bavel, D. M. Vietor, D. Weaver, R. W. Weaver, C. W. Wendt, A. F. Wiese, L. P. Wilding, D. A. Zuberer

*Graduate Advisor

The graduate programs of the Department of Soil and Crop Sciences are designed to prepare individuals for careers in research, teaching, extension, industry, and management of agronomic enterprises. The Department is housed in a well equipped new building. Agronomy, food science and technology, plant breeding, and soil science are the principal majors available to students.

Programs of professional study in soils, agricultural chemistry, agricultural development, food science and technology, and crops aim to prepare students for professional careers and lead to the Master of Agriculture degree. There is no language requirement at the M.S. or Ph.D. level.

Research oriented programs in agronomy, food science and technology, genetics, plant breeding, and soil science lead to a M.S. or Ph.D. degree in these fields. Members of the faculty have expertise in cereal chemistry, crop breeding, crop physiology, environmental agronomy, cytogenetics, protein chemistry, soil chemistry, soil fertility, soil genesis and classification, soil microbiology, soil mineralogy, soil physics, soil-plant-water relations, turfgrass science, and weed science. Recipients of the M.S. and Ph.D. degrees may obtain a research, teaching, or extension oriented position upon graduation.

Multidisciplinary programs can be arranged with other academic departments in the University. The facilities of the Electron Microscopy, Remote Sensing, and Real Estate Research Centers are accessible, as are those of the Texas Water Resources Institute and the Institute of Statistics.

(Agro.)

601. Grain and Cereal Crops. (3-0). Credit 3. Grain and cereal ecology, use, physiology and morphology; critical review of world literature reporting recent investigations in this field. Prerequisite: Agro. 306 or equivalent.

602. Forage Crops. (3-0). Credit 3. Pasture production, management and use. Factors affecting forage quality and animal performance; world literature.

603. Cytological and Histological Principles in Plant Breeding. (2-3). Credit 3. Modern concepts and recent developments for advanced students in plant and soil sciences and related fields employing microscopic evaluation. Specimen preparation, stain technology, theory and use of microscopes, micromanipulators, microtomes, the microtome cryostat, use of equipment in modern cytological research. Prerequisites: Graduate classification; Biol. 422 or approval of instructor.

605. Pedology. (3-0). Credit 3. Soil genesis, morphology, and classification. Development of a working knowledge of soil taxonomy and diagnostic horizons used in placement of soils. Prerequisites: Agro. 301, 411 or equivalent; or approval of instructor. Two 2-day field trips for which departmental fees may be assessed to cover costs.

610. Host Plant Resistance. (3-0). Credit 3. Host plant resistance programs from standpoint of plant breeder, plant pathologist, and entomologist. Team taught with each discipline represented. Roundtable discussion of assigned readings and lectures included. Prerequisite: Approval of instructors.

612. Forage Crops Management. (3-0). Credit 3. Forage plant development, population dynamics and growth behavior patterns. Applications of ecological and physiological principles to forage management. Principles and practices of forage crops investigations; current literature and concepts. Prerequisites: Agro. 308 or approval of instructor.

617. Advanced Soil Physics. (3-3). Credit 4. Physical properties of soil; dynamics of soil, water and ion movement, soil aeration and soil thermal relationships. Prerequisites: Agro. 445 or equivalent, a two-semester course in physics, and one semester of calculus. (Offered in 1982-83 and alternate years thereafter.)

618. Advanced Soil Analysis. (2-3). Credit 3. Fundamental procedures for analysis of soils and sediments including chemical, spectrophotometric, electrometric, chromatographic and sample handling; methods important to the soils researcher and analyst. Prerequisite: Agro. 422 or approval or instructor.

620. Saline and Sodic Soils. (2-3). Credit 3. Fundamentals in diagnosis, nature and management of saline and sodic soils, especially as they relate to physiochemical properties of soils and agronomic phases of irrigation agriculture. Water quality, as related to growth and development of crop plants. Prerequisite: Agro. 445 or approval of instructor. (Offered in 1982-83 and alternate years thereafter.)

621. Principles of Crop Ecology. (2-2). Credit 3. Basic principles of environmental physics and crop physiology. Application to current research in crop ecology; radiation, water vapor, and carbon dioxide exchange as related to crop productivity. Prerequisite: Approval of instructor.

622. Environmental Aspects of Crop-Water Relations. (3-0). Credit 3. Review and synthesis of physical processes that affect crop-water balance and water use by plant communities with special reference to productivity, water use efficiency and water management in crop production. Prerequisites: Agro. 440, 445; Ag.En. 410; Met. 465; P.Phy. 314 or equivalent. (Offered in 1983-84 and alternate years thereafter.)

624. Physical Chemistry of Soils. (3-3). Credit 4. Physical chemistry of clay minerals and inorganic and organic soil colloids; specific and non-specific absorption; kinetic processes and chemical equilibria in soils. Prerequisites: Agro. 626; Chem. 324 or approval of instructor.

626. Soil Mineralogy. (3-3). Credit 4. Crystal structures and properties of more important minerals in soils and sediments, especially clay minerals combined with identification techniques involving X-ray diffraction, electron microscopy, infrared and chemical methods.

627. Soil Fertility Relationships. (3-0). Credit 3. Behavior of nitrogen, phosphorus and potassium in soils. Secondary nutrients, micronutrients and soil acidity and liming. Interpretation of fertility data from current laboratory, greenhouse and field experiments. Prerequisites: Agro. 422; P.Phy. 314.

630. Cereal Grains for Human Food. (3-3). Credit 4. Fundamental concepts of dry milling, wet milling, oil extraction, baking, malting, brewing, storage, sanitation, and quality evaluation and control interrelated with physical and biochemical properties of cereals and their products. Use of instruments and techniques to evaluate cereal quality. Prerequisite: Approval of instructor. Cross-listed with F.S.T. 630.

634. Oilseed Proteins for Foods. (3-0). Credit 3. World production, composition, processing technologies, uses of products (oil, meal and protein concentrates) in feeds and foods; present and potential food applications of oilseed proteins. Prerequisites: Chem. 228, 317. Cross-listed with F.S.T. 634. (Offered in 1982-83 and alternate years thereafter.)

636. Principles of Food Analysis. (3-0). Credit 3. Classical and modern analytical methods and instruments in terms of their principles, applications, and limitations as applied to analyses of foods, food ingredients, food additives and other food products for chemical, physical, functional, nutritional and organoleptic characteristics. Cross-listed with F.S.T. 636. Prerequisites: Chem. 228, 317; F.S.T. 314 or approval of instructor.

641. Plant Breeding I. (3-0). Credit 3. Theoretical and practical aspects of plant breeding, including genetic basis. Application of breeding methods and interdisciplinary considerations in breeding problems. Prerequisites: Agro. 304 or Hort. 404; Gen. 301; Stat. 652.

642. Plant Breeding II. (3-0). Credit 3. Expectations of genetic improvement for different plant breeding methods; relative efficiency for crops of different reproductive mechanisms. Genetic variances, covariances, and genotype-environment interaction components of variance used in planning selection procedures. Prerequisites: Agro. 641; Gen. 613; Stat. 619.

650. Chemical Weed Control. (2-3). Credit 3. Families of herbicides. Relationship of molecular structure to herbicidal activity, mode of action, pathways of degradation and herbicidal interactions. Prerequisite: Agro. 450 or approval of instructor.

660. Growth and Development of Turfgrass. (3-0). Credit 3. Growth of turfgrasses as influenced by the major atmospheric environmental factors. Seasonal and vertical variations; manipulation of these parameters. Mechanisms of stress injury, stress hardiness and cultural practices for minimizing stress damage in perennial grasses. Prerequisite: Agro. 428 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. For graduate students and staff members in soils and crops. Presentation and discussion of special topics and research data in field of agronomy. Participation required of all graduate students in agronomy.

684. Professional Internship. Credit 1 to 4. Program planned to provide professional training in student's particular field of interest. Faculty and employer will supervise the activity. Work-study will be planned as a part of the master of agriculture degree program in agricultural chemistry, crops, seed technology, and soils. Prerequisite: Approval of instructor.

685. Problems. Credit 1 to 4 each semester. Advanced problems in some phase of agronomy not directly related to thesis or dissertation.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of agronomy. May be repeated for credit. Prerequisite: Approval of department head.

691. Research. Credit 1 or more each semester. Investigations leading to thesis or dissertation.

SPECIAL EDUCATION

(See Educational Psychology)

INSTITUTE OF STATISTICS

M. A. Chmielewski, P. F. Dahm, R. J. Freund, C. E. Gates, E. E. Gbur, Jr., R. R. Hocking, O. C. Jenkins, M. T. Longnecker, J. H. Matis, H. J. Newton, W. C. Parr, E. Parzen, L. J. Ringer*, R. L. Sielken, Jr., W. B. Smith (Director), T. E. Wehrly

*Graduate Advisor

The Institute of Statistics offers a graduate program, leading to the degrees of master of science or doctor of philosophy. The Institute also jointly sponsors graduate work in econometrics and cooperates closely with all subject matter area departments in setting up flexible minor programs in statistics.

The Institute of Statistics offers two options in its master's degree programs: (1) the M.S. degree (thesis option) which requires the preparation of a thesis and, (2) the M.S. (non-thesis option) which requires more formal course work in lieu of the thesis. Both programs provide a balanced training in statistical methods and statistical theory and are intended to prepare the student to adapt statistical methodologies to practical problems.

The aim of the Ph.D. program is to provide comprehensive and balanced training in statistical methods and statistical theory. Particular emphasis will be placed on training students to independently recognize the relevance of statistical methods to the solution of specific problems and to enable them to develop new methods when they are needed. The training will also aim at conveying a sound knowledge of existing statistical theory, including the mathematical facility to develop new results in statistical methodology. At the same time, the program will be kept sufficiently flexible to permit students to develop their specific interests.

The following courses are offered on an irregular basis: 603, 604, 615, 617, 618, 621, 622, 625, 626, 629, 632, 634, 635, 636. Contact the graduate advisor for specific offerings for any given term.

(Stat.)

601. Statistical Analysis. (3-2). Credit 4. For students in engineering, physical and mathematical sciences. Introduction to probability, probability distributions and statistical inference. Hypotheses testing using t and F tests. Introduction to methods of analysis such as tests of independence, simple regression, analysis of variance, with some consideration of planned experimentation. Prerequisite: Math. 122 or 152.

603. Biological Statistics Including Bio-Assay. (3-0). Credit 3. Bio-assay for quantitative and quantal responses. Absolute and comparative potencies, dose-, time- and dose x time response curves. Application of probit analysis to insecticide and radiation dose response studies. Prerequisite: Stat. 601 or 652.

604. Special Problems in Statistical Computations and Analysis. (3-0). Credit 3. Computer algorithms for programming; statistical analysis, efficient uses of existing statistical computer programs, generation of random numbers and statistical variables, programming of simulation studies, selected topics in statistical analysis not covered in Stat. 601 or 652. Prerequisites: C.S. 201; Stat. 608 or 619.

606. Design of Experiments. (2-2). Credit 3. Fundamental concepts in the design of experiments, justification of linear models, randomization, principles of blocking, and the use of concomitant observations; construction and analysis of basic designs including confounding, fractional replication, composite designs and incomplete block designs. Prerequisite: Stat. 619 or approval of department head.

607. Sampling. (3-0). Credit 3. Planning, execution and analysis of sampling from finite populations; simple, stratified, multistage and systematic sampling; ratio estimates. Prerequisite: Stat. 601 or 651.

608. Least Squares and Regression Analysis. (3-0). Credit 3. Regression analysis, simple, multiple, and curvilinear; orthogonal polynomials. Analysis of non-orthogonal and incomplete experiments by least squares methods, computer methods for least squares problems. Prerequisite: Stat. 601 or 652.

609. Order Statistics and Non-Parametric Methods. (3-0). Credit 3. Application of distribution-free and rank procedures for estimation, confidence interval construction and hypothesis testing. Both exact and approximate methods considered. Prerequisite: Stat. 601 or 652.

610. Theory of Statistics I. (3-0). Credit 3. Brief introduction to probability theory. Distributions and expectations of random variables, transformations of random variables and order statistics. Generating functions and basic limit concepts. Prerequisite: Math. 221 or 253 or equivalent.

611. Theory of Statistics II. (3-0). Credit 3. Theory of estimation and hypothesis testing. Point estimation, interval estimation, sufficient statistics, decision theory, most powerful tests, likelihood ratio tests, chi-square tests. Prerequisite: Stat. 610 or equivalent.

612. Theory of Linear Models. (3-0). Credit 3. Theory of least squares, theory of general linear hypotheses and associated small sample distribution theory, analysis of multiple classifications. Prerequisites: Math. 423; Stat. 611 or equivalent.

613. Intermediate Theory of Statistics. (3-0). Credit 3. General theory of estimation and sufficiency, including maximum likelihood, and minimum variance estimation. Neyman-Pearson theory of testing hypotheses. Elements of decision theory. Prerequisites: Math. 409; Stat. 611.

614. Advanced Theory of Statistics. (3-0). Credit 3. Approximation theorems of mathematical statistics. Convergence and limiting distributions. Sample statistics and transformations. U, V, Von-Mises, M, L and R statistics. Robustness and asymptotic relative efficiency. Prerequisite: Stat. 611 or approval of instructor.

615. Stochastic Processes and Time Series. (3-0). Credit 3. Survey of the theory of Poisson processes, discrete and continuous time Markov chains, renewal processes, birth and death processes, diffusion processes and covariance stationary processes. Prerequisites: Math. 409, 601; Stat. 611.

616. Multivariate Analysis. (3-0). Credit 3. Multivariate normal distributions and multivariate generalizations of classical test criteria, Hotelling's T^2, discriminant analysis and elements of factor and canonical analysis. Prerequisites: Math. 409; Stat. 601 or 652, 611, 612.

617. Theory of Sampling. (3-0). Credit 3. General randomization theory of multistage sampling of finite populations, sampling with and without replacement and with equal and unequal probabilities, ratio and regression estimates, analytic studies and multiframe problems. Prerequisites: Stat. 607; approval of instructor.

618. Advanced Experimental Design. (3-0). Credit 3. Randomization theory of experimental design. General analysis of experimental design models. Role of Galois fields and their related finite geometries in the general p^n factorial representation, confounding and fractional replication. Construction and analysis of balanced and partially balanced incomplete block designs. Designs for special situations. Prerequisites: Stat. 606, 611, 612.

619. Analysis of Variance. (3-0). Credit 3. Extensive treatment of the analysis of variance for the analysis of designed experiments: randomized blocks, Latin squares, split plot and factorials. Evaluation of treatment response: multiple comparisons, orthogonal contrasts, and regression. Analysis using concomitant information. Some consideration of the analysis of non-orthogonal data. Prerequisite: Stat. 601 or 652.

621. Advanced Topics in Statistical Theory. (3-0). Credit 3. Topics in statistical theory not provided for in other courses and readings of current research topics in statistical theory published in leading statistical journals. Prerequisite: Approval of instructor.

622. Advanced Topics in Statistical Methodology. (3-0). Credit 3. Topics in statistical methodology not provided for in other courses and readings of current topics in statistical methodology published in leading statistical journals. Prerequisites: Stat. 606, 608, 612.

625. Statistical Methods in Reliability. (3-0). Credit 3. Statistical theories pertinent to solution of engineering problems in reliability introduced, established and applied. Distribution and failure theory including exponential, log normal, gamma, and Weibull. Parameters studied include mean time to failure, failure rate, variances and standard deviations, confidence limits and tests of hypotheses. Prerequisites: I.En. 614; Stat. 601; or approval of instructor.

626. Statistical Methods of Process Control and Optimization. (3-0). Credit 3. Introduction to statistical time series analysis. Autocorrelation and spectral characteristics of univariate, autoregressive, moving average models. Identification, estimation and forecasting. Introduction to process control using interrelationships among multiple time series. Prerequisite: Stat. 601 or approval of instructor.

628. Mathematical Programming I. (3-0). Credit 3. Developing and understanding computer algorithms for solving unconstrained optimization and linear programming problems. Parametric and sensitivity analysis. Network flow analysis. Special algorithms. Prerequisites: Math. 304 or equivalent or approval of instructor.

629. Mathematical Programming II. (3-0). Credit 3. Theory, applications and algorithms for integer and mixed integer-continuous variable linear programming problems. Branch-and-bound, implicit enumeration and cutting plane algorithms. Prerequisite: Stat. 628 or approval of instructor.

632. Statistical Decision Theory. (3-0). Credit 3. Decision rules, quantifying risks, and choosing an action, Bayes or minimax solutions, sequences of decisions over time, sequential analysis. Prerequisite: Stat. 611 or approval of instructor.

634. Response Surface Design and Analysis. (3-0). Credit 3. Definition of response surface and relation to multiple regression; ridge analysis; first, second and third order, designs for response surface estimation; optimization of response surface designs for various criteria; the Box-Draper theory, and EVOP. Prerequisites: Stat. 606, 608.

635. Application of Stochastic Processes to the Natural Sciences. (3-0). Credit 3. Basic concepts, Random walks, Markov chains, branching processes, Markov processes in continuous time, homogeneous and nonhomogeneous processes, multi-dimensional processes, queuing processes, epidemic processes, competition and predation, diffusion and non-Markovian processes. Prerequisites: Stat. 611 or 615; approval of instructor.

636. Methods in Multivariate Analysis. (3-0). Credit 3. Multivariate extensions of the chi-square and t-tests, discrimination and classification procedures. Applications to diagnostic problems in biological, medical, anthropological and social research. Multivariate analysis of variance, principal component and factor analysis, canonical correlations. Prerequisites: Math. 423, Stat. 608.

637. Statistical Methods in Ecology. (3-0). Credit 3. Derivation and application of statistical distributions for sampling models, birth-death processes, time intervals, size models, heterogeneous and clustered models in ecology. Stochastic models for population growth, competition and predation and multi-dimensional processes. Prerequisites: Stat. 601 or 652 with approval of instructor.

640. Use of Statistical Software for Computers. (1-0). Credit 1. Brief survey of statistical software. Instruction on use of software currently used at this university. Prerequisite: Stat. 608 or 619.

651. Statistics in Research I. (3-0). Credit 3. For graduate students in other disciplines. A non-calculus exposition of the concepts, methods and usage of statistical data analysis. T-tests, analysis of variance and linear regression. Prerequisite: Math. 102 or equivalent.

652. Statistics in Research II. (3-0). Credit 3. Continuation of Stat. 651. Concepts of experimental design, individual treatment comparisons, randomized blocks and factorial analysis, multiple regression, x^2 tests and a brief introduction to covariance, non-parametric methods and sample surveys. Prerequisite: Stat. 651.

671. Methods of Statistical Data Modeling I. (3-0). Credit 3. Introduction to new methods of statistical analysis, especially statistical data modeling, exploratory data analysis, adaptive and robust estimation. Prerequisite: Stat. 611 or equivalent.

672. Methods of Statistical Data Modeling II. (3-0). Credit 3. Continuation of Stat. 671; exploratory data analysis, multiparameters, nonparametric regression, censored sample analysis and confirmatory statistical inference. Prerequisites: Stat. 611, 671.

673. Time Series Analysis I. (3-0). Credit 3. Introduction to diverse modes of analysis now available to solve for univariate time series; basic problems of parameter estimation, spectral analysis, forecasting and model identification. Prerequisite: Stat. 611 or equivalent.

674. Time Series Analysis II. (3-0). Credit 3. Continuation of Stat. 673; multiple time series, ARMA models, tests of hypotheses, estimation of spectral density matrix, transfer function and forecasting. Prerequisites: Stat. 611 or equivalent; 673.

684. Professional Internship. Credit 1 to 3. Practicum in statistical consulting for students in Ph.D. program. Students will be assigned consulting problems brought to the Institute of Statistics by researchers in other disciplines. Prerequisite: Master's in statistics or equivalent.

685. Problems. Credit 1 to 4. Individual instruction in selected fields in statistics; investigation of special topics not within scope of thesis research and not covered by other formal courses. Prerequisites: Graduate classification; approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of statistics. Open to non-majors. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Statistical Research. (3-0). Credit 3. An indoctrination of graduate students into the theoretical and methodological principles of conducting original research in the science of statistics. Outline of guidelines common to all M.S. and Ph.D. research topics but illustrated by and oriented towards the specific research topics of students attending the section of the course. May be repeated for credit. Prerequisite: Graduate classification in the Institute of Statistics.

691. Research. Credit 1 or more. Research for thesis or dissertation. Prerequisite: Graduate classification.

See Econometrics for descriptions of related courses.

SYSTEMS ENGINEERING
(See Interdisciplinary Engineering)

TEXAS A&M UNIVERSITY — BAYLOR COLLEGE OF MEDICINE UNIVERSITY OF TEXAS SYSTEM

(TAMU)

699. Courses at Baylor College of Medicine or at Institutions Within The University of Texas System. Credit 1 or more each semester or summer session. Designed to serve registration needs of graduate students who will engage in graduate work through interinstitutional cooperative agreements with Baylor College of Medicine and with The University of Texas System. Specific arrangements for registration in this course must be made through the Graduate College of Texas A&M University well in advance of the time that the student expects to enroll in the course. Prerequisites: Written permission of the chairman of the student's advisory committee, the head of the student's major department, the dean of the Graduate College of Texas A&M University, and the dean of the Graduate School of Baylor College of Medicine or the proper authority of the institution within The University of Texas System at which the student proposes to take the course.

DEPARTMENT OF URBAN AND REGIONAL PLANNING

R. S. Cornish, R. G. Echols, J. R. Gardner, J. H. Hinojosa, D. L. Pugh* (Head), W. G. Roeseler*, V. G. Stover, D. A. Sweeney

*Graduate Advisor

The graduate program in the Department of Urban and Regional Planning serves two distinct purposes: to provide the planning profession in Texas with competent personnel in government and private industry through the master of urban planning degree program and to develop high level researchers and policy analysts through the doctor of philosophy degree program in urban and regional science.

Candidates for both degrees are encouraged to apply from a broad range of disciplines, as these programs are interdisciplinary in character. A close, effective relationship exists between faculty and students in the department. Major supporting fields include architecture, education, engineering, humanities, medicine, physical and social sciences and veterinary medicine.

(Plan.)

601. Introduction to Urban Planning. (3-9). Credit 6. Basic issues of urban development with respect to physical, social, economic and general environmental aspects. A comprehensive city plan will be prepared for a community of approximately 50,000 or less in Texas.

602. Metropolitan Development Planning. (3-9). Credit 6. Preparation of a major plan element of the comprehensive plan for a large metropolitan area. Students work in cooperation with metropolitan or municipal planning staffs, conduct general research; analysis and synthesis; develop particularized plans; and draft implementing tools. Each participant assigned specific responsibilities.

603. Regional and Area Planning. (3-9). Credit 6. General course in regional planning, resources conservation, and exploration addressing a predominantly agricultural or mining area of Texas or the general Southwest. Students prepare specific plan documents in cooperation with a regional or state planning agency.

604. Regional Planning and Metropolitan Impacts. (3-9). Credit 6. Plans and impact statements prepared for specific categories of the development plan for a region containing one or more major metropolitan areas. Inter-regional relationships analyzed with respect to urban management, environment, transportation, health care, conservation and other aspects.

612. Transportation in City Planning. (2-3). Credit 3. Influence of transportation in shaping urban form; relationship between land use and transportation; conceptual layout of street systems. Trends in urban development; site development with emphasis on onsite circulation and relationship to the street system. Guidelines for the redevelopment of existing streets and adjacent lands. Cross-listed with C.E. 612.

613. Planning Methods and Techniques. (3-0). Credit 3. Methods and techniques of research, data collection and analysis; coordination planning process with public policy and plan implementation.

615. Contemporary Urban Affairs. (3-0). Credit 3. Contemporary problems of urban and metropolitan areas: housing, employment, education, health, government and others.

621. Concepts of Development Planning in Latin America. (2-3). Credit 3. Literature and programs of development planning in Latin American countries; comparison and evaluation of programs; relevance of development planning in U. S. to Latin America; applicability of planning concepts and programs in developing countries to U. S.

623. Development Planning in Third World Countries. (3-0). Credit 3. Lectures and research projects of "Third World" development problems; application of planning methods and techniques towards long-term solutions in the context of unfolding contemporary world events. Role of international lending institutions, technical assistance and funding requirements.

630. Survey of Health Planning Processes. (3-0). Credit 3. Application of planning process to health systems development. Historical and legal basis, principal agencies and institutions, role of health planner, citizen participation.

631. Planning and Programming Health Systems. (3-0). Credit 3. Specific health planning issues; distribution of manpower and facilities, financial resources, local-federal partnership, system's organization and governance.

632. Applied Regional Health Planning. (3-9). Credit 6. Practical applications of health planning theory and techniques. Students work in cooperation with state or regional health planning agencies to analyze and develop specific plans and solutions for current health planning problems. Prerequisite: Approval of instructor.

640. Law and Legislation Related to Planning. (3-0). Credit 3. Legislative process and planning legislation. Enabling legislation and legal tools of planner: zoning, subdivision ordinances, eminent domain, extraterritorial jurisdiction and other related planning instruments.

641. Problems of Environmental Planning Administration. (3-0). Credit 3. State and federal legislation pertaining to environmental and consumer protection aspects of urban planning; review of administrative procedures; major judicial decisions.

654. Planning Administration and Management. (1-0). Credit 1. Issues of professional practice in public and private sectors.

656. Housing and Community Facilities. (3-0). Credit 3. Housing, its development, planning, marketing, designing, financing, and production. Student problems dealing with urban renewal, neighborhood structure and community facilities.

657. Systems Analysis in Urban and Regional Planning. (3-0). Credit 3. Concepts and methods of systems analysis and their application to the planning process, such as, problem description and goal formulation, modeling and simulation, optimization of alternatives, usage of computers. Role and place of urban systems theory. Illustrative case studies.

658. Plan Implementation. (3-0). Credit 3. Techniques of implementing major urban development programs and plans; capital improvements programming and budgeting; overview of regulatory measures; public involvement process; fiscal planning; federal financial assistance and application procedures.

659. Survey Research in Urban and Regional Planning. (2-3). Credit 3. Survey research methods, from the design of the research project to the presentation of findings. Students complete an actual project to illustrate theories. Questionnaire and survey design, data processing and handling. Computer data analysis.

660. Models of Analysis in Urban and Regional Planning. (3-0). Credit 3. Selected quantitative methods used in urban and regional planning. Matrix methods (population models, economic models, transportation planning), probabilistic models (migration studies, demand for services) and statistical models (urban indicators, factorial studies). Theoretical presentations supplemented by practical problems.

665. Comprehensive Planning. (3-0). Credit 3. Comprehensive urban and regional planning process; relationship to plan documents and to management decisions; budgeting and financing. Criteria for location of key activity centers; three-dimensional conceptualization of planning goals and formulation of implementation programs; institutional roles and public involvement.

666. Evolution of Contemporary Planning. (3-0). Credit 3. Survey of American planning beginning with colonial town plans; the French and English concepts; Pierre l'Enfant's Washington; Olmsted, Kessler and the City Beautiful movement; company towns; garden cities of the 1930's; planning with the physical environment; parkways and freeways; Segoe, McHarg; planning stereotypes; present-day concepts and accomplishments.

667. Development Feasibility and Design. (3-4). Credit 5. Selected residential and nonresidential development projects of varying size are analyzed by student teams with respect to the following: economic feasibility and cash flow; site analysis; and design concept. Interdisciplinary faculty team. Prerequisite: Approval of department head. Cross-listed with Arch. 667 and Land. 667.

670. Urban Public Transportation Planning. (2-3). Credit 3. Planning, operations, fiscal, management and legal aspects of urban, rural and regional public transportation modes. Preparation of transportation systems program elements. Cross-listed with C.E. 670.

672. Urban Transportation Study. (3-3). Credit 4. Procedures and techniques of traditional urban transportation studies. Study design, data collection and processing, trip generation, trip distribution, traffic assignment and mode choice. Data reliability; sketch planning and abbreviated study techniques. Cross-listed with C.E. 672.

673. Comprehensive Transportation Planning and Urban Development. (3-9). Credit 6. Comprehensive plan for multiple urban transport modes are prepared for selected metropolitan area. Following data collection and problem identification plans and programs for 10-15-25 year goals are prepared. Interrelationship of transportation and land development are stressed, as well as opportunities for public-private partnership. Cross-listed with C.E. 671.

675. Theory of Planning and Urbanism. (2-0). Credit 2. Theories of planning and urbanization in world literature; physical community design as expression of ideology and cultural value systems.

678. Planning for Social Services. (3-0). Credit 3. Survey of physical and institutional requirements for delivery of social services: welfare, senior citizens, child care and youth programs; juvenile delinquency and criminal correction programs; public recreation programs; relocation of persons displaced by public action; health care delivery; housing policies; animal and pest control. Analysis and planning techniques.

684. Professional Internship. Credit 1 to 8. Professional practice under approved arrangement with public or private agencies.

685. Problems. Credit 1 to 6 each semester. Individual and group problems dealing with application of planning theory and practice. Opportunities to select foreign and domestic planning project of special interest.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified field of urban and regional planning. May be repeated for credit.

691. Research. Credit 1 or more each semester. Ph.D. research and dissertation.

DEPARTMENT OF VETERINARY ANATOMY

B. V. Beaver, W. E. Haensly, M. A. Herron, A. G. Kemler, W. R. Klemm*, N. H. McArthur, J. E. Martin, M. J. Shively, R. F. Sis (Head), G. G. Stott

*Graduate Advisor

(V.A.)

601. Anatomy. (2-6). Credit 4 each semester. Topographical dissection of one of the following domestic animals: horse, cow, dog or cat. Prerequisite: V.A. 202 or 902 or 305 or equivalent. May be repeated for credit.

602. Histology. (2-6). Credit 4. Microscopic structure of anatomical systems of domestic animals. Work arranged for needs of student and in accordance with previous training. Prerequisite: Basic courses in morphology.

603. Neuroanatomy. (2-6). Credit 4. Gross, developmental, and microscopic anatomy of nervous systems of domestic animals. Prerequisite: Approval of instructor.

604. Neuroendocrine Anatomy. (2-6). Credit 4. Comparative morphology of the neuroendocrine system of laboratory and domestic animals: the light and electron microscopy of the hypothalamus, pituitary, thyroid, parathyroid, adrenal, testes, ovary and pineal glands. Prerequisite: Approval of instructor.

606. Anatomy of Laboratory Animals. (2-6). Credit 4. Gross and microscopic anatomy of laboratory animals. Prerequisite: V.A. 202 or 901 or 305 or equivalent.

609. Anatomy of Reproductive Systems. (2-6). Credit 4. Gross and microscopic anatomy of the reproductive systems of domestic animals. Prerequisite: V.A. 202 or 901 or 601 or 602 or equivalent.

612. Mammalian Embryology. (3-3). Credit 4. Embryology of domestic mammals; gametogenesis, fertilization, cell proliferation and differentiation, and organogenesis; selected commonly occurring congenital defects of domestic animals used to emphasize embryologic sequences and processes. Prerequisite: V.A. 601 and 602 or approval of instructor.

681. Seminar. (1-0). Credit 1. Review and discussion of current scientific work in anatomy and related subjects.

685. Problems. Credit 1 to 4 each semester. Problems in either gross or microscopic anatomy along lines chosen by individual. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of veterinary anatomy. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research. (3-0). Credit 3. Design of research in various subfields of veterinary anatomy and the evolution of research results with the aid of examples taken from the current scientific literature.

691. Research. Credit 1 or more each semester. Original research on selected thesis problem in anatomy.

DEPARTMENT OF VETERINARY LARGE ANIMAL MEDICINE AND SURGERY

J. M. Bowen, C. L. Boyd* (Head), M. R. Calliham, D. V. Hanselka, J. R. Joyce, W. C. McMullan, R. J. Martens, E. L. Morris, J. C. Ramge, W. J. Roenigk, M. F. Young

*Graduate Advisor

(V.L.A.M.)

601. Control of Diseases of Cattle. (3-0). Credit 3. Etiology, epidemiology, immunology, preventive measures and management practices pertinent to disease in feedlot cattle. Prerequisites: Baccalaureate degree; approval of department head.

603. Surgery. Credit 1 to 8 each semester. Special surgery of large animals. Prerequisite: D.V.M. degree. Cross-listed with V.S.A.M. 603.

612. Diagnostic Radiology. Credit 2 or 3 each semester. Radiographic interpretation of domestic animals; film reading. Use of special techniques; contrast media and diagnostic aids. Prerequisite: D.V.M. degree. Cross-listed with V.S.A.M. 612.

621. Reproductive Diseases of Female Domestic Animals. Credit 1 to 4. Diagnosis, treatment, and control of diseases primarily affecting reproduction in female domestic animal. Prerequisite: D.V.M. degree. May be repeated for credit.

622. Andrology. Credit 1 to 4. Diagnosis, treatment, and control of diseases primarily affecting reproduction in male domestic animal. Evaluation of semen and its preparation for use by artificial insemination. Prerequisite: D.V.M. degree. May be repeated for credit.

630. Veterinary Diagnostics. Credit 1 to 3. Advanced training in arts and science of diagnosis. Clinical and theoretical diagnostic models used for application of procedures which can be expected to yield accurate diagnoses. The logic of diagnosis is emphasized through rational application of facts disclosed by examination techniques and critically selected laboratory procedures. Prerequisite: D.V.M. degree. May be repeated for credit. Cross-listed with V.S.A.M. 630.

632. Veterinary Dermatology. (4-0). Credit 4. Pathogenesis, diagnosis and therapy of integumentary diseases of domestic animals; diseases of infectious, nutritional, neoplastic, endocrinologic and immunologic influence. Prerequisite: D.V.M. degree or approval of the department head. Cross-listed with V.S.A.M. 632.

636. Veterinary Ophthalmology. (3-0). Credit 3. Large and small animal ophthalmic diseases; diagnosis, instrumentation, therapy, surgical approaches and complications. Prerequisite: D.V.M. degree or approval of the department head. Cross-listed with V.S.A.M. 636.

669. Veterinary Clinical Cardiology. (2-0). Credit 2. Diagnosis and treatment of clinical cardiac disease in domestic animals; special techniques such as phonocardiography, cardiac catheterization, and angiocardiography. General principles of clinical cardiology as applied to all species of animals, as well as specific clinical case presentations. Prerequisite: D.V.M. degree or equivalent. Cross-listed with V.S.A.M. 669.

681. Seminar. (1-0). Credit 1. Current scientific work in medical and surgical fields in and related to large animal medicine and surgery. May be repeated for credit. Prerequisites: D.V.M. degree and approval of department head.

685. Problems. Credit 1 to 8 each semester. Original investigations of problems in the field of large animal surgery, therapeutics, or radiology. May be repeated for credit. Prerequisites: D.V.M. degree and approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of large animal medicine or surgery. May be repeated for credit. Prerequisites: D.V.M. degree and approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis.

DEPARTMENT OF VETERINARY MICROBIOLOGY AND PARASITOLOGY

R. R. Bell, T. M. Craig, J. E. Grimes, L. C. Grumbles, C. F. Hall, F. C. Heck*, D. H. Lewis* (Interim Head), C. W. Livingston, Jr., R. W. Loan, S. McConnell, S. A. Naqi, B. Panigrahy, H. W. Renshaw, G. C. Shelton, R. B. Simpson, J. P. Smith, Jr., G. G. Wagner, J. D. Williams

*Graduate Advisor

The Department of Veterinary Microbiology and Parasitology offers programs of study leading to the M.S. and Ph.D. degrees in veterinary microbiology and the M.S. degree in veterinary parasitology. The programs are designed to prepare the graduate for a career in research, teaching, diagnostic work or some other related area in microbiology or parasitology. Faculty specialty areas include bacteriology, mycology, virology, immunology, protozoology, helminthology, entomology, avian diseases and aquatic animal medicine.

The department requires no foreign language for the Ph.D. degree program; however, language requirements for the individual student will be determined by the student's advisory committee.

VETERINARY MICROBIOLOGY
(V.Mi.)

643. Pathogenic Bacteriology. (3-4). Credit 4. Pathogenic microorganisms, their cultural and biological characteristics and pathogenicity. Prerequisite: Minimum of eight hours of undergraduate microbiology.

644. Rickettsial and Chlamydial Organisms. (3-0). Credit 3. Organisms in the orders Rickettsiales and Chlamydiales which are of importance in the medical sciences.

645. Host-Agent Interactions in Veterinary Medicine. (3-0). Credit 3. Basic concepts of infection versus disease. Interdisciplinary approaches to problems in microbiology; contribution of constitutive and inducible host responses, agent escape mechanisms and movement of potential pathogens in the ecosystem. Prerequisite: V.Mi. 405 or equivalent.

646. Avian Virus Diseases. (3-3). Credit 4. Viral diseases of poultry; methods of isolation and identification of causative agents. Practice consists of conducting postmortem examinations and diagnostic procedures on naturally and experimentally infected birds. Prerequisite: D.V.M. degree or approval of instructor.

647. Virology. (3-3). Credit 4. Virus infections in animals; types of infections, mode of transmission, intracellular pathology, epidemiology, isolation and identification of inciting agents. Tissue cultivation, animal inoculations and diagnostic tests. Prerequisite: V.Mi. 438 or equivalent.

648. Medical Mycology. (3-3). Credit 4. Actinomycetes, yeasts and molds that are pathogenic to humans and animals; morphology, cultural characteristics, pathogenicity and identification. Practice consists of exercises in cultural methods, morphological characteristics, biochemical reactions and diagnosis. Prerequisite: Minimum of eight hours of undergraduate microbiology.

649. Immunology. (3-3). Credit 4. Humoral and cell mediated arms of immunologic responses; relative relationships and immunochemical applications. Antigen-antibody reactions pertinent to diagnostic serology and *in vitro* cell mediated methods.

650. Experimental Microbiology. (3-3). Credit 4. Familiarization, development, and integration of techniques into experimental design of microbiologic investigation. Virus and protein purification, immunofluorescence, agar diffusion, immunoelectrophoresis, germ free animal techniques, microflora analysis and specialized serologic tests. Prerequisites: Bich. 410 or equivalent; eight hours of microbiology.

653. Diagnostic Virology. (2-4). Credit 4. Essential techniques for isolation and characterization of the many viruses used in a diagnostic virology laboratory. Methods for rapid diagnosis. Prerequisites: V.Mi. 647 or the equivalent and approval of instructor.

654. Tissue Culture Techniques. (1-9). Credit 4. Tissues culture techniques as they apply to a wide range of biological problems. Principles of cell, organ and explant culture *in vitro* and the technical skills required to use these techniques. Prerequisites: Graduate classification; V.Mi. 647 or equivalent.

655. Anaerobic Bacteriology. (3-3). Credit 4. Practical considerations for recovery, characterization and identification of anaerobic bacteria and the relation of these organisms to health and disease. Intensive training in application of techniques for processing anaerobic bacteria. Prerequisite: 8 hours of microbiology including V.Mi. 643 or its equivalent.

660. Diseases of Marine Invertebrates. (4-0). Credit 4. Response of invertebrates to noninfectious and infectious agents. Subject oriented and phylogenetic within each category. Prerequisites: 12 hours of biological science, including at least three hours of histology or microtechniques and approval of instructor.

661. Diseases of Fish. (3-4). Credit 4. Etiology, epidemiology, pathology, symptoms, diagnosis, treatment, and prevention of infectious diseases of propagated and wild fish. Prerequisite: Approval of instructor.

662. Viral Oncogenesis and Tumor Immunology. (3-0). Credit 3. Viral etiology and related immunologic considerations of natural occurring and inducible cancer in animals. Morphology, classification, and transmission of oncogenic viruses and candidate viruses. Cell mediated and humoral immunologic responses to virus induced cancer. Prerequisites: V.Mi. 438, 649 or equivalent and approval of instructor.

681. Seminar. (1-0). Credit 1. Review and discussion of current scientific work and research in field of microbiology and related subjects. Prerequisite: Graduate major or minor in microbiology or related fields.

685. Problems. Credit 1 to 4 each semester. Problems course in microbiology. Prerequisites: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of veterinary microbiology. May be repeated for credit. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more. Research for thesis or dissertation.

VETERINARY PARASITOLOGY

(V.Par.)

601. Parasitology. (3-3). Credit 4. Important helminth parasites of domestic and laboratory animals; their identification, distribution and life history. Prerequisite: V.Par. 483, 484 or equivalent.

603. Host — Helminth Relationship. (2-3). Credit 3. Behavior, physiology, ecology, genetics, host relationships, host specificity, biological relationships, peculiarities and research potential of helminth parasites of veterinary importance. Prerequisites: V.Par. 601, or Biol. 627 or equivalent.

604. Parasitic Protozoa. (3-3). Credit 4. Taxonomy, morphology, life cycle, physiology, distribution, genetics, host relations, methods and diagnosis concerned with protozoan parasites affecting vertebrates, including humans. Prerequisite: V.Par. 484 or Biol. 108 or 438 or Ento. 208 or equivalent.

685. Problems. Credit 1 to 4 each semester. Special problems concerned with parasites of domestic animals or poultry. Prerequisites: V.Par. 601 or equivalent; approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis.

DEPARTMENT OF VETERINARY PATHOLOGY

L. G. Adams, C. H. Bridges, D. E. Corrier, R. A. Green, C. A. Holmberg, K. H. Nielsen, K. R. Pierce (Head)*, W. K. Read, R. W. Storts, J. W. Templeton, K. G. Thompson, J. E. Womack

*Graduate Advisor

There is no departmental requirement for foreign languages. These are considered in the same status as other supplementary areas of study, to be included when indicated by the individual needs of students.

(V.Pat.)

601. Basic Pathology. (3-3). Credit 4. Pathologic processes occurring in diseased cells, tissues and organs of animals; their pathogenesis and morphologic manifestations. Prerequisites: Courses in gross and microscopic mammalian anatomy and physiology and approval of instructor.

640. Mechanisms of Disease. (3-0). Credit 3. Concepts of pathogenesis of disease in animals. Prerequisite: D.V.M. degree or equivalent.

641. Systemic Pathology I. (2-4). Credit 4. Disease manifestations in special organs and tissues and interrelations of pathologic processes in individual and functionally related organs. Prerequisite: D.V.M. degree or equivalent.

642. Nutritional and Metabolic Diseases. (3-3). Credit 4. Spontaneous and experimental diseases caused either by deficiencies, excesses or imbalances of specific nutrients, or by regulatory disturbances of metabolism in laboratory or domestic animals. Prerequisites: Bich. 411 or 604 and V.A. 903 or Biol. 343.

643. Applied Pathology. Credit 1 or more each semester. Application of information and concepts of pathology and clinical pathology to the diagnosis of animal disease. Gross pathological changes observed in necropsy are correlated with and corrected by histopathologic observations. Confirmatory clinical pathologic, immunologic and microbiologic methods used where indicated. Prerequisite: D.V.M. degree or equivalent.

645. Neoplastic Diseases. Credit 1 to 8. Theoretical, histopathological, and clinical aspects of neoplasia. Diagnosis of neoplastic and related conditions in all species. Prerequisite: D.V.M. degree or equivalent.

650. Neuropathology of Animals. Credit 1 to 4. Pathology and pathogenesis of diseases of the central and peripheral nervous systems. Interpretation of gross and microscopic lesions of the nervous system associated with disease processes. Prerequisite: D.V.M. degree or equivalent.

651. Systemic Pathology II. (1-3) Credit 2. Continuation of V.Pat. 641. Disease manifestations in special organs and tissues and interrelations of pathologic processes in individual and functionally related organs. Prerequisite: V.Pat. 641.

653. Diseases of Laboratory Animals. (2-2). Credit 3. Pathology and pathogenesis of spontaneous infectious, parasitic, metabolic and neoplastic diseases of laboratory animals. Prerequisite: V.M.Id. 922 or equivalent.

681. Seminar. (1-0). Credit 1. For graduate and special students in veterinary pathology. Presentation and discussion of special topics and research data concerning pathology and pathogenesis of diseases. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 4 each semester. Advanced special problems concerned with pathogenesis and pathology of disease. Prerequisite: Approval of department head.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of veterinary pathology. May be repeated for credit.

690. Theory of Research. (3-0). Credit 3. Theory and design of research related to current biomedical problems, especially those involving study of animal disease. Philosophical perspectives underlying historical advances in research pertaining to the study, prevention and treatment of disease. Prerequisite: Graduate classification.

691. Research. Credit 1 or more each semester. Research reported by writing of thesis or dissertation as partial requirement for M.S. or Ph.D. degree.

DEPARTMENT OF VETERINARY PHYSIOLOGY AND PHARMACOLOGY

M. S. Amoss, Jr., J. G. Anderson, Jr., E. M. Bailey, B. J. Camp, L. D. Claborn, D. R. Clark, N. P. Clarke, D. R. Gross, D. Hightower, W. L. Jenkins, D. H. Jones, H. L. Kim, D. C. Kraemer, J. D. McCrady* (Head), A. A. Price, S. H. Safe, S. W. J. Seager, D. O. Wiersig

*Graduate Advisor

Graduate programs leading to the Master of Science and Doctor of Philosophy degrees in physiology or toxicology are designed to prepare the graduate for research, teaching and other related areas. Faculty specialty areas include physiology, pharmacology, toxicology, endocrinology, reproduction, bioelectronics, biochemistry, biomathematics, bionucleonics, and nuclear medicine. A broad program of research in many areas including toxicology, cardiovascular physiology, endocrinology, reproduction, and nuclear medicine is available.

There is no departmental requirement for foreign languages. These are considered in the same status as other supplementary areas of study, to be included when indicated by the individual needs of students.

(V.P.P.)

601, 602. Physiology. (3-3). Credit 4 each semester. Recent phases of physiology, modern experimental methods. Work arranged to suit needs of student and in harmony with previous training. Prerequisite: Basic courses in morphology, organic chemistry and physiology.

603. Endocrinology. (3-3). Credit 4. Physiology, biochemistry, and pharmacology of the endocrines. Laboratory emphasizes a number of classical experiments with clinical application. Prerequisites: Basic courses in morphology, physiology and biochemistry.

606. Toxicology II. (3-3). Credit 4. Effects of organic intoxicants; herbicides, insecticides, rodenticides, and fungicides on mammalian species. Effects of plants and other biotoxins on animal species. Prerequisite: V.P.P. 627 or 607.

607. Pharmacology. (3-3). Credit 4. Pharmacokinetic and pharmacodynamic principles of pharmacology; absorption, distribution, excretion and dose-response relationships. Prerequisites: V.P.P. 601 or equivalent; basic statistics course.

608 Systems Pharmacology. (3-3). Credit 4. Effects of drugs on the major organ systems of animals. Prerequisite: V.P.P. 607.

613. Cardiovascular Physiology. (3-3). Credit 4. Cardiovascular physiology using highly specialized techniques and equipment. Prerequisite: V.P.P. 602 or 611 or equivalent.

614. Gastrointestinal and Ruminant Physiology. (3-3). Credit 4. Detailed physiologic study of digestion in monogastric and ruminating domestic animals. Prerequisite: V.P.P. 601 or equivalent.

615. Physiology of the Kidney and Body Fluids. (3-0). Credit 3. Kidney and body fluids. Prerequisite: V.P.P. 601 or equivalent.

616. Neurophysiology. (3-0). Credit 3. Physiology of nervous system. Prerequisite: V.P.P. 602 or equivalent.

617. Respiratory Physiology. (2-3). Credit 3. Gas exchange, regulation of respiration, response to various gases, reflexes associated with respiration and the mechanical factors of breathing in health and disease. Pulmonary circulation and non-respiratory functions of the lungs. Prerequisites: V.P.P. 601 and 602 or equivalent.

618. Physiologic and Biochemical Disorders of Endocrine Function. (3-0). Credit 3. Endocrine influences on organ and tissue function, including modification of specific cellular mechanisms. Physiologic changes and clinical signs arising from dysfunction of each endocrine gland. Metabolic and biochemical alterations. Prerequisites: V.P.P. 329, V.P.P. 603, Biol. 649, or approval of instructor.

619. Molecular Endocrinology. (3-0). Credit 3. Structure-function relationships of hormones, their receptors and biologic activities. Prerequisites: V.P.P. 603 or Biol. 649, Bich. 410 or equivalent and approval of instructor.

624. Surgery for Physiologists. (2-6). Credit 4. Physiological applications of experimental mammalian surgery. Surgical procedures used in the preparation of classical experiments in physiology. Prerequisites: Approval of instructor.

625. Physiological Measurements. (3-3). Credit 4. Modern methods of measurement and recording of physiological phenomena in the living body as related to diagnosis, research and teaching. Prerequisite: E.E. 630 or equivalent.

626. Bionucleonics II. (3-3). Credit 4. Applications of nuclear science to quantitation of physiologic parameters, visualization of organs and lesions, and determination of kinetic phenomena in clinical and research animals. Prerequisites: Graduate classification, V.P.P. 601 or equivalent, and/or approval of instructor.

627. Toxicology. (3-3). Credit 4. Absorption, kinetics and excretion of foreign compounds, including methods of assessing effects of toxicants and of inorganic compounds on a mammalian system. Prerequisites: Bich. 411; V.P.P. 601 or equivalent.

628. Toxicity Testing Concepts. (1-6). Credit 3. Toxicity testing for compliance with federal drug and chemical laws. Prerequisite: V.P.P. 627.

629. Toxic Plants and Biotoxins. (2-3). Credit 3. Indigenous and introduced plants toxic to animals and humans. Vertebrate and invertebrate toxins. Field trips for plant identification. Prerequisites: V.P.P. 627; approval of instructor.

631. Instrumentation in Toxicological Analysis. (2-6). Credit 4. Introduction to analytical methods in toxicology; procedures using modern laboratory instruments. Prerequisites: Chem. 316, 319; V.P.P. 601 or equivalent.

632. Metabolic and Detoxication Mechanisms. (3-0). Credit 3. Fate of foreign compounds; their inhibitory and antagonistic action toward normal metabolic processes of the animal body. Prerequisites: Bich. 603; approval of instructor and department head.

633. Natural Products Toxicology. (3-0). Credit 3. Occurrence, isolation, characterization, and toxicity of natural toxicants in human and animal foodstuffs of plant, animal and microbial origin. Prerequisite: V.P.P. 627; B.S. degree or approval of instructor.

634. Industrial and Environmental Toxicology. (3-0). Credit 3. Hazards encountered from poisons contaminating environment. Prerequisite: Approval of instructor and department head.

639. Genetic and Molecular Toxicology. (2-3). Credit 3. Theoretical and practical approach to a number of *in vitro* and *in vivo* microbial and mammalian systems involved in short term testing for environmental and industrial toxicants. Prerequisites: V.P.P. 627; graduate course in microbiology; approval of instructor.

681. Seminar. (1-0). Credit 1. Review and discussion of current scientific work in physiology and related subjects. Prerequisite: Approval of department head.

685. Problems. Credit 1 to 4 each semester. Problems in physiology, pharmacology, or toxicology. Prerequisite: D.V.M. degree or appropriate specialized training.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of veterinary physiology and pharmacology. May be repeated for credit. Prerequisite: Approval of instructor.

690. Theory of Research. (3-0). Credit 3. Introduction to the theoretical and methodological principles of conducting original research in the physiologic and toxicologic sciences. Problems in various specialized research areas discussed. Prerequisite: Graduate classification.

691. Research. Credit 1 or more each semester. Original investigations in veterinary physiology, pharmacology, or toxicology to be submitted by writing of thesis or dissertation as partial fulfillment for M.S. or Ph.D. degree. Prerequisite: Approval of department head.

DEPARTMENT OF VETERINARY PUBLIC HEALTH

A. B. Childers, Jr., R. P. Crawford, A. I. Flowers, N. D. Heidelbaugh* (Head), G. N. Joiner, W. F. McCulloch, D. N. McMurray, T. D. Phillips, L. H. Russell, Jr.

*Graduate Advisor

Veterinary public health is that part of public health which uses professional veterinary skills, knowledge and resources for the protection and improvement of human health.

The department offers the following degree programs:

Epidemiology	M.S.
Laboratory animal medicine	M.S.
Food science and technology	M.S. and Ph.D.
Veterinary public health	Ph.D.
Veterinary medical sciences	Ph.D.

The department's principal teaching and research activities involve the study of: a) **epidemiology** of acute and chronic diseases (infectious and noninfectious) with emphasis on those diseases and disease processes common to humans and animals; b) **food and feed protection** including the means to develop and implement technological and/or regulatory practices designed to protect and/or improve aspects of human food and/or animal feed which can influence public health and/or animal health; c) **animal control** consisting of a multidisciplined approach to adequately reduce adverse public health implications resulting from pet, stray, feral, and exotic animals; d) **preventive medicine** emphasizing methods to protect and improve human and animal health through development of new veterinary knowledge to defend populations against disease; e) **public health practice** involving the protection and improvement of the health of people and animals by environmental, occupational and human health programs; f) **humane sciences** emphasizing the scholarly interdisciplinary elucidation of people-animal relationships. g) **comparative medicine** emphasizing research in animal systems which are comparable to human systems in such areas as toxicology, environmental and occupational medicine, disease prophylaxis, disease occurrence and aging; h) **laboratory animal medicine** emphasizing the study of and provision for breeding, maintenance, and disease preventive procedures involving individual animals and animal colonies used in research.

Graduate degree programs are prepared on an individual basis by the student's graduate committee in consultation with the student. In developing such individual graduate degree programs, emphasis is placed on attaining a good match between the student's preferences and what is judged to be an area of opportunity in the rapidly changing field of public health practice.

The graduate programs in epidemiology, laboratory animal medicine, and food science and technology are interdepartmental. A minimum of 32 semester hours and a thesis are required for the M.S. degree. A non-thesis M.S. degree option is available for students who have broad academic backgrounds and goals. Six semesters of full-time graduate study (96 semester hours) beyond the B.S. degree and a dissertation are part of the minimum requirements of the Ph.D. degree.

(V.P.H.)

601. Food Hygiene. (3-4). Credit 4. Causes of spoilage, detection of adulterants and regulations governing the inspection of foods of animal origin. Prerequisite: Graduate classification.

607. Applied Epidemiology. (3-3). Credit 4. Application of epidemiologic concepts to the study of disease occurrence. Descriptive and analytical epidemiologic methods in the investigation of diseases of contemporary interest. Prerequisite: Graduate classification.

618. Food Toxicology. (3-0). Credit 3. Potential toxicity and other public health implications of various foods, food components, food processing and storage, chemical and microbial contaminants, and naturally occurring toxic factors associated with foods. Prerequisite: Graduate classification.

632. Public Health Concepts. (3-0). Credit 3. History, organization and administration of local, state, national and international health agencies; development of public health education; concepts of health and disease; introduction to relationships of selected human and animal diseases. Prerequisite: Graduate classification.

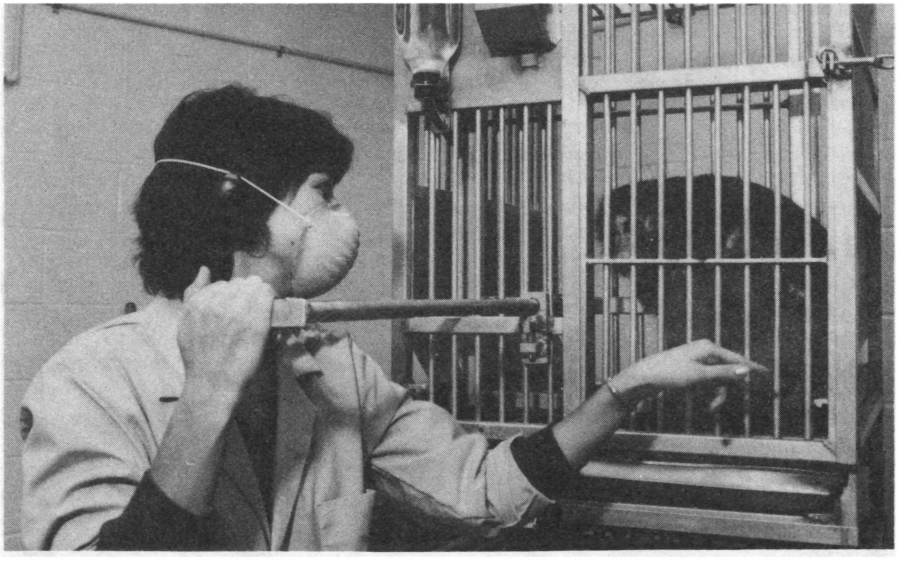
633. Animal Diseases in Comparative Medicine. (3-0). Credit 3. Selected diseases transmitted between animals and humans; transmission, prevention, control and use of animal models of human diseases. Prerequisite: Graduate classification.

681. Seminar. (1-0). Credit 1. Review and discussion of current scientific work and research in the field of veterinary preventive medicine, public health and laboratory animal medicine. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 4 each semester. Problems course in veterinary public health. Prerequisite: Approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Selected topics in an identified area of veterinary public health. May be repeated for credit. Prerequisites: Approval of instructor and department head.

691. Research. Credit 1 or more each semester. Research reported by writing of thesis or dissertation as partial requirement for M.S. or Ph.D. degree. Prerequisite: Approval of department head.



DEPARTMENT OF VETERINARY SMALL ANIMAL MEDICINE AND SURGERY

M. R. Calliham, D. K. Chester, E. W. Ellett, S. M. Hartsfield, M. R. Herron, H. P. Hobson, K. W. Knauer, R. F. Playter* (Head), W. J. Roenigk

*Graduate Advisor

(V.S.A.M.)

603. Surgery. Credit 1 to 8 each semester. Special surgery of domestic animals. Prerequisite: D.V.M. degree or approval of department head. Cross-listed with V.L.A.M. 603.

612. Diagnostic Radiology. Credit 2 or 3 each semester. Radiographic interpretation of domestic animals; film reading. Use of special techniques; contrast media and diagnostic aids. Prerequisite: D.V.M. degree or approval of department head. Cross-listed with V.L.A.M. 612.

630. Veterinary Diagnostics. Credit 1 to 3. Advanced training in arts and science of diagnosis. Clinical and theoretical diagnostic models used for application of procedures which can be expected to yield accurate diagnoses. The logic of diagnosis is emphasized through rational application of facts disclosed by examination techniques and critically selected laboratory procedures. Prerequisite: D.V.M. degree or approval of department head. May be repeated for credit. Cross-listed with V.L.A.M. 630.

632. Veterinary Dermatology. (4-0). Credit 4. Pathogenesis, diagnosis and therapy of integumentary diseases of domestic animals; diseases of infectious, nutritional, neoplastic, endocrinologic and immunologic influence. Prerequisite: D.V.M. degree or approval of the department head. Cross-listed with V.L.A.M. 632.

634. Veterinary Anesthesiology. (2-0). Credit 2. Types of anesthesia, anesthetic agents and their adjuncts, methods of administration, anesthetic complications, artificial ventilation, control of acid-base balance, evaluation of clinical cases. Prerequisite: D.V.M. degree or approval of instructor.

636. Veterinary Ophthalmology. (3-0). Credit 3. Large and small animal ophthalmic diseases; diagnosis, instrumentation, therapy, surgical approaches and complications. Prerequisite: D.V.M. degree or approval of the department head. Cross-listed with V.L.A.M. 636.

669. Veterinary Clinical Cardiology. (2-0). Credit 2. Diagnosis and treatment of clinical cardiac disease in domestic animals; special techniques such as phonocardiography, cardiac catheterization and angiocardiography. General principles of clinical cardiology as applied to all species of animals, as well as specific clinical case presentations. Prerequisite: D.V.M. degree or approval of department head. Cross-listed with V.L.A.M. 669.

681. Seminar. (1-0). Credit 1. Current scientific work in medical and surgical fields in and related to small animal medicine and surgery. May be repeated for credit. Prerequisites: D.V.M. degree and approval of department head.

685. Problems. Credit 1 to 8 each semester. Original investigations of problems in field of small animal surgery, therapeutics or radiology. Prerequisite: D.V.M. degree and approval of instructor.

689. Special Topics in . . . Credit 1 to 4. Special topics in an identified area of small animal medicine or surgery. May be repeated for credit. Prerequisites: D.V.M. degree and approval of instructor.

691. Research. Credit 1 or more each semester. Research for thesis.

DEPARTMENT OF WILDLIFE AND FISHERIES SCIENCES

D. V. Aldrich, K. A. Arnold*, J. W. Bickham, L. H. Blankenship, M. E. Chittenden, Jr., W. J. Clark, J. T. Davis, J. R. Dixon, L. J. Folse, Jr., W. E. Grant, F. S. Hendricks, J. M. Inglis, W. H. Kiel, Jr., W. G. Klussmann (Head), A. M. Landry, Jr., A. L. Lawrence, J. D. McEachran, W. H. Neill, R. L. Noble, S. M. Ray, D. J. Schmidly, M. J. Shult, N. J. Silvy, R. D. Slack, R. R. Stickney, R. K. Strawn, W. G. Swank, L. W. Varner, F. R. Walther

*Graduate Advisor

Graduate programs leading to master of agriculture, master of science and doctor of philosophy degrees are designed to prepare a graduate for secondary school, college or university teaching, research, fisheries and wildlife management, vertebrate biology and systematics, conservation of renewable resources and ecological impact assessment.

Faculty in this department are especially qualified to direct graduate research in (1) ecology, systematics and behavior of vertebrates; (2) wildlife and fisheries management; (3) aquaculture; (4) limnology and; (5) ecological impact assessment. Facilities are available at Texas A&M University at Galveston and through cooperative arrangements with the Texas Parks and Wildlife Department for students to work on problems basic to the management of both game and nongame species of wildlife and to pursue basic investigations in both freshwater and saltwater fisheries. The department has a research and reference collection of some 150,000 fish, 60,000 amphibians and reptiles, 11,000 birds, 37,000 mammals, and can secure additional materials on loan from other institutions for use in distributional and taxonomic studies.

The Caesar Kleberg Research Program in wildlife ecology is administered in the department, and ecological research is sponsored by this program in Texas and in many countries of the world. Freshwater and marine environments for fisheries teaching and research programs are available near the campus and at Galveston. The department has an aquaculture facility (laboratory and ponds) devoted to teaching and research on production of fish and invertebrate organisms for food and sport fishing. Studies in environmental conservation and education are available to those students interested in preparing themselves for public service in a number of fields other than research and management.

The department has no standard requirements for proficiency in foreign languages. Any requirements for foreign languages are set by the student's advisory committee.

(W.F.S.)

600. Field and Laboratory Methods. (1-6). Credit 3. Experience in field studies, organizing field notes, collecting and preserving vertebrate animals for teaching and museum purposes. Methods for maintaining live animals and for identifying animals collected. Training in preparing skeletons, corrosion models, cleared specimens and in plastic embedding. Prerequisite: Eighteen hours of biological sciences or approval of instructor.

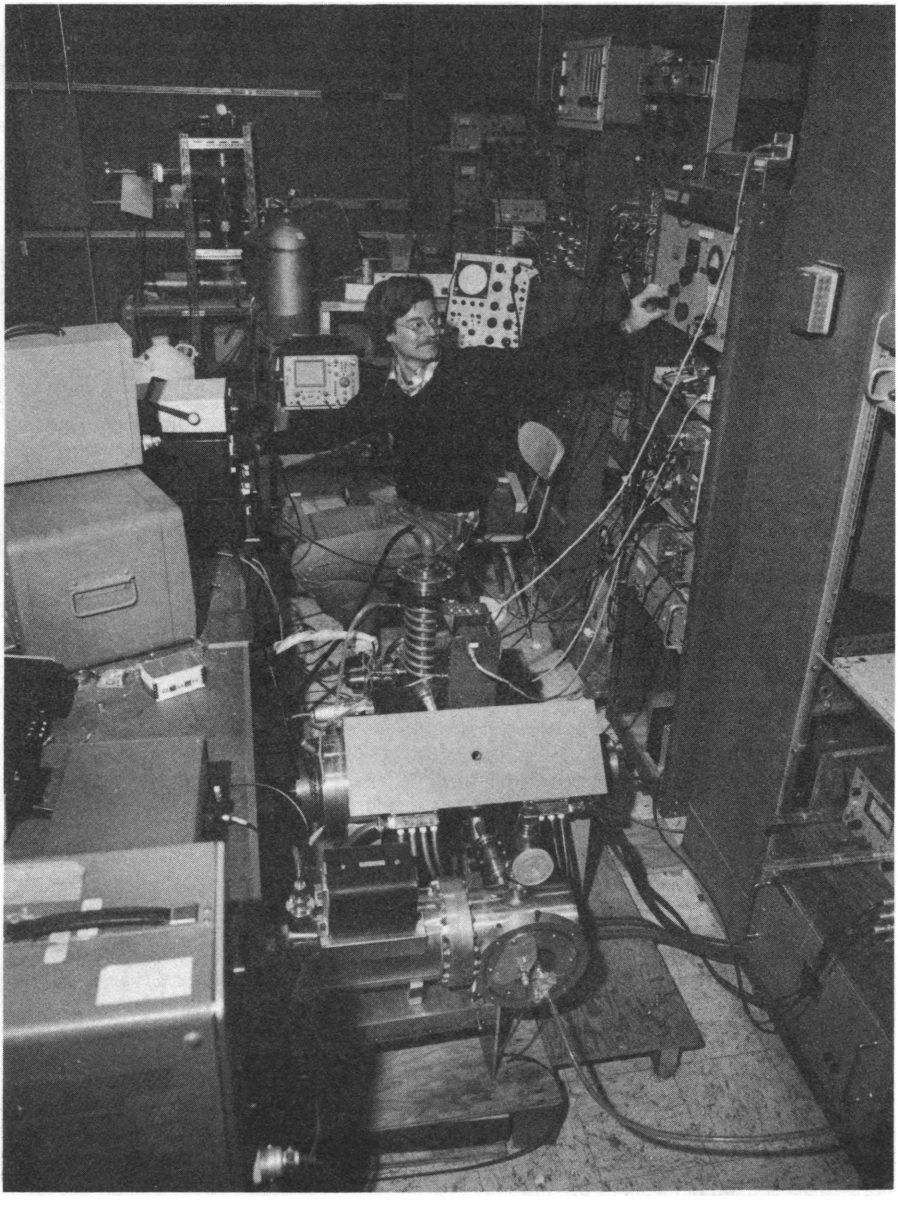
601. Vertebrate Systematics. (1-6). Credit 3. Theory and practice of biological systematics and taxonomy; historical development of discipline, mechanisms of speciation, the origin of higher categories, and major taxonomic philosophies (numerical taxonomy, phylogenetic systematics, and evolutionary systematics). Theory involved in the study of vertebrates.

603. Vertebrate Ecology. (2-3). Credit 3. Ecology of the individual, population and ecosystem; epistemology of major ecological concepts. Theory evolved in the study of vertebrates.

604. Wildlife and Fisheries Systems Analysis. (2-3). Credit 3. Systems analysis techniques applied to problems in wildlife and fisheries sciences. Philosophical and technical discussion of the conceptualization, formulation, evaluation and use of models. Prerequisites: Stat. 302 or equivalent; Math. 230 or equivalent; and approval of instructor.

605. Systematic Ichthyology. (2-3). Credit 3. Functional morphology, phylogeny, ecology and zoogeography of fishes of the world. Relating adaptive morphology and ecology to phylogeny of fishes.

606. Systematic Herpetology. (2-3). Credit 3. Distribution, evolution, speciation and new systematics of amphibians and reptiles; extensive field studies of local problem groups and philosophy and role of herpetology as a science. Prerequisite: W.F.S. 315.



607. Systematic Ornithology. (2-3). Credit 3. Living birds of the world; diversity, radiation, adaptation, distribution and past history. Contrasts both between the taxa and between the continental avifaunas. Field trips required for which departmental fees may be assessed to cover costs. Prerequisites: W.F.S. 402 or equivalent experience in ornithology.

609. Wildlife Research Methods. (3-0). Credit 3. Research methods applied to wildlife management and related subjects. Review of the scientific method; research proposals and data analysis. Prerequisite: W.F.S. 408 or approval of instructor.

610. Systematic Mammalogy. (2-3). Credit 3. Distribution, speciation and systematics of recent mammals of world; research methods and techniques used in systematic investigations of mammals. Prerequisite: Approval of instructor.

611. Estuarine Ecology. (3-3). Credit 4. Principles governing the relationships of estuarine organisms to their environment. Productivity, adaptations to environment, community structure, and factors affecting the distribution and abundance of biota. Prerequisites: Invertebrate zoology and ichthyology or approval of instructor.

613. Shore and Estuarine Fishes. (0-9). Credit 3. Field survey of fishes found in shallow-water habitats along the Gulf of Mexico. Extensive collecting trips made; ecological data taken; and collected specimens identified, counted and evaluated in laboratory. Prerequisite: W.F.S. 312 or approval of instructor.

614. Biological Limnology. (2-3). Credit 3. Theory and application of procedures for obtaining reliable quantitative measurements of aquatic populations. Statistical approaches dictated by the nature of the distributions and basic optimization procedures are reviewed, leading to studies of the design of sampling programs under various statistical and resource constraints.

615. Mariculture. (3-3). Credit 4. Environmental, physiological, behavioral, legal and economic factors which determine the success of efforts to cultivate saltwater species having economic importance. Practices employed in various parts of the world to produce fishes, molluscs and crustaceans. Prerequisites: Ichthyology and invertebrate zoology or approval of instructor.

616. Physiological Ecology of Vertebrates. (3-4). Credit 4. Effects and limitations of temperature, photoperiod, and other environmental factors on the distribution and abundance of animals. Comparative behavioral and physiological adjustments to environment as an evolutionary response. Students will be expected to develop and execute a laboratory investigation in an appropriate subject area. Emphasis on terrestrial vertebrates in 616T; emphasis on aquatic vertebrates, particularly fishes, in 616A.

618. Dynamics of Fish Populations. (2-2). Credit 3. Principles and practices of stock identification, recruitment, growth, abundance, mortality and regulation and yields of fisheries stocks. Prerequisites: W.F.S. 311 or 312; Math. 230; Stat. 651; or approval of instructor.

619. Analytical Procedures in Fisheries. (2-2). Credit 3. Theory and application of qualitative and quantitative analytical procedures in fisheries research and management. Population and community parameters useful in evaluation of management techniques and other environmental alterations. Prerequisites: W.F.S. 410 or equivalent; Stat. 651.

620. Vertebrate Ethology. (3-2). Credit 4. Phylogenetic evolution of behavior; the behavior patterns that animals exhibit for functioning in their environments; problems of everyday activities; social organization; agonistic behavior; territoriality and population integration; reproductive behavior; predator-prey relations; domestication.

681. Seminar. (1-0). Credit 1 each semester. Important current developments in wildlife or fisheries fields with special reference to literature.

684. Professional Internship. Credit 1 to 4 each semester. On-the-job training in fields of wildlife and fisheries sciences. Prerequisite: Graduate classification in wildlife and fisheries sciences.

685. Problems. Credit 2 to 6 each semester. Individual study and research on selected problem approved by instructor and graduate advisor. Credit adjusted in accordance with requirements of each individual case. Prerequisite: Approved proposal.

689. Special Topics in . . . Credit 1 to 4. Special topics in wildlife ecology, fisheries ecology, vertebrate systematics, evolutionary biology of vertebrates and conservation education. May be repeated for credit.

691. Research. Credit 1 or more each semester. Original research on selected wildlife problem to be used in thesis or dissertation.

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