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Graduate Catalog

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Texas A&M University

Graduate Catalog

RECORD OF 1972-1973 SESSION

ANNOUNCEMENT FOR 1973-1974 SESSION

TABLE OF CONTENTS

Academic Calendar ix
Graduate Faculty 1
General Information 43
Graduate Degree Information 54
Financial Assistance 71
Graduate Courses by Departments 75

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THE ACADEMIC CALENDAR FOR 1973-74

Summer Session 1973

June 4	Monday. Registration for the first term.
June 5	Tuesday. Beginning of classes, 8 a.m.
June 7	Thursday. Last day for enrolling in the University for the first term and for adding new courses.
June 8	Friday. Last day for dropping courses with no record.
June 18	Monday. Last day for dropping courses without penalty.
July 4	Wednesday. Independence Day Holiday.
July 10	Tuesday. Last day for first term classes. Beginning of final examinations, 7 p.m.
July 11	Wednesday. Last day of first term final examinations.
July 12	Thursday. Registration for the second term.
July 13	Friday. Beginning of classes, 8 a.m. All final grades due, 10 a.m.
July 17	Tuesday. Last day for enrolling in the University for the second term and for adding new courses.
July 18	Wednesday. Last day for dropping courses with no record.
July 26	Thursday. Last day for dropping courses without penalty.
August 14	Tuesday. Grades for graduating students due, 10 a.m.
August 16	Thursday. Last day of second term classes. Beginning of final examinations, 7 p.m.
August 17	Friday. Last day of second term final examinations. Commencement for first and second term graduating students, 8 p.m.
August 20	Monday. All final grades due, 10 a.m.

Fall Semester 1973

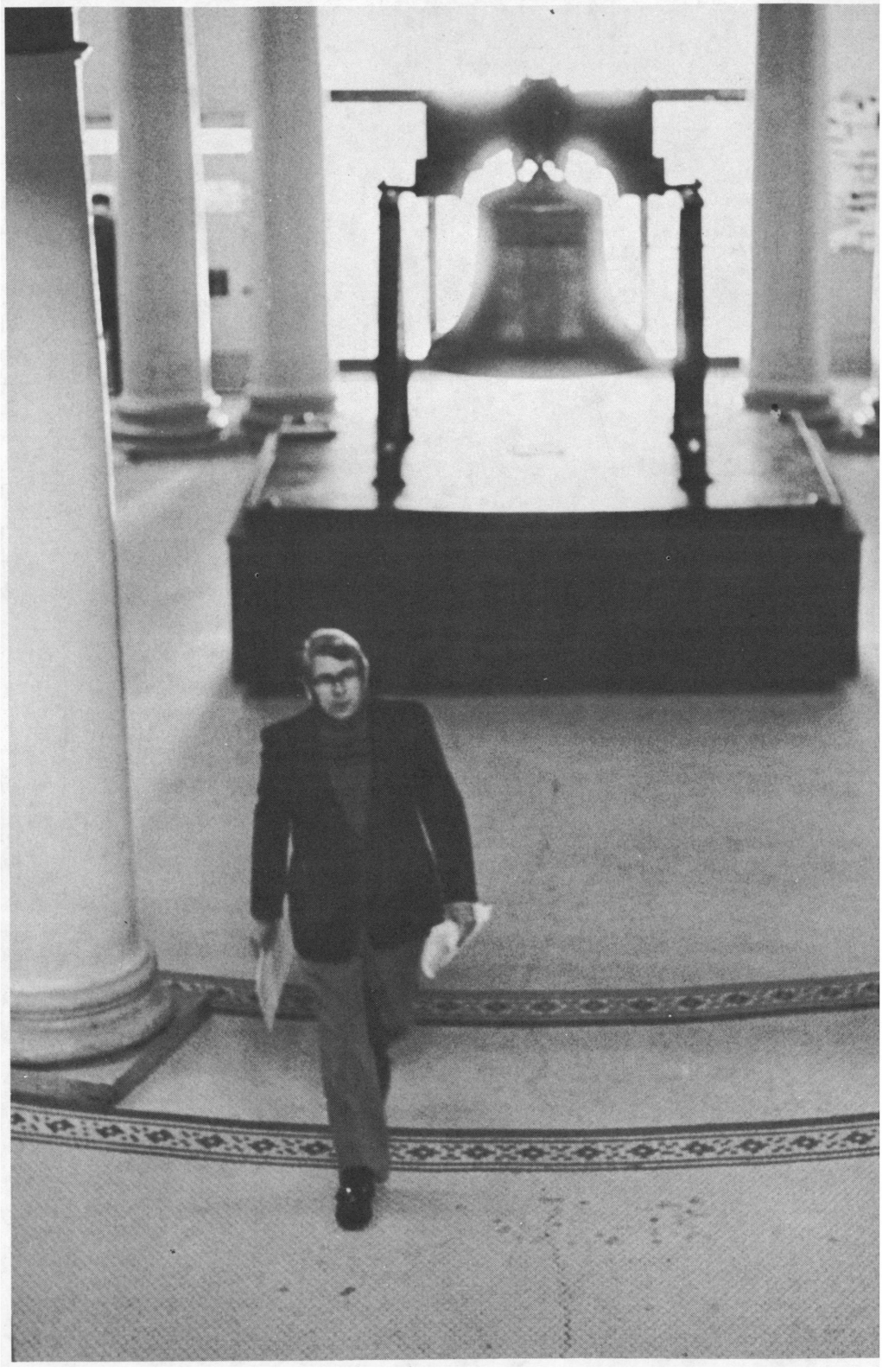
August 27-31	Monday through Friday. Delayed registration, adds and drops.
September 3	Monday. Beginning of Fall Semester classes, 8 a.m.
September 7	Friday. Last day for enrolling in the University for the Fall Semester or for adding new courses.
September 18	Tuesday. Last day for dropping courses with no record.
September 28	Friday. Last day for dropping courses without penalty.
October 22	Monday. Mid-semester grade reports due.
November 22-25	Thursday-Sunday inclusive. Thanksgiving Holidays.
December 10	Monday. Grades for graduating students due, 10 a.m.
December 14	Friday. End of Fall Semester classes, 5 p.m.
December 15	Saturday. Commencement
December 17	Monday. First day of Fall Semester examinations.
December 21	Friday. Last day of Fall Semester examinations.
December 22	Saturday. All final grades due, 1 p.m.

Spring Semester 1974

January 9-11	Wednesday through Friday. Delayed registration, adds and drops.
January 14	Monday. Beginning of Spring Semester classes, 8 a.m.
January 18	Friday. Last day for enrolling in the University for the Spring Semester or for adding new courses.
January 29	Tuesday. Last day for dropping courses with no record.
February 8	Friday. Last day for dropping courses without penalty.
March 4	Monday. Mid-semester grade reports due.
March 8	Friday. Beginning of Spring recess, 5 p.m.
March 18	Monday. End of Spring recess, 8 a.m.
April 29	Monday. Grades for graduating students due, 10 a.m.
May 3	Friday. End of Spring Semester classes, 5 p.m.
May 4	Saturday. Commencement and Final Review
May 6	Monday. First day of Spring Semester examinations.
May 11	Saturday. Last day of Spring Semester examinations.
May 13	Monday. All final grades due, 10 a.m.

Summer Session 1974

June 3	Monday. Registration for the first term.
June 4	Tuesday. Beginning of classes, 8 a.m.
June 6	Thursday. Last day for enrolling in the University for the first term and for adding new courses.
June 7	Friday. Last day for dropping courses with no record.
June 17	Monday. Last day for dropping courses without penalty.
July 4	Thursday. Independence Day Holiday.
July 9	Tuesday. Last day for first term classes. Beginning of final examinations, 7 p.m.
July 10	Wednesday. Last day for first term final examinations
July 11	Thursday. Registration for the second term.
July 12	Friday. Beginning of classes, 8 a.m. All final grades due, 10 a.m.
July 16	Tuesday. Last day for enrolling in the University for the second term and for adding new courses.
July 17	Wednesday. Last day for dropping courses with no record.
July 25	Thursday. Last day for dropping courses without penalty.
August 13	Tuesday. Grades for graduating students due, 10 a.m.
August 15	Thursday. Last day of second term classes. Beginning of final examinations, 7 p.m.
August 16	Friday. Last day of second term final examinations. Commencement for first and second term graduating students, 8 p.m.
August 19	Monday. All final grades due, 10 a.m.



GRADUATE FACULTY

(Listings of degrees and rank correct as of October 15, 1972. Listings of Graduate Faculty membership correct as of February 1, 1973. Figures in parentheses indicate date of first appointment on the University Staff and date of appointment to present position, respectively.)

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, Ernest David, *Associate Professor of Wildlife and Fisheries Sciences.* (1967, 1971) B.S., Oklahoma State University, 1961; M.S., University of Wisconsin, 1964; Ph.D., 1968.

Adair, Thomas W., III, *Assistant to the President; Secretary, Academic Council; and Associate Professor of Physics.* (1966, 1972) B.S., Texas A&M University, 1957; M.A., Rice University, 1960; Ph.D., Texas A&M University, 1965.

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

Adams, John E., *Research Soil Scientist, Blackland Research Center (Temple).* (1969) B.S., University of Nebraska, 1942; M.S., 1949; Ph.D., Iowa State University, 1956.

Adams, Leslie Garry, *Associate Professor of Veterinary Pathology.* (1969, 1972) B.S., Texas A&M University, 1963; D.V.M., 1964; Ph.D., 1968.

Adkins, William G., *Professor of Economics and Research Economist, Texas Transportation Institute.* (1956, 1964) B.S., Texas A&M University, 1951; M.S., 1953; Ph.D., 1963.

Adkisson, Perry Lee, *Professor of Entomology and Head of Department.* (1958, 1968) B.S., University of Arkansas, 1950; M.S., 1954; Ph.D., Kansas State University, 1956.

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

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

Aldrich, David Virgil, *Associate Professor of Biology, of Marine Sciences, of Oceanography and of Wildlife and Fisheries Sciences (Galveston).* (1966, 1969) A.B., Kenyon College, 1950; M.A., Rice University, 1952; Ph.D., 1954.

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

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

Allen, William R., *Professor of Economics.* (1971) A.B., Cornell College, 1948; Ph.D., Duke University, 1953.

Alter, Alan Brian, P.E., *Associate Professor of Mechanical Engineering.* (1949, 1972) B.S., University of Pittsburgh, 1948; M.S., Texas A&M University, 1953; Ph.D., 1971.

Alworth, Charles Wesley, P.E., *Assistant Professor of Electrical Engineering.* (1968) B.S., University of Oklahoma, 1965; M.S., 1967; Ph.D., 1969.

Anderson, Carol Riggs, *Associate Professor of Educational Psychology.* (1969, 1972) B.S., Texas Woman's University, 1958; M.A., 1962; Ed.D., Columbia University, 1966.

Anderson, Jack W., *Assistant Professor of Biology.* (1969) B.A., California State College, 1964; M.A., 1966; Ph.D., University of California, 1969.

Anderson, Robert John, *Assistant Professor of Computing Science and of Industrial Engineering.* (1967, 1970) B.A., Cornell College, 1955; M.S., University of Wisconsin, 1957; Ph.D., Texas A&M University, 1970.

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

Anstadt, George L., *Visiting Member, Department of Veterinary Public Health.* (1962, 1969) B.S., Pennsylvania State University, 1953; V.M.D., University of Pennsylvania, 1957; M.S., 1969.

Anthony, Rayford Gaines, P.E., *Associate Professor of Chemical Engineering.* (1966, 1969) B.S., Texas A&M University 1958; M.S., 1962; Ph.D., University of Texas, 1966.

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

Arnold, Keith Alan, *Associate Professor of Wildlife and Fisheries Sciences.* (1966, 1972) A.B., Kalamazoo College, 1959; M.S., University of Michigan, 1961; Ph.D., Louisiana State University, 1966.

Arnott, Howard J., *Visiting Member, Department of Biology.* (1971) B.A., University of Southern California, 1952; M.S., 1953; Ph.D., University of California at Berkeley, 1958.

Ashburn, Arnold G., *Associate Professor of Educational Administration.* (1971) B.A., Hardin-Simmons University, 1953; B.D., Southwestern Baptist Theological Seminary, 1956; Th.D., 1961; Ph.D., University of Southern Mississippi, 1967.

Ashcraft, Allan Coleman, *Professor of History.* (1956, 1971) B.A., Texas A&M University, 1950; M.A., Columbia University, 1951; Ph.D., 1960.

Atkins, John G., *Plant Pathologist, TAES (Beaumont).* (1965) B.S., Central Missouri State College, 1938; M.S., Louisiana State University, 1940; Ph.D., Cornell University, 1947.

Atkinson, Robert Leon, *Associate Professor of Poultry Science.* (1955, 1968) B.S., Texas A&M University, 1949; M.S., 1950; Ph.D., University of California, 1958.

Ayoub, Abdel-Kader, *Associate Professor of Electrical Engineering.* (1968, 1971) B.S., University of Alexandria (United Arab Republic), 1948; M.S., University of Texas, 1952; Ph.D., 1955.

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

Baker, Lee Edward, *Visiting Member, Department of Veterinary Physiology and Pharmacology.* (1971) B.S., University of Kansas, 1945; M.S., Rice University, 1960; Ph.D., Baylor University, 1965.

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

Ballinger, Richard Henry, *Professor of English.* (1954, 1957) B.A., University of Texas, 1936; M.A., 1936; Ph.D., Harvard University, 1953.

Bancroft, Richard W., *Visiting Member, Department of Veterinary Public Health.* (1962, 1969) B.S., Stanford University, 1938; M.S., University of Southern California, 1947; Ph.D., 1951.

Banks, William Carl, *Professor of Veterinary Medicine and Surgery.* (1951, 1955) D.V.M., Texas A&M University, 1941; M.S., 1952.

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

Barry, Peter James, *Assistant Professor of Agricultural Economics.* (1971) B.S., University of Illinois, 1963; M.S., 1964; Ph.D., 1969.

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., *Assistant Professor of Civil Engineering.* (1969) B.S., University of Wisconsin, 1960; M.S., 1962; Ph.D., Lehigh University, 1970.

Bashaw, Elexis Cook, *Research Agronomist, ARS, USDA, and Lecturer in 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.

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 Institute of Technology, 1961; Ph.D., 1963.

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

Baur, Joseph Ralph, *Plant Physiologist, ARS, USDA, Department of Range Science.* (1967) B.S., Purdue University, 1960; M.S., 1963; Ph.D., Texas A&M University, 1967.

Bay, William Wallace, *Associate Professor of Veterinary Pathology.* (1966, 1968) B.S., Texas A&M University, 1948; D.V.M., 1948; M.S., Purdue University, 1950; Ph.D., 1952.

Beals, Robert P., P.E., *Associate Professor of Industrial Engineering.* (1966, 1971) B.S., Wayne State University, 1953; M.S., 1956; Ph.D., Texas A&M University, 1970.

Bearden, Harold D., *Director, Texas Engineering Extension Service.* (1947, 1957) B.S., Texas Tech University, 1931; M.A., University of Texas, 1936.

Becka, Richard, *Associate Professor of Philosophy.* (1968) B.S., John Carroll University, 1950; M.A., St. Louis University, 1952; Ph.D., University of Ottawa (Canada), 1963.

Beckman, Edward Lewis, *Professor of Marine Sciences (Galveston).* (1972) B.S., Northwestern University, 1939; M.S., University of Southern California, 1949; M.D., Northwestern University Medical School, 1943.

Bell, Alois A., *USDA Scientist, Department of Plant Sciences.* (1970) M.Sc., University of Nebraska, 1958; Ph.D., 1961.

Bell, Rurel Roger, *Professor of Veterinary Parasitology and Head of Department.* (1952, 1968) D.V.M., University of Georgia, 1952; M.S., Texas A&M University, 1955; Ph.D., University of Minnesota, 1968.

Benedict, Chauncey Roy, *Professor of Plant Physiology.* (1966, 1969) B.S., Cornell University, 1954; M.S., 1956; Ph.D., Purdue University, 1960.

Bennett, Earl Dean, *Associate Dean, College of Business Administration; Director of Graduate Programs; and Professor of Accounting.* (1968, 1969) B.S., John Brown University, 1945; M.B.A., Harvard University, 1947; C.P.A., Louisiana, 1948; Ph.D., University of Michigan, 1959.

Benson, Fred Jacob, P.E., *Dean, College of Engineering; Administrator, Texas Engineering Experiment Station; and Professor of Civil Engineering.* (1937, 1962) B.S., Kansas State University, 1935; M.S., Texas A&M University, 1936.

Benton, Wilbourn Eugene, *Professor of Political Science.* (1957, 1962) B.A., Texas Tech University, 1939; M.A., 1941; Ph.D., University of Texas, 1948.

Berg, Robert R., *Director of University Research and Professor of Geology.* (1967, 1972) B.A., University of Minnesota, 1948; Ph.D., 1951.

Bergum, Bruce O., *Associate Professor of Psychology.* (1969) B.S., Northwestern University, 1952; M.S., 1953; Ph.D., 1958.

Berner, Leo, Jr., *Associate Dean of the Graduate College and Professor of Oceanography.* (1966, 1972) B.A., Pomona College, 1943; M.S., University of California at Los Angeles, 1952; Ph.D., 1957.

Bernstein, Robert A., *Assistant Professor of Political Science.* (1969) B.S., Cornell University, 1965; M.S., 1966; Ph.D., 1970.

Berridge, Robert I., *Assistant Professor of Educational Administration.* (1971) B.S., Seton Hall College, 1951; M.S., Texas A&M University, 1958; Ed.D. Michigan State University, 1969.

Berry, Ivan L., *Agricultural Engineer, USDA, Department of Agricultural Engineering.* (1969) B.S., University of Missouri, 1960; M.S., 1961; Ph.D., Texas A&M University, 1969.

Bertrand, Clint Albert, *Associate Professor of Engineering Technology.* (1953, 1965) B.S., Texas A&M University, 1953; M.S., 1959; D.Ed., 1964.

Bilan, M. Victor, *Visiting Member, Department of Forest Science.* (1970) Diplom, University of Munich (Germany), 1949; M.F., Duke University, 1954; D.F., 1957.

Billingsley, Ray Verne, *Professor of Agricultural Economics.* (1966, 1972) B.S., Oklahoma State University, 1949; M.S., 1952; Ph.D., North Carolina State University, 1956.

Bird, Luther Smith, *Professor of Plant Pathology.* (1950, 1966) B.S., Clemson University, 1948; M.S., Texas A&M University, 1950; Ph.D., 1955.

Blackhurst, Homer T., *Professor of Horticulture.* (1947, 1950) A.B., Glenville State College, 1935; M.S., Texas A&M University, 1940; Ph.D., 1947.

Blakley, George Robert, *Professor of Mathematics and Head of Department.* (1970) A.B., Georgetown University, 1954; M.A., University of Maryland, 1959; Ph.D., 1960.

Blankenship, Lytle H., *Associate Professor of Wildlife and Fisheries Sciences.* (1969) B.S., Texas A&M University, 1950; M.S., University of Minnesota, 1952; Ph.D., Michigan State University, 1956.

Bloodworth, Morris Elkins, *Professor of Soil Science and Head, Department of Soil and Crop Sciences.* (1956, 1963) B.S., Texas A&M University, 1941; M.S., 1953; Ph.D., 1958.

Bockholt, Anton J., *Associate Professor of Agronomy.* (1967, 1971) B.S., Texas A&M University, 1952; M.S., 1958; Ph.D., 1967.

Boone, James Leroy, Jr., *Professor of Industrial Education and Head of Department.* (1952, 1971) B.S., Texas A&M University, 1947; M.Ed., 1948; D.Ed., 1966.

Boone, James R., *Assistant Professor of Mathematics.* (1968) B.S., Texas A&M University, 1961; M.S., 1962; Ph.D., Texas Christian University, 1968.

Borman, Christopher A., *Assistant Professor of Educational Psychology.* (1970) B.S., Indiana University, 1956; M.A., Northwestern University, 1963; Ed.D., Indiana University, 1970.

Boswell, Thurman E., *Associate Professor, TAMU Plant Disease Research Station (Yoakum).* (1970, 1971) B.S., Texas A&M University, 1951; M.S., 1958; Ph.D., 1968.

Bottino, Nestor Rodolfo, *Associate Professor of Biochemistry and Biophysics.* (1965, 1969) Licentiate in Chemistry, University of La Plata (Argentina), 1951; Doctor of Chemistry, 1954.

Bottrell, Dale G., *Associate Professor of Entomology.* (1967, 1970) B.S., Oklahoma State University, 1963; Ph.D., 1967.

Bouma, Arnold H., *Professor of Oceanography.* (1966, 1970) B.S., State University, Groninger (Netherlands), 1956; M.S., Utrecht University (Netherlands), 1959; Ph.D., 1961.

Bourgeois, Anthony Emile, *Associate Professor of Psychology.* (1966, 1970) B.S., University of Southwestern Louisiana, 1962; Ph.D., Baylor University, 1966.

Bovey, Rodney William, *Research Agronomist, ARS, USDA, Department of Range Science.* (1966) B.S., University of Idaho, 1956; M.S., 1959; Ph.D., University of Nebraska, 1964.

Bowen, Hollis Hulon, *Associate Professor of Horticulture.* (1965, 1971) B.S., University of Arkansas, 1960; M.S., 1961; Ph.D., Rutgers University, 1965.

Bowers, David R., *Professor of Journalism.* (1964, 1967) B.J., University of Missouri, 1946; A.M., 1947; Ph.D., University of Iowa, 1954.

Boyce, Meherwan Phiroz, *Assistant Professor of Mechanical Engineering.* (1969) B.S., South Dakota School of Mines and Technology, 1962; M.S., State University of New York at Buffalo, 1964; Ph.D., University of Oklahoma, 1969.

Boyd, Charles Leroy, *Professor of Veterinary Medicine and Surgery,* (1964, 1971) D.V.M., Texas A&M University, 1945; M.S., 1967.

Branson, Robert Earl, *Professor of Agricultural Economics.* (1955, 1958) B.S., Southern Methodist University, 1941; M.P.A., Harvard University, 1948; M.A., 1949; Ph.D., 1954.

Bravenec, Lorence L., *Associate Professor of Accounting.* (1971) B.A., University of Texas, 1957; LL.B., 1960; LL.M., New York University, 1966; C.P.A., Texas, 1972.

Breitenkamp, Edward Carlton, *Professor of Modern Languages.* (1953, 1963) B.A., Drake University, 1936; M.A., 1938; Ph.D., State University of Iowa, 1951.

Breitmeyer, Michael O., *Visiting Member, Department of Industrial Engineering.* (1972) B.Ch.E., University of Louisville, 1963; M.S., University of Wisconsin, 1965; Ph.D., 1967.

Bridges, Charles Hubert, *Professor of Veterinary Pathology and Head of Department.* (1954, 1960) D.V.M., Texas A&M University, 1945; M.S., 1954; Diplomate, American College of Veterinary Pathologists, 1956; Ph.D., Texas A&M University, 1957.

Brigham, Raymond D., *Associate Professor of Agronomy, ARS, USDA (Lubbock).* (1957) B.S., Texas Tech University, 1950; M.S., Iowa State University, 1952; Ph.D., 1957.

Bright, Thomas Jerry, *Assistant Professor of Oceanography.* (1969) B.S., University of Wyoming, 1964; Ph.D., Texas A&M University, 1968.

Brooks, David Whitehead, *Associate Professor of Chemistry.* (1967, 1970) B.A., New York University, 1962; M.A., Columbia University, 1962; Ph.D., 1965.

Brown, Herman Dale, *Associate Professor of Agricultural Education.* (1962, 1966) B.S., Texas A&M University, 1953; M.Ed., 1962; Ed.D., Oklahoma State University, 1965.

Brown, Kirk W., *Assistant Professor of Soil Science.* (1970) B.S., Delaware Valley College, 1962; M.S., Cornell University, 1964; Ph.D., University of Nebraska, 1969.

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Szabuniewicz, Michael, *Professor of Veterinary Physiology and Pharmacology.* (1962, 1971) D.V.M., Academy of Veterinary Medicine, Livov (Poland), 1934; D.V.Sc., 1937.

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Thurston, E. Laurence, *Assistant Professor of Biology.* (1970) B.S., State University of New York at Genesco, 1964; M.S., Iowa State University, 1967; Ph.D., 1969.

Tieh, Thomas T., *Associate Professor of Geology.* (1966, 1971) B.S., University of Illinois, 1958; M.S., Stanford University, 1962; Ph.D., 1965.

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van Overbeek, Johannes, *Professor of Biology and Head of Department.* (1966) B.S., State University of Leyden (Netherlands), 1928; M.S., Utrecht University (Netherlands), 1932; Ph.D., 1933; Doctor Honoris Causa, State Faculty of Agricultural Sciences, Fembloux (Belgium), 1960.

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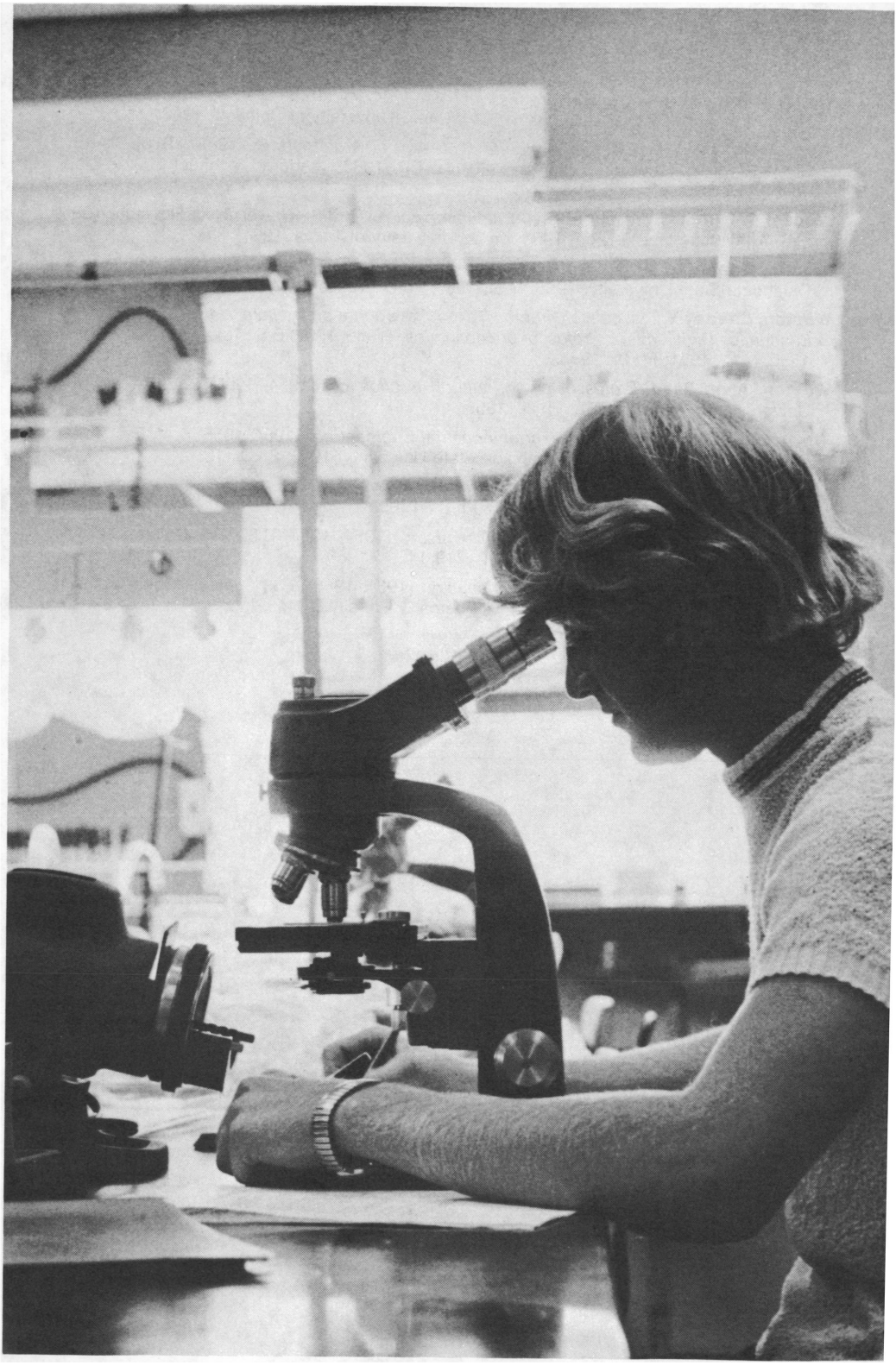

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The Dean of the Graduate College is responsible for the academic programs of all graduate students. He is the representative of the Graduate Faculty and is the medium of communication between the graduate students and the University administration.

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.

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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 Science (M.S.)
Master of Statistics (M.Stat.)

Master of Urban Planning (M.U.P.)
Doctor of Education (D.Ed.)
Doctor of Environmental Design (D.E.D.)
Doctor of Philosophy (Ph.D.)

GRADUATE DEGREES CURRENTLY OFFERED

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- Agricultural Development
- Agricultural Economics
- Animal Science
- Crops
- Dairy Science
- Economic Entomology
- Fisheries Science
- Floriculture
- Horticulture
- Interdisciplinary
- Agricultural Chemistry
- Food Technology
- Plant Sciences
- Poultry Science
- Range Science
- Recreation and Resources Development
- Rural Sociology
- Soils
- Wildlife and Fisheries Sciences
- Natural Resources Development
- Plant Protection

Master of Education, with an option in
- Agricultural Education

Master of Science, with options in
- Agricultural Economics
- Agricultural Education
- Agricultural Engineering
- Agronomy
- Animal Breeding
- Animal Nutrition
- Animal Science
- Biochemistry
- Biophysics
- Dairy Science
- Entomology
- Floriculture
- Food Technology
- Forestry
- Genetics
- Horticulture
- Physiology of Reproduction
- Plant Breeding
- Plant Pathology
- Plant Physiology
- Poultry Science
- Range Science
- Recreation and Resources Development
- Soil Chemistry
- Soil Physics
- Wildlife and Fisheries Sciences

Doctor of Philosophy, with options in
- Agricultural Economics
- Agricultural Engineering
- Agronomy
- Animal Breeding
- Animal Nutrition
- Animal Science
- Biochemistry
- Dairy Science
- Entomology
- Food Technology
- Forestry
- Genetics
- Horticulture
- Physiology of Reproduction
- Plant Breeding
- Plant Pathology

- Plant Physiology
- Poultry Science
- Range Science
- Recreation and Resources Development
- Soil Chemistry
- Soil Physics
- Wildlife and Fisheries Sciences

COLLEGE OF ARCHITECTURE AND ENVIRONMENTAL DESIGN

Master of Architecture, with options in

- Building Design
- Construction Management
- Interior Space Design
- Systems Development
- Urban Design

Master of Landscape Architecture

Master of Urban Planning (Interdisciplinary) with an option in

- Urban and Regional Planning

Doctor of Environmental Design, with options in

- Architecture
- Landscape Architecture
- Urban and Regional Planning

COLLEGE OF BUSINESS ADMINISTRATION

Master of Business Administration, with options in

- Accounting
- Business Computing Science
- Business Statistics
- Finance
- Management
- Marketing

Master of Science, with options in

- Accounting
- Business Computing Science
- Business Statistics
- Finance
- Management
- Marketing

Doctor of Philosophy (Business Administration), with options in

- Accounting
- Finance
- Management
- Marketing

COLLEGE OF EDUCATION

Master of Education, with options in

- Adult and Extension Education
- Curriculum and Instruction
- Educational Administration
- Educational Psychology
- Educational Technology
- Health and Physical Education
- Industrial Education

Master of Science, with options in

- Adult and Extension Education
- Curriculum and Instruction
- Educational Administration
- Educational Psychology
- Health and Physical Education
- Industrial Education

Doctor of Education, with options in

- Adult and Extension Education
- Industrial Education
- Vocational Education

Doctor of Philosophy (Education), with options in

- Adult and Extension Education
- Curriculum and Instruction
- Educational Administration
- Educational Psychology
- Vocational Education

Doctor of Philosophy (Health and Physical Education)

COLLEGE OF ENGINEERING

Master of Computing Science

Master of Engineering, with options in

- Aerospace Engineering
- Agricultural Engineering
- Chemical Engineering
- Civil Engineering
- Electrical Engineering
- Industrial Engineering
- Mechanical Engineering
- Nuclear Engineering
- Petroleum Engineering

Master of Science, with options in

- Aerospace Engineering
- Agricultural Engineering
- Chemical Engineering
- Civil Engineering
- Computing Science
- Electrical Engineering
- Industrial Engineering
- Industrial Hygiene
- Industrial Safety
- Industrial Technology
- Interdisciplinary Engineering
- Mechanical Engineering
- Nuclear Engineering
- Petroleum Engineering

Doctor of Philosophy, with options in

- Aerospace Engineering
- Agricultural Engineering
- Chemical Engineering
- Civil Engineering
- Computing Science
- Electrical Engineering
- Industrial Engineering
- Interdisciplinary Engineering
- Mechanical Engineering
- Nuclear Engineering
- Petroleum Engineering

COLLEGE OF GEOSCIENCES

Master of Science, with options in

- Geography
- Geology
- Geophysics
- Meteorology
- Oceanography

Doctor of Philosophy, with options in

- Geography
- Geology
- Geophysics
- Meteorology
- Oceanography

COLLEGE OF LIBERAL ARTS

Master of Arts, with options in

- English
- History
- Modern Language
- Political Science

Master of Science, with options in

- Economics
- Psychology
- Sociology

Doctor of Philosophy, with options in

- Economics
- English
- History (American)
- Sociology

COLLEGE OF SCIENCE

Master of Science, with options in

- Biology
- Botany
- Chemistry
- Mathematics
- Microbiology
- Physics
- Statistics
- Zoology

Master of Statistics

Doctor of Philosophy, with options in

- Biology
- Botany
- Chemistry
- Mathematics
- Microbiology
- Physics
- Statistics
- Zoology

COLLEGE OF VETERINARY MEDICINE

Master of Science, with options in

- Epidemiology
- Laboratory Animal Medicine
- Veterinary Anatomy
- Veterinary Medical Sciences (Radiology and Nuclear Medicine)
- Veterinary Medicine and Surgery
- Veterinary Microbiology
- Veterinary Parasitology
- Veterinary Pathology
- Veterinary Physiology
- Veterinary Toxicology

Doctor of Philosophy, with options in

- Veterinary Anatomy
- Veterinary Medical Sciences
- Veterinary Microbiology
- Veterinary Pathology
- Veterinary Physiology
- Veterinary Public Health
- Veterinary Toxicology

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 researches. 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.

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, Sam Houston State University, Stephen F. Austin State University, and West Texas State University. Details concerning these cooperative graduate programs are available from the Graduate Deans of the institutions involved.

ADMISSION

Texas A&M University is a coeducational university admitting all qualified men and women to all academic studies on the same basis without regard to race, creed, color, or national origin.

To be admitted to the Graduate College (except under double registration), an applicant (1) must hold a 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 for the Aptitude Test of the Graduate Record Examination. This test must be taken within five (5) years of the date of application for admission to the Graduate College. Applicants in the Department of Biology are also required to submit scores on the appropriate Advanced Test. Approximately six weeks are required for scores to be received by the Graduate College after the tests are

administered. Scores made on the Graduate Record Examination more than five (5) calendar years prior to application for admission to the Graduate College may not be used to satisfy the GRE requirements.

The GRE during 1973-74 will be given at various centers, including Texas A&M University, throughout the United States and in other countries on the following dates:

October 27, 1973
December 8, 1973
January 19, 1974
February 23, 1974
April 27, 1974
June 15, 1974

To determine the most convenient locations, prospective applicants should write to The Educational Testing Service, 1947 Center Street, P. O. Box 1502, Berkeley, Calif. 94701, or The Counseling and Testing Center, Texas A&M University, College Station, Texas 77843.

Students living in the United States should make application for the Graduate Record Examination not less than four weeks in advance of a scheduled test date (above). Students living outside the continental limits of the United States should make application for the Graduate Record Examination not less than six (6) weeks in advance of a scheduled test date.

Inquiries regarding admission to the Graduate College should be addressed to: The Dean 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 at the office of the Dean of Admissions and Records, should be filed at least four 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.

In addition to the records sent to this office, the student should have in his possession a copy of his record for use in conference with members of the Graduate Faculty in planning his 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 five (5) calendar years only, unless the student during this period engages in active graduate work.

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

A student whose academic record is not satisfactory for this purpose, whose scores on the GRE are not satisfactory, or who is changing fields of study may be required to take additional work to strengthen his background and preparation for graduate study in his field. Such work will normally be arranged in conference with the student's Advisory Committee or the chairman of his major department.

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

Foreign 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 Graduate Record Examination. In addition, prospective students from other countries must demonstrate acceptably 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), 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 08540, U.S.A.

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

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

REGISTRATION

Before his first registration the student should consult the graduate advisor representing the field of his major interest. This advisor will assist him in planning his first registration.

The load for a full-time graduate student is twelve (12) to sixteen (16) hours per semester or six (6) hours per six-week summer term. The maximum load for Graduate Assistants on one-half time employment is nine (9) to twelve (12) hours per semester or four (4) hours per six-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 (4) hours of 691 (Research) credit each semester or 12-week summer session until all requirements for the degree have been completed. Students who are completing thesis or dissertation research **in absentia** must register for no more and no less than four (4) hours of 691 (Research) credit each semester or 12-week summer session until all requirements for the degree have been completed, unless an approved petition for exception is on file in the Graduate College prior to registration.

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** (1970), p. 70.

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

Double Registration. Undergraduates at this University who, at the beginning of a given semester, are within twelve (12) hours of graduation or at the beginning of a summer term are within six (6) hours of graduation may apply for provisional admission to the Graduate College provided they meet the Graduate Record Examination requirements and have a B average or better for the last three semesters of course work. Such students must complete the undergraduate work and obtain the Bachelor's degree during the first semester or summer term in the Graduate

College before being eligible for full admission to the Graduate College. The maximum total credit hour load for double registered students is sixteen (16) hours in the regular semester or six (6) hours in a six-week summer term.

A superior undergraduate student is otherwise eligible to enroll in a graduate course for graduate credit only if he 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 and is not including it for credit on his undergraduate degree program. Such petitions must be approved by the Head of the student's major (undergraduate) department **and** the student's academic dean.

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 (8) hours taken prior to admission to the Graduate College may be utilized 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 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 degree program for consideration by the student's full Advisory Committee.

FEES

The fees set out herein for graduate students for the session of 1973-74 are strictly approximations and are subject to change because of economic conditions and/or legislative requirements. The tuition fee listed below is based on registration for fifteen (15) semester credit hours during the Fall and Spring Semesters and six (6) semester credit hours during the First and Second term of the Summer Session.

			Summer Session	
	First Semester	Second Semester	First Term	Second Term
Tuition Fee (See Explanation of Fees) for Texas residents	$ 60.00	$60.00	$ 25.00	$ 25.00
Tuition Fee (See Explanation of Fees) for nonresidents	$600.00	$600.00	$240.00	$240.00
Student Services Fee	$ 30.00	$ 30.00	$ 9.00	$ 9.00
Building Use Fee	$ 28.50	$ 28.50	$ 14.25	$ 14.25
Student Center Complex	$ 10.00	$ 10.00	$ 5.00	$ 5.00

In addition to expenses as outlined above, state law requires the payment of laboratory fees which shall reflect the cost of materials and supplies used and which shall be not less than $2.00 nor more than $8.00 per laboratory course.

Each applicant for an advanced degree is required to pay a diploma fee of $5.00. A fee of $15.00 is required to cover the cost of binding three copies of the thesis. Each candidate for the doctorate is required to pay a dissertation microfilming fee of $25.00. 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 recorded on the student's records.

Any student registering for "Degree Only" will be required to pay a service fee of $15.00.

EXPLANATION OF FEES

Tuition

Resident students (Texas residents) pay four dollars ($4) per semester credit hour, but the total of such charges shall be not less than fifty dollars ($50) per semester or trimester, and not less than twenty-five dollars ($25) per six-week summer term.

Nonresident students pay forty dollars ($40) per semester credit hour.

Alien students pay fourteen dollars ($14) per semester credit hour, but the total of such charge shall be not less than two hundred dollars ($200) per semester or trimester and not less than one hundred dollars ($100) per six-week summer term.

Any nonresident student who was enrolled for the spring semester of 1971 may continue to enroll at the same tuition rate that was effective at the time of his original enrollment, or until one of the following conditions first occurs: (1) he receives the degree at the degree level toward which he was working during the spring semester of 1971; or (2) he voluntarily or involuntarily withdraws from the University; or (3) the termination of the spring semester of 1975.

Former students who in either semester do not register on the days set apart for that purpose pay an additional fee of $4.00.

Student Services

The student services fee is required of all students and covers the services at the University Hospital, Memorial Student Center, and the Intramural Program. It entitles the student to receive the Battalion newspaper, and covers admission to all athletic events played at the University under the auspices of the Athletic Department, to Town Hall Programs, and to the Great Issues and Recital Series.

Building Use Fee

The building use fee is required of all students and is to cover bonded indebtedness incurred for the expansion, air conditioning, and/or rehabilitation of the Memorial Student Center, G. Rollie White Coliseum, various University auditoriums, the University Library, Kyle Field Stadium, and the Student Health Center.

Student Center Complex Fee

This fee is required of all students for operating, maintaining, improving and equipping the Student Center Complex.

Refunds

Any student withdrawing officially (a) during the first week of classwork in a semester or trimester will receive a refund of four-fifths of the tuition fee; (b) during the second week of classwork, three-fifths; (c) during the third week of classwork, two-fifths; (d) during the fourth week of classwork, one-fifth; (e) after the fourth week of classwork, nothing. Any student withdrawing officially from school during the first week of a semester or trimester will receive a refund of 100% of student services, building use, student center complex and laboratory fees; after the first week of school, no refund will be made. No refunds will be made until three weeks have elapsed from the time the fees were paid.

Any student withdrawing officially during the first week of classwork in a summer term will receive a refund of one-half of the tuition fee; after the first week of classwork, nothing. No refund of student services, building use, student center complex or

laboratory fees will be made after the second day of classwork of the summer term.

UNIVERSITY HOUSING — RESIDENCE HALLS AND MARRIED STUDENT APARTMENTS

Although residence in the University dormitories is not required of graduate students, many of the unmarried students prefer these accommodations. For married students, University-owned apartments, both furnished and unfurnished, are available. Rentals range from approximately $45.00 to $135.00 per month, including normal utilities, dependent upon the type of apartment desired. Application for a married student apartment should be made directly to the Student Apartments Office, Box 117, Faculty Mail Service, Texas A&M University, College Station, Texas, 77843.

DEGREE PROGRAM

A graduate student's Degree Program includes all courses which are listed on his official form (except prerequisites or "other courses"). All courses on the approved Degree Program must be completed with a satisfactory grade to meet the 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.

SCHOLARSHIP

A minimum grade point ratio (G.P.R.) of 3.00 (B average based on a 4.00 maximum) in all course work other than in those courses in which grades of Satisfactory (S) or Unsatisfactory (U) are given 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 utilized in computing the grade point ratio.

A course 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 utilized 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 degree program from another institution shall be utilized in computing the student's final over-all grade point ratio.

Courses listed for graduate credit on the official 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 grade point ratio falls below the minimum of 3.00, the student will be on scholastic probation. If the minimum grade point ratio is not attained in a reasonable time, the student will be required to withdraw from the Graduate College. A grade of C is the lowest grade for which graduate credit will be given. In courses receiving grades of Satisfactory (S) or Unsatisfactory (U), only the S grade is acceptable toward the completion of a degree program.

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 time and most of his energy to his graduate studies **on the Main Campus under the direction of his major professor and his 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 development in order to guide and direct his studies and to determine his 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, program of study, etc., must be proposed to the Dean of the Graduate College by petition, with endorsements by all members of the student's Advisory Committee.

THE DEGREE OF MASTER OF SCIENCE

Residence

In partial fulfillment of the residence requirement for the degree of Master of Science, the student must complete, on the Main Campus at College Station, nine (9) credit hours during one semester or during two consecutive six-week summer terms. Except for the allowable transfer and extension credits noted below, the remainder of the course work must be completed "on-campus." In this context the term "campus" refers to any properties under the jurisdiction of the Texas A&M University System. The term "Main Campus" refers to the campus of Texas A&M University located at College Station, Texas. 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 (9) 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 (9) 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 (9) credit hours per semester, or nine (9) credit hours per 12-week summer session. Specific authorization for such programs must be granted in advance by the employing agency.

Student's Advisory Committee

A student should consult with the departmental graduate advisor or department chairman in the field of his major interest for the selection of his graduate Advisory Committee. An Advisory Committee for the Master's degree will be composed of not fewer than three members of the Graduate Faculty, one of whom must be from outside the major field. The chairman of the committee will direct the student's total graduate program.

Degree Program

The student's Advisory Committee, in consultation with the student, will develop his 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 Degree Program must be submitted on the official form with endorsements by the student's Advisory Committee. Any prerequisite courses recommended should also be listed on the form.

Thesis Proposal

The student must prepare a thesis proposal for approval by his Advisory Committee. This proposal must be submitted in quadruplicate for the approval of the Dean of the Graduate College at least fourteen (14) weeks prior to the close of the semester or summer session in which the student expects to receive his degree.

Credit Requirement

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

Ordinarily the student will devote the major portion of his 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 (6) 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 was below B may be transferred for graduate credit. **(Note also b and d, below).**
   b. Not more than a total of twelve (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. **(Note also c, below).**
   c. Not more than a total of twelve (12) credit hours of 689 (Special Topics).
   d. Not more than a total of twelve (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 (8) hours each of 691 (Research), or 685 (Problems), nor more than three (3) hours of 690 (Theory of Research) — nor more than twelve (12) hours of any combination of these.
3. Not more than two (2) hours of seminar.
4. Not more than eight (8) 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 utilized for the degree of Master of Science.

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.

Time Limit

Effective September 1, 1969, 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 (7) consecutive calendar years. All students who were enrolled in the Graduate College for Master's degree work prior to September 1, 1969, must complete all requirements for the degree no later than August 31, 1976.

Transfer of Credit

A student who has earned twelve (12) hours of graduate resident credit at Texas A&M University may be authorized, upon the advice of his Advisory Committee and with the advance approval of the Dean of the Graduate College, to transfer from another institution more than six (6) 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.

Foreign Languages

There is no specific language requirement for the Master of Science degree. For other Master's degrees, departments may, at their discretion, require a reading knowledge of one or more foreign languages.

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 resident staff of the Texas A&M University System above the rank of Assistant Professor, or its equivalent, will not be granted a Master's degree at this institution. They may, however, enroll for graduate work.
2. Members of the faculty and staff of Texas A&M University will not be granted a graduate degree by Texas A&M University after receiving tenure at this institution.
3. Item 2, above, does not apply to those members of the faculty and staff who gained admission to the Graduate College of Texas A&M University and enrolled in course work leading to a graduate degree prior to January 1, 1972.

Thesis

An acceptable thesis is required for the degrees of Master of Arts and Master of Science and is optional for the degree of Master of Urban Planning. The thesis should embody original work on the part of the candidate. It must be grammatically correct, reflecting the ability of the candidate to express himself clearly. In general, the format should be consistent with that used in scholarly journals in the candidate's field. An abstract not exceeding 600 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 (3) copies of the thesis in its final form must be filed with the Theses/Dissertations Clerk of the Graduate College (Room 248, University Library), after approval by the student's Advisory Committee, by dates announced each semester.

A thesis binding fee must be paid to the Fiscal Department and the receipt shown to the secretary of the Dean of the Graduate College before the degree can be conferred.

Application for Degree

Formal application for the degree must be filed in the office of the Dean of the Graduate College not later than ninety (90) days prior to the end of the semester, or thirty (30) days prior to the end of the summer term in which the student expects to complete his 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, or for either six-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 not less than than two (2) weeks before the date on which the degree is to be conferred. Three (3) copies of the thesis in final form signed by the student's Advisory Committee and the Head of the student's major department must be submitted to the Graduate College, together with the announcement for the final examination, at least two (2) weeks in advance of the scheduled date for the 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 open to members of the Graduate Faculty only and is conducted by the student's Advisory Committee as finally constituted.

Candidates may exempt the final examination provided their grade point ratio 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 in which the examination is to be given.

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 this 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 Technology, 3) Natural Resource Development and 4) Plant Protection.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

Approximately twelve (12) of the thirty-six (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. The reports are expected to be of a scholarly nature and may carry up to four (4) hours of credit by registration in 685 (Problems) courses.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 for the degree.

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 Agriculture are identical with those for the degree of Master of Science.

MASTER OF ARCHITECTURE

The Department of Architecture in the College of Architecture and Environmental Design offers five 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 each option (Building Design, Urban Design, Interior Space Design, Systems Development and Construction Management) requires the completion of fifty-two (52) hours of course work and a satisfactory comprehensive final examination. Holders of the Bachelor of Environmental Design degree from Texas A&M University and holders of five (5) 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 coursework in the Department of Environmental Design to attain B.E.D. equivalency.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized toward the degree of Master of Architecture — nor any combination of 684, 685, and 690 totaling in excess of 25% of the total credit hour requirement for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credit noted under the degree of Master of Science, the remainder of the course work must be completed on campus.

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

The degree of Master of Arts currently is offered to students majoring in English, History, Political Science, or Modern Language. The residence requirements for this degree are exactly the same as for the Master of Science degree, as is the requirement of a thesis. The thesis is expected to be a competently phrased narrative of the student's original research topic. Of the total of thirty (30) semester hours required for the Master of Arts degree, no more than six (6) credit hours for thesis research may be counted toward the degree. At least twenty-four (24) hours of credit must be for course work, including at least sixteen (16) hours of course work at the graduate level. The 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 utilized for the degree of Master of Arts.

Foreign Languages: For the degree of Master of Arts a reading knowledge (usually represented by two (2) years of college study) of at least one foreign language is required.

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

THE DEGREE OF MASTER OF BUSINESS ADMINISTRATION

The College of Business Administration offers graduate programs leading to the degree of Master of Business Administration. Students may concentrate in the professional fields of accounting, business computing science, finance, management, marketing or business statistics.

The holder of a bachelor's degree in Business Administration will normally be prepared to go directly into graduate courses in a professional field which requires a minimum of thirty-six (36) credit hours. The holder of a bachelor's degree not in Business Administration will be required to take preprofessional courses as explained in the section **Graduate Courses of Instruction by Departments.**

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized toward the degree of Master of Business Administration — nor any combination of 684, 685, and 690 totaling in excess of 25% of the total credit hour requirement for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 (2) 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.

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 thirty-six (36) hours of course work and a satisfactory comprehensive final examination.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 (2) weeks in advance of the scheduled date.

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 and physical education, or industrial education may become candidates for the degree of Master of Education. This is a non-thesis degree which requires thirty-six (36) hours of course work and a satisfactory comprehensive final examination.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 requirment for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 (2) weeks in advance of the scheduled date.

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 his last semester may apply for admission to the Graduate College to work toward the non-thesis degree of Master of Engineering, majoring in his particular field of engineering. Approximately one-third of the required thirty-six (36) credit hours of course work will be taken in fields outside of the major field.

The work in the major field will include one or two written reports (not necessarily involving results of research conducted by the candidate) for which up to four (4) hours credit in 685 (Problems) courses is permissible.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 for the degree.

The minimum residence requirement for the degree of Master of Engineering is one full semester of sixteen (16) credit hours, or the equivalent, on the Main Campus at College Station.

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 (2) weeks in advance fo the scheduled date.

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 forty (40) hours of course work and a satisfactory comprehensive final examination.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 STATISTICS

Graduate students majoring in statistics may become candidates for the degree of Master of Statistics, a non-thesis degree designed to complement the Master

of Science degree in statistics. The Master of Statistics degree requires the completion of thirty-six (36) credit hours of course work, a special problem for which three (3) hours of 685 credit is given, and a comprehensive final examination.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized toward the degree of Master of Statistics — nor any combination of 684, 685, and 690 totaling in excess of 25% of the total credit hour requirement for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 (2) weeks in advance of the scheduled date.

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

THE DEGREE OF MASTER OF URBAN PLANNING (Interdisciplinary)

Students holding the baccalaureate degree may become candidates for the degree of Master of Urban Planning (Interdisciplinary). 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 forty-eight (48) hours of course work and a satisfactory oral examination.

No more than eight (8) credit hours of 684 (Professional Internship), eight (8) credit hours of 685 (Problems), nor more than three (3) credit hours of 690 (Theory of Research) may be utilized 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 for the degree.

To satisfy the residence requirement the student must complete twelve (12) credit hours on the Main Campus at College Station. Except for the allowable transfer and extension credits noted under the degree of Master of Science, the remainder of the course work must be completed "on-campus."

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 (2) weeks in advance of the scheduled date.

Except as noted above, the requirements for the degree of Master of Urban Planning (Interdisciplinary) 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 4 weeks prior to registration (3-4 months prior to registration for foreign students; use foreign student application)
2. Become familiar with general regulations in Master's Degree section of catalogue		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 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 deadlines in Graduate College Calendar
7. Check to be sure Degree Program and Advisory Committee are up to date and all course work is complete	ADCom / Dean	Well before final examination. Follow regular procedures for changes (see catalogue)
8. File the completed, approved thesis with the Graduate College and announcement for final oral examination	ADCom & DH / Dean	At least 2 weeks prior to final oral examination (see catalogue for specific details)
9. File letter-of-intent to continue for Doctorate, if you so plan	DH / Dean & D. A. & R.	Immediately upon completion of all requirements for Master's degree
10. Arrange for cap and gown at Exchange Store		See deadline in Graduate College Calendar.

THE DEGREE OF DOCTOR OF PHILOSOPHY

Work leading to the Degree of Doctor of Philosophy is designed to give the candidate a thorough and comprehensive knowledge of his professional field and to train him 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 his demonstrated ability to do independent research. In addition, the candidate must have acquired the ability to express himself 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

Students who enter the doctoral degree programs with baccalaureate degrees must spend two academic years in resident study on the Main Campus at College Station. Students who hold Master's degrees when they enter doctoral degree programs must spend one (1) academic year in resident study on the Main Campus. In either case, one (1) academic year beyond the first year of graduate study must be in continuous residence on the Main Campus of Texas A&M University at College Station. One academic year may include two (2) adjacent regular semesters or one (1) regular semester and one (1) adjacent 12-week summer session.

To satisfy the continuous residence requirement, the student must complete a minimum of nine (9) credit hours per semester or 12-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 (1) academic year (eighteen [18] credit hours) on the Main 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 [9] credit hours per semester) on a proportionate basis. Full-time staff members of the University or of closely affiliated organizations stationed at the Main Campus may fulfill total residence requirements by the completion of less-than-full course loads.

A minimum of ninety-six (96) credit hours beyond the baccalaureate degree or sixty-four (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 his Advisory Committee and approval of the Dean of the Graduate College, a student may be permitted to carry on work in connection with his dissertation *in absentia*. In case credit is desired for off-campus research, the student must maintain his registration at the University.

TIME LIMIT

Effective September 1, 1969, no student will be granted a doctoral degree (Ph.D.,D.Ed. or equivalent degree) from Texas A&M University unless all requirements for that degree are completed within a period of ten (10) consecutive calendar years.

Students who enrolled in the Graduate College for doctoral degree work prior to September 1, 1969, must complete all requirements for the doctoral degree no later than August 31, 1979.

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 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 (4) members of the Graduate Faculty** representative of the student's several fields of study and research; **one (1) 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 requesting that they consider serving on his Advisory Committee. The student will then personally interview each prospective committee member to determine whether he will accept the assignment.

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 degree program and a research problem which when completed, as indicated by the dissertation (or its equivalent for the degree of Doctor of Environmental Design), will constitute the basic requirements for the degree. **The student's degree program must be submitted to the Graduate College prior to the third semester's registration.** The degree program will be submitted on standard forms for the approval of the Dean of the Graduate College, who will, at the time of approval, appoint a representative of the Graduate Council to the student's Advisory Committee. A field of study may be chiefly in one department or may be in a combination of departments.

TRANSFER OF CREDIT

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 equivalent is not transferable. Texas A&M University does not normally accept for transfer credit course work taken at colleges and universities of foreign countries.

LANGUAGES

All students are required to possess a competent command of English. Effective September 1, 1972, the doctoral (Ph.D.) foreign language requirement at Texas A&M University was made a matter of departmental option, to be administered

and monitored by the individual departments of academic instruction. The chosen option or options of each department are indicated in this catalogue at the beginning of the section listing the course offerings of the individual departments.

EXAMINATIONS

The student's major department and his 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. To qualify for the Preliminary Examination, the student must have completed all but approximately six (6) hours of the formal course work on the Degree Program, excluding 684 (Professional Internship), 690 (Theory of Research), and 691 (Research). 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 his particular field, **unless he chooses to waive participation in the written examination.** If he does choose to waive participation in the written examination, this fact must be indicated on the announcement of the examination. Two (2) 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 continuation of the oral portion of the Preliminary Examination, or (2) to 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.

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 (2) weeks. If a departmental examination is utilized 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.

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

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

In case a student is required by his Advisory Committee to take, as a part of the written portion of a Preliminary Examination, an examination administered by a department, the following procedures must be observed by the department:

a. Offer the examination at least once every six (6) months. The departmental examination should be announced at least thirty (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 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 must also make recommendations regarding admission to candidacy.

After a student has passed the required preliminary oral and written examinations for the doctoral degree, he must complete all remaining requirements for the degree within three (3) calendar years, or he will be required to repeat the Preliminary Examination.

By permission of his Advisory Committee and the Dean of the Graduate College, a student who has failed in his Preliminary Examination may be given one re-examination, but only after a period of at least six (6) months has elapsed.

A student must be registered in any semester in which he 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 his Advisory Committee, and (3) completed the formal course work. The student must be admitted to candidacy at least seven (7) months before the time when the degree is expected to be received, but usually not before the completion of two (2) full years of graduate work.

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 resident staff of the Texas A&M University System above the rank of Assistant Professor, or its equivalent, will not be granted the doctoral degree at this institution. They may, however, enroll for graduate work.
2. Members of the faculty and staff of Texas A&M University will not be granted a graduate degree by Texas A&M University after receiving tenure at this institution.
3. Item 2, above, does not apply to those members of the faculty and staff who gained admission to the Graduate College of Texas A&M University and enrolled in course work leading to a graduate degree prior to January 1, 1972.

DISSERTATION

The general field of research to be used for the dissertation should be agreed on by the student and his 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 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. 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. Suggestions as to form should be obtained from the office of the Graduate College.

By dates announced each semester the candidate must submit to the office of the Theses/Dissertations Clerk of the Graduate College (Room 248, University Library) three (3) 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 600 words and a vita page are included in the dissertation. Two (2) 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 of $25.00. This fund is used to film doctoral dissertations in cooperation with University Microfilms.

APPLICATION FOR DEGREE

Formal application for the degree must be filed in the office of the Dean of the Graduate College not later than ninety (90) days prior to the end of the semester, or thirty (30) days prior to the end of the summer term in which the student expects to complete his 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, or for either term of the summer session at the end of which the degree is to be conferred.

FINAL EXAMINATION

The candidate for the doctoral degree must pass a final examination not less than two (2) weeks before the date on which the degree is to be conferred. Three (3) copies of the dissertation in final form signed by the department head and members of the student's Advisory Committee, with the exception of the Graduate Council Representative, must be submitted to the Graduate College, together with the announcement for the final examination, 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 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. The final examination will be open to members of the Graduate Faculty only. The Advisory Committee will submit its recommendations to the Dean of the Graduate College regarding acceptability of the candidate for the doctoral degree.

THE DEGREE OF DOCTOR OF EDUCATION

The Doctor of Education program is designed to offer opportunity for advanced study and research to persons who have demonstrated superior scholarship and

a promise of leadership in professional education. The final basis for granting the degree shall be the candidate's grasp of the subject matter of a broad field of study and his demonstrated ability to do independent research. At present this program is available in the fields of Adult and Extension Education, Industrial Education, and Vocational Education.

Program of Study. After his acceptance as an applicant for the Doctor of Education degree, a student's tests and record of work during the first session of residence will be used by the student and his Advisory Committee as a partial basis for planning and developing his doctoral program.

Statistics. A student must demonstrate competence in statistics and educational research procedures.

Educational Experience. Ordinarily, the student must have had a period of teaching experience deemed sufficient in amount and quality in the opinion of his Advisory Committee to warrant his continuing toward a doctorate.

The announcement for the final examination must be submitted to the Graduate College at least two (2) weeks in advance of the scheduled date. Except as noted above, the requirements for the degree of Doctor of Education are identical with those for the degree of Doctor of Philosophy.

THE DEGREE OF DOCTOR OF ENVIRONMENTAL DESIGN

The Doctor of Environmental Design program is intended to provide the candidate with academic and research competence of the highest order in the professions of architecture, landscape architecture, or urban and regional planning.

Students entering the D.E.D. program must complete ninety-six (96) semester hours of approved graduate study beyond the baccalaureate degree. In addition, the candidate must exercise his option and complete one of the three following assignments to demonstrate professional competence:

A. A written dissertation 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.

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 committee, for selecting his own degree program. Courses will be selected from current, approved interdisciplinary listings.

Admission Requirements. In addition to the normal admission requirements of the Graduate College, each applicant must submit the following to the College of Architecture and Environmental Design:

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.

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

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 4 weeks prior to registration (3-4 months prior to registration for foreign students; use foreign student application)
2. Familiarize yourself with general regulations and doctoral degree sections of catalogue		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 Degree Program	ADCom / Dean	Prior to Preliminary Examination (see catalogue for specific details)
6. Arrange Preliminary Examination	ADCom / Dean	At least 7 months prior to expected graduation date
7. Submit Dissertation Proposal	ADCom / Dean	At least 7 months prior to expected graduation date
8. Request ADCom to recommend admission to Candidacy; completion of 5, 6, and 7 above required	ADCom / Dean	At least 7 months prior to expected graduation date
9. Prepare rough draft of Dissertation	ADCom	
10. Apply for degree	Dean	During final semester; see Graduate College Calendar for deadlines
11. Submit 3 approved copies of Dissertation and 2 extra copies of Dissertation Abstract and announcement for final examination	ADCom, DH & Dean	At least 2 weeks prior to final examination (see catalogue for specific details)
12. Arrange for cap, gown, and hood at Exchange Store		See deadline in Graduate College Calendar.

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 ninety (90) days prior to the end of the semester or thirty (30) days prior to the end of the summer term in which the student expects to have the degree conferred.

Each candidate for a degree must attend the commencement exercises in appropriate academic regalia unless a petition to be excused, signed by the Chairman of the student's Advisory Committee and the Head of the student's major department, is approved by the Dean of the Graduate College. The petition should be submitted at least thirty (30) days prior to commencement.

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 or dissertation, 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. Acknowledgment should be given in the publication that the work is in partial fulfillment of graduate degree requiremnts.

FINANCIAL ASSISTANCE

Assistantships, both teaching and nonteaching, which require one-half time service are available to qualified students. An appointment to the latter is normally for nine (9) months, whereas the appointment to a teaching assistantship may vary from nine (9) to twelve (12) months. Graduate Assistantships — Research are usually twelve (12) month appointments, although vacancies may be filled for shorter periods.

A course load of nine (9) to twelve (12) credit hours of academic work per semester and four (4) per summer term are normally required of graduate assistants.

The stipend for all assistantships is competitive with that paid by most other institutions. Stipends are paid in monthly installments.

A limited number of Graduate College 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 Graduate College Fellow may be required to spend up to one-fourth time on **relevant teaching activities** during one semester only (or during one 12-week summer session) during a 12-month period. Since Graduate College Fellowships normally permit full-time study and research, the holder of such a grant will be expected to register for twelve (12) to sixteen (16) credit hours per semester and six (6) hours per six-week summer term.

Texas A&M University also offers approved fellowships or traineeships under the NDEA Title IV Program; the National Science Foundation Regular Traineeship programs; and traineeships in Nuclear Science and Engineering sponsored by the AEC. Additional fellowships sponsored by individuals, industrial corporations,

and private foundations are available in certain departments. In addition to the basic stipend, many of these fellowships provide dependency allowances, tuition and fees and other expenses.

Applications for all assistantships and fellowships, together with transcripts, letters of recommendation, and Graduate Record Examination scores, should be filed with the Dean of the Graduate College on or before March 1 preceding the academic year for which awards are to be made.

Forms for making application for assistantships and fellowships are available in the office of the Graduate College. Information regarding assistantships and fellowships may be obtained by writing directly to the head of the department concerned.

LIBRARY FACILITIES

UNIVERSITY LIBRARY

The university's principal research collections, numbering in excess of 760,000 volumes, are housed in a new, centrally located facility providing seating for 2,000 readers and an ultimate shelving capacity of 1,000,000 volumes. The upper two floors have perimeter carrels and lockers for assignment to graduate students. There are, in addition, approximately 150 closed studies for use by faculty members engaged in research requiring extensive or constant use of library materials.

The general collections are organized for use on the subject division plan with a basic collection (first floor), documents division (second floor), humanities and social sciences division (third floor), and science and technology division (fourth floor). Reference assistance pertinent to the subject matter is available in each of these areas, and a general reference desk is maintained in the basic collection.

An "open stack" arrangement allows free access to all materials except those in the special collections area. Tables are interspersed among shelving to provide convenient study space in all areas.

Approximately 13,000 serials titles are received currently as well as some 180 state, national and foreign newspapers. The library is also a depository for selected federal documents. Deposits also are maintained for the unclassified reports of the Atomic Energy Commission and the National Aeronautics and Space Administration.

With the exception of periodicals, government documents, and certain books temporarily reserved by departments for reference or required reading, most books are loaned for a period of one month. Periodicals do not circulate.

The library is a member of the Center for Research Libraries, so that faculty and students may have access to the Center's approximately 3 million volumes of research materials.

SPECIAL COLLECTIONS

These collections, housed on the third floor, consist of several thousand rare books concerning many and varied disciplines. The Jeff Dykes Range Livestock Collection, one of the outstanding collections in the nation, forms an important part of these collections. The Dykes Collection consists of more than 5,000 items available for research upon every aspect of the range livestock industry. The emphasis is somewhat heavier on the industry in the United States west of the Mississippi River, but one finds items dealing with the subject on a worldwide basis.

UNIVERSITY ARCHIVES

This section, located on the third floor, includes inactive records of the University and its various colleges, subdivisions, and departments, as well as manuscript collections of individuals, organizations, and companies.

VETERINARY BRANCH

This branch is located in the Veterinary Medicine Building and is primarily a reference library with over 20,000 volumes. The library subscribes to approximately 450 American and foreign periodicals and receives pertinent publications from other colleges and experiment stations.

OTHER LIBRARIES

Many departments maintain working collections of books and periodicals for use within the departments. Some of the collections are fairly large and well organized; others are small but well chosen. Use of these libraries is controlled by the departments concerned.

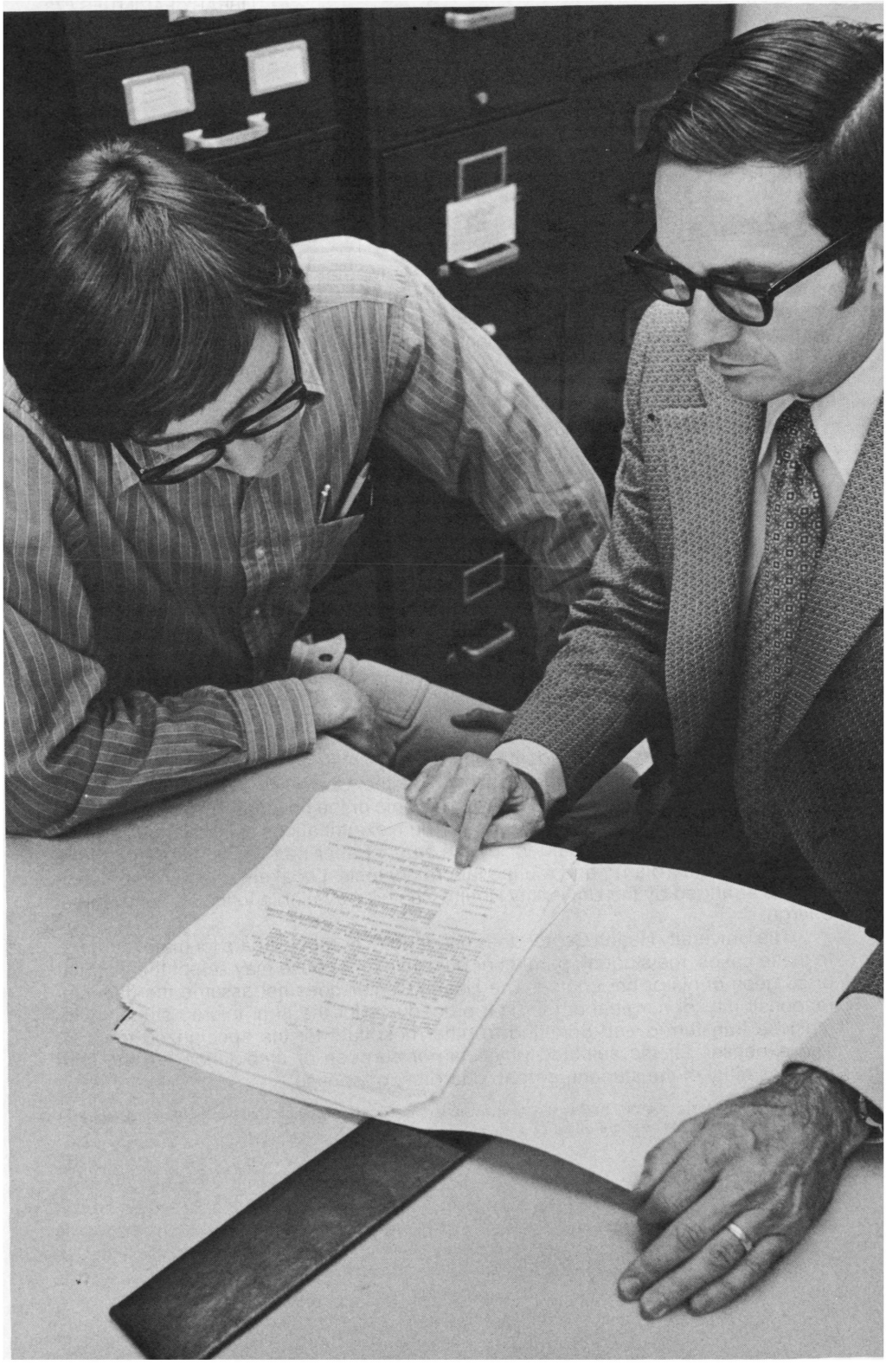
THE UNIVERSITY HEALTH CENTER

The University Health Center provides a modern clinic for out-patient services and bed-space for 42 in-patients. The facilities of the clinic include physiotherapy, a modern laboratory, x-ray and diagnostic departments. The medical staff includes not only general practioners, but also specialists in medicine; surgery; ear, nose and throat; orthopedics; urology; gynecology; psychiatry and clinical psychology.

The student service fee includes non-restricted clinic visits, diagnostic examinations, care of illnesses or accidents, and ten days of treatment(s) for each semester for the cases that require hospitalization at the University, routine medications (medications which are not available at the clinic or the hospital must be purchased by the student), x-rays (not included are barium examinations or intravenous studies with dyes, which must be paid for by the student after permission is granted from the parent or guardian)*, and routine laboratory tests. Local emergency ambulance service arranged by the University Health Center is available to the student without charge.

The University Health Center does not perform or provide care for major surgery. In these cases, the student, parents or guardian, or spouse may select the hospital or surgeon of his or her choice. The Health Center does not assume the financial responsibility for surgical or medical procedures for the ill or injured student who must be transferred and admitted to other hospitals for the specialized therapy. The expenses for the selected physician or surgeon or ambulance are the sole responsibility of the student, parent, guardian, or spouse.

*These specific tests are not performed at the University Health Services, but are scheduled either at the hospitals in Bryan or at the office of a qualified radiologist.



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 eighteen weeks.

Roman numerals to the right of the credit value of each course 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 the offering of the course.

DEPARTMENT OF ACCOUNTING

E. D. Bennett, L. L. Bravenec, P. W. Ljungdahl, W. S. Manning, K. S. Most (Head)*

The graduate courses in the Department of Accounting provide further study facilities for those preparing to work in public accounting and as accountants in government and business. They also include courses suitable for those preparing for teaching careers, particularly at college level. A graduate program consisting of 36 hours of course work, and including work in related fields such as computer science, management, and economics, leads to the M.B.A. degree with a major in accounting. It is possible for a graduate student to complete the requirements for the degrees of M.S. and Ph.D. with a major field in accounting.

The bachelor's degree in accounting is the normal requirement for admission to graduate courses in accounting, but the holder of a degree obtained in some other field can take preparatory courses in accounting at the graduate level, representing 6-9 credit hours of additional work, to qualify for admission.

(Acct.)

602. Business Combinations and Accounting Measurements. (3-0). Credit II, S Accounting treatments for business combinations are investigated together with the reporting practices followed by conglomerate companies. Accounting for intangible assets and for employee pension and stock option plans. Students will examine Security and Exchange

*Graduate Advisor

Commission decisions, corporation annual reports and stock exchange listing statements and develop case studies during the term. Prerequisite: Acct. 641 or equivalent.

612. Advanced Taxes. (3-0). Credit 3. II, S Study of special income tax problems of taxpayers; Federal estate and gift taxes; Texas inheritance tax; Texas franchise tax on corporations; claims for refund of taxes.

616. Institutional Accounting. (3-0). Credit 3. I, S Study of 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. I, S 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. II, S Intensive examination of financial accounting. Emphasis upon conceptual aspects obtained through the problem approach. Prerequisites: Graduate classification and Acct. 640 or equivalent.

649. Managerial Accounting. (3-0). Credit 3. I, S Cost accounting concepts and utilization of accounting data in planning and control of operations. Prerequisites: Acct. 640 or equivalent.

651. Development of Accounting Thought. (3-0). Credit 3. II Inquiry into criteria for choices among income-determination and asset-valuation rules in context of public reporting. Prerequisite: Acct. 641 or approval of instructor.

661. Interdisciplinary Interface of Accounting Thought. (3-0). Credit 3. II Implications for accounting thought of recent developments in selected disciplines, such as economics, communication theory, behavioral sciences and law. Prerequisite: Acct. 651.

671. Contemporary Accounting Topics. (3-0). Credit 3. I, II Current issues and research in topical areas: financial data audit and control; international accounting; 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. I, S In depth investigation of some primary aspects of managerial accounting needs including planning, internal control, cash and inventroy management, data systems and analysis, and mergers and acquisitions. Prerequisite: Acct. 649 or equivalent.

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

685. Problems. Credit 1 to 3 each semester. I, II, S 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. II 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.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

DEPARTMENT OF AEROSPACE ENGINEERING

L. A. Carlson, A. E. Cronk (Head)*, W. E. Haisler, W. P. Jones, W. B. Ledbetter, S. H. Lowy, D. J. Norton, J. L. Rand, B. M. Rao, C. A. Rodenberger, C. H. Samson, Jr., R. A. Schapery, J. A. Stricklin, R. S. Wick

The Department of Aerospace Engineering offers graduate work as preparation for research careers or as more complete training in the engineering practices. Programs leading to the degrees of M.Engr., M.S. and Ph.D. are offered. There

*Graduate Advisor

are no foreign language requirements in these programs. Major areas of interest are aerodynamics, structural analysis and propulsion.

Wind-tunnels provide equipment for aerodynamic research in fundamental fluid flow problems or in three-dimensional testing of complete airplane models. Investigations of structural problems are undertaken in well equipped structures laboratories.

(Aero.)

601. Principles of Fluid Motion. (4-0). Credit 4. I Mathematical methods of analysis are emphasized. Perfect fluid theory development. Introduction to unsteady aerodynamics. Prerequisite: Aero. 303.

603. Aerodynamics of the Airplane. (4-0). Credit 4. II Application of vector analysis to two and three dimensional airfoil theory; viscosity and compressibility; drag of aircraft components; static and dynamic stability criteria. Prerequisite: Aero. 303.

604. Compressible Flow. (3-0). Credit 3. I Interfering flow fields in supersonic flows, shock wave boundary layer interactions, control surfaces in supersonic flow. Prerequisite: Aero. 472 or approval of instructor.

606. Space Propulsion. (3-0). Credit 3. II Analysis of propulsion systems. High temperature flow and electrical fields including equilibrium and non-equilibrium chemistry. Applications to current propulsion devices. Prerequisite: Aero 604; or approval of instructor.

607. Hypersonic Aerodynamics. (3-0). Credit 3. II Analysis of very high speed flows, including second-order small disturbance theory, Newtonian theory, numerical computation schemes for blunt body flows. Prerequisite: Aero. 472 or approval of instructor.

608. Aircraft Flutter Analysis. (4-0). Credit 4. II 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.

610. Nuclear Rocket Propulsion. (3-0). Credit 3. II Basic rocket performance, system analysis, heat transfer and fluid flow, materials, nucleonics, system and component testing. Prerequisites: Aero. 417; N.E. 601.

612. Space Technology II. (3-0). Credit 3. II Satellite launch trajectories, oblate effects and precession, lunar trajectories, interplanetary operations and orbit transfers, satellite recovery and re-entry. Prerequisite: Aero. 423.

620. Unsteady Aerodynamics. (3-0). Credit 3. II Introduction to unsteady airfoil theory and discussion of techniques used for determining airloads and airload distributions on oscillating lift surfaces, e.g. aircraft wings and tailplanes. Treatment of problems of unsteady incompressible, subsonic, transonic and supersonic flows in two and three dimensions. Exact solutions and various approximations for particular cases will be given. Prerequisites: Aero. 601, Math. 602 or registration therein.

631. Nonequilibrium Flows. (3-0). Credit 3. I Analysis of nonequilibrium flow fields in rocket and wind tunnel nozzles and behind shock waves studied by introducing reaction rate equations into the fundamental aerodynamic relation. Prerequisite: Aero. 435 or approval of instructor.

632. Structural Design of Missiles and Spacecraft. (3-0). Credit 3. II Flight loads; environment; heat transfer and thermal stresses; materials and material behavior; pressure-stabilized structures; aeroelastic effects and dynamic loads; structural fatigue; reliability. Prerequisite: Graduate classification.

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

677. Rarefied Gas Dynamics. (3-0). Credit 3. II Analysis of phenomena occurring in low density flows emphasizing slip regime problems and solutions based on second-order solutions to the Boltzmann equation. Prerequisite: Aero. 477 or approval of instructor.

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

691. Research. Credit 1 or more each semester. I, II, S Technical research projects approved by Department Head.

(The Aerospace Engineering courses in applied mechanics such as elasticity, plasticity, continuum mechanics, etc., are listed under the section entitled Mechanics and Materials under Interdisciplinary Engineering.)

DEPARTMENT OF AGRICULTURAL ECONOMICS

W. G. Adkins, P. J. Barry, R. V. Billingsley, R. E. Branson, R. A. Dietrich, V. W. Edmondson, D. E. Farris, R. J. Freund, C. R. Harston, H. O. Hartley, J. A. Hopkin (Head), L. L. Jones, R. Kay, R. D. Lacewell, C. F. Lard, J. G. McNeely, J. R. Martin, D. S. Moore, J. Nichols, C. E. Shafer, H. B. Sorensen, T. L. Sporleder, R. Stelly, T. R. Timm, W. L. Trock, E. Uvacek, W. J. Vastine, A. B. Wooten*

The objective of the Department of Agricultural Economics Program 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, irrespective of his 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 he is expected to acquire a knowledge of economic theory, and 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 his thesis or dissertation research.

The M.S. degree requires a thesis and is oriented to the basic professional requirements. The Master of Agriculture offers a selection among 5 programs oriented to employment by agri-business firms, agencies or organizations. The Ph.D. programs concentrate on the theory, quantitative tools and methodology required of the professional agricultural economist.

No foreign language requirement is stipulated for students pursuing Ph.D. programs in Agricultural Economics. However, a student's Advisory Committee may prescribe a level of foreign language proficiency if such is considered necessary for the student to effectively pursue his Ph.D. dissertation.

(Ag. Ec.)

602. Agricultural Market Organization and Structure. (3-0). Credit 3. I Analysis of the 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: Ag.Ec. 314.

*Graduate Advisor

603. Land Economics. (3-0). Credit 3. II Study of selected problems of allocation and utilization of natural resources with special reference to government organizations, quasi-government bodies, and other interest groups. Prerequisite: Ag.Ec. 422 or approval of Department Head.

604. Economics of Natural Resources Development. (3-0). Credit 3. I Critical evaluation of policies and procedures in natural resource development and use. Emphasis given to the identification of problems in resource development, the political-economic decision-making processes, and analytical tools which can contribute to economic decisions. Prerequisite: Econ. 323 or equivalent.

607. Research Methodology. (3-0). Credit 3. I Scientific approach; role of theory and assumptions, bias and prejudice; attributes of problems; methods and tools of agricultural economics and sociology research. Student evaluates research studies and develops thesis prospectus or equivalent. Prerequisite: Approval of Department Head.

611. Production Economics — Static. (3-0). Credit 3. I Economic principles for analyzing agricultural production and resource use; problems are treated regarding the technical unit, the firm and society emphasizing conditions for efficiency. Prerequisite: Approval of Department Head.

613. Contemporary Thought in Agricultural Economics. (3-0). Credit 3. I Study of contemporary contributions to the thought and analysis of aggregate relationships and problems in the agricultural economy. Prerequisite: Approval of Department Head.

614. Agricultural Policy. (3-0). Credit 3. I Analysis of public policies and programs affecting agriculture. Development of policies and programs for agriculture and their bases. Prerequisite: Ag.Ec. 429 or approval of Department Head.

617. Market Development Research Theory. (3-0). Credit 3. II Analysis of the 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 are examined. Considerable emphasis on market development technical research methods and operations. Prerequisite: Approval of Department Head.

619. Farm and Ranch Business. (2-2). Credit 3. I Interrelationship of factors affecting profits in farming and ranching. Organization and management of actual farm and ranch businesses. Relation of theory and practice in farming and ranching. Prerequisite: Approval of Department Head.

620. Capital Market in Agriculture. (3-0). Credit 3. S Role of capital in economic growth, and structure of the capital market for agriculture. Determinants of aggregate capital supply. Prerequisites: Ag.Ec. 430 or approval of Department Head.

627. Agricultural Market and Price Analysis. (3-0). Credit 3. I 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; B.Ana. 303.

629. Public Administration in Agriculture. (3-0). Credit 3. S Study of 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. Prerequisite: Approval of Department Head.

630. Financial Planning of the Farm Firm. (3-0). Credit 3. II 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. Prerequisites: Ag.Ec. 325; Econ. 203; or approval of instructor.

632. Production Economics — Dynamic. (3-0). Credit 3. II Proceeding from static partial equilibrium analysis into dynamic theories of production economics. Study in depth of decision-making process. Consideration of risk, uncertainty, farmer life cycles, and goals other than profit maximizing. Exploring interdisciplinary approaches in study of decision-making. Prerequisite: Ag.Ec. 611.

633. Economics of Underdeveloped Agricultural Areas. (3-0). Credit 3. S Function of agriculture in economic growth. Agricultural productivity as influenced by an economy's

physical, cultural, and institutional attributes. Economic problems of underdeveloped areas. Prerequisite: Approval of Department Head.

634. Operations Research in Agriculture. (3-0). Credit 3. II 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 graduate students in the College of Agriculture other than in agricultural economics. Prerequisites: Six hours of mathematics or statistics; 15 hours of advanced technical agriculture.

641. Operations Research Methods in Agricultural Economics. (2-2). Credit 3. II Planning statistical research project: developing forms; selecting sample; conducting study; tabulating, analyzing and interpreting the data. Prerequisites: B.Ana. 303 or Stat. 406 or equivalent; 15 hours of social science; approval of Department Head.

655. Agricultural Marketing Operations. (3-0). Credit 3. I Examining concept of commodity system: the structure and performance of; forces of change affecting; responses of marketeers to change within. Primarily emphasizing practical management: analysis, planning, organization and control. Prerequisites: Ag.Ec. 314, Econ. 203, or equivalent.

681. Seminar. (1-0). Credit 1 each semester. I, II, S 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. I, II, S A work-study course for Master of Agriculture program in Agricultural Economics. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of a selected problem in the field of agricultural economics. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Initiation and completion of a research project of approved scope for an advanced degree. Prerequisite: Approval of Department Head.

DEPARTMENT OF AGRICULTURAL EDUCATION

H. D. Brown, J. E. Christiansen, D. E. Herring, J. W. Holcomb, O. M. Holt, E. H. Knebel (Head)*, E. S. Webb*

Advanced study in agricultural education provides an opportunity for teachers of vocational agriculture to improve their efficiency as master teachers. Agricultural extension personnel and other professional workers in colleges, business, industry, and developing countries may also improve themselves through selected courses designed to meet the needs of professional persons in building programs for implementing changes. 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 should have at least one year of successful professional experience. However, evidence of maturity, purposefulness and scholastic ability may be considered in lieu of experience upon the approval of the Agricultural Education faculty and the Head of the Department.

*Graduate Advisor

The staff of the Department of Agricultural Education maintains close and continuous contact with teachers and agricultural extension service workers in the field by visiting departments of vocational agriculture and county offices of agricultural extension agents, by attending professional meetings, by assisting with in-service training, and by conducting off-campus classes of instruction. This intimate and continuous contact enables the staff to conduct its graduate programs with understanding and appreciation of the relative importance of the many complex problems and difficulties that professional agricultural workers encounter in their work.

(Ag.Ed.)

601. Advanced Methods in Agricultural Education. (3-0). Credit 3. I 1973; S 1974; II 1975 Advanced course in methods of teaching. Prerequisite: Professional experience or approval of Department Head.

605. Supervision of Occupational Experience Programs in Agriculture. (3-0). Credit 3. S 1973; I 1974 Advanced study of 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. I, II, S 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. I, II, S Identification of the basic principles that motivate adults to learn. Procedures are examined that are purported to implement these principles in bringing about changes in adult behavior. Prerequisite: Professional experience or approval of Department Head.

613. Administration and Supervision of Agricultural Education. (3-0). Credit 3. I, S Problems of organization, administration, financing, and supervision of vocational agriculture and extension work. Prerequisite: Professional experience or approval of Department Head.

615. Philosophy of Agricultural Education. (3-0). Credit 3. II, S Study of philosophy and evaluation of education in agriculture. Emphasis on development and use of evaluative criteria. Prerequisite: Professional experience or approval of Department Head.

616. Program Building in Agricultural Education. (3-0). Credit 3. II, S Organization of educational programs in agriculture on local, state, and national basis. Prerequisite: Professional experience or approval of Department Head.

619. Workshop in Agricultural Education. Credit 1 to 3. I, II, S Offered for three or six weeks or full semester to study selected problems in agricultural or extension education. Consultants are utilized in specialized areas. Prerequisite: Professional experience or approval of Department Head.

630. Guidance and Counseling for Rural Youth. (3-0). Credit 3. II, S Analysis of occupational and vocational opportunities of rural youth; techniques of individual group counseling in guidance. Practicum in personality and occupational interest testing. Prerequisite: Approval of Department Head.

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

681. Seminar. (1-0). Credit 1 each semester. I, II,S Group study and discussion of current developments in agricultural education. Special emphasis given to 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. I, II, S 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. I, II, S Studies related to classroom, laboratory, supervised farming, work experience, extension education, adult educational activities in agricultural programs. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Initiation and completion of research for advanced degree. Prerequisite: Approval of Department Head.

DEPARTMENT OF AGRICULTURAL ENGINEERING

I. L. Berry, E. A. Hiler, P. Hobgood (Head), J. P. Hollingsworth, E. B. Hudspeth, O. R. Kunze*, D. L. Reddell, J. W. Sorenson, B. R. Stewart, R. E. Stewart*, L. H. Wilkes

The Department of Agricultural Engineering offers graduate studies leading to the degrees of Master of Science, Master of Engineering, and Doctor of Philosophy. The department does not have a Ph.D. foreign language requirement. Depth of study and specialization may be elected in certain special fields such as machinery, product processing, structures, soil and water, food technology, animal environment, and forest engineering (in cooperation with 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 physical science or engineering.

Excellent facilities for research are available, including modern buildings, apparatus, technical support, and field plots.

(Ag.En.)

601. Research Instrumentation. (3-0). Credit 3. I Analysis of research techniques, scientific method, and design of experiments. Study of automatic control systems with special reference to living systems subjected to environmental stress, and the instrumental techniques for measurement of such interaction. Prerequisite: Approval of Department Head.

602. Irrigation and Drainage. (3-0). Credit 3. II 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. Prerequisite: Approval of Department Head.

603. Agricultural Machinery. (3-0). Credit 3. I (1973 and alternate years thereafter.) Functional farm machinery design. Encompasses analysis of problem need, functional requirements, common materials used, design, testing,and production of efficient operational units. Prerequisite: Approval of Department Head.

605. Agricultural Structures. (3-0). Credit 3. I (1972 and alternate years thereafter.) Structural, environmental, and economic problems encountered in agricultural buildings. Special emphasis on design considerations for structural materials. Research methods and procedures as applied to agricultural structures. Prerequisite: Approval of Department Head.

606. Agricultural Process Engineering. (3-0). Credit 3. II (1972 and alternate years thereafter.) Engineering principles involved in mechanical handling, cleaning and sort-

*Graduate Advisor

ing, size reduction, conditioning and storage of agricultural products. Includes use of refrigeration, electric energy, and radiation. Prerequisite: Approval of Department Head.

609. Farm Power. (3-0). Credit 3. II (1973 and alternate years thereafter.) Theory and principles of operation as applied to internal combustion engines used for agriculture. Emphasis given to application and functional design requirements and testing procedures. Prerequisite: Approval of Department Head.

613. Small Watershed Hydrology. (3-0). Credit 3. I Hydrology of agricultural watersheds, with emphasis on soil and water conservation, precipitation frequency analysis, infiltration, ground water, runoff, erosion theory, sediment transport theory, evapotranspiration, reduction of water losses, and experimental techniques. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1 each semester. I, II Reviews, reports, and discussion of ideas, recent advances and current topics. Prerequisite: Graduate classification.

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

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

ANIMAL BREEDING

A major in animal breeding may be undertaken by selecting appropriate courses in genetics and in animal science, dairy science, or poultry science. For more information, see listing under Genetics.

ANIMAL NUTRITION

Advanced studies may be undertaken in the Departments of Animal Science, Poultry Science or Biochemistry and Biophysics with a major in animal nutrition. Students entering this program should have adequate preparation in general biology or zoology, mathematics, chemistry, and physics. Deficiencies in the above areas may be corrected during the first year of graduate study.

Candidates for degrees in animal nutrition may acquire advanced training in nutrition, biochemistry, mathematics, physiology, pathology, statistics, chemistry, physics and other pertinent areas in science and technology. At least one listed area other than nutrition should be selected as a minor subject and be emphasized in the degree program.

Various classes of animals, animal facilities, laboratories, and modern research equipment are available for use in research in most areas of ruminant and nonruminant nutrition.

DEPARTMENT OF ANIMAL SCIENCE

J. W. Bassett*, O. D. Butler, Jr. (Head)*, M. C. Calhoun, Z. L. Carpenter*, T. C. Cartwright*, B. F. Cobb, B. M. Colvin, C. W. Dill, W. C. Ellis*, H. A. Fitzhugh, Jr.*, J. L. Fleeger*, J. H. Hesby*, N. M. Kieffer*, G. T. King*, H. O. Kunkel, W. A. Landmann*, Gary T. Lane*, R. E. Leighton*, F. A. Orts, L. S. Pope, H. E. Randolph, J. K. Riggs*, L. M. Schake*, G. C. Smith*, A. M. Sorensen, Jr.*, T. D. Tanksley, Jr.*, W. B. Thomas, C. Vanderzant*, D. F. Weseli*

Advanced study in animal science prepares the graduate 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 Nutrition	(M.S. and Ph.D.)
Dairy Manufacturing	(M.S., M.Agr., and Ph.D.)
Dairy Production	(M.S., M.Agr., and Ph.D.)
Food Technology	(M.S. and Ph.D.)
Livestock Production	(M.S. and M.Agr.)
Meat Science	(M.S., M.Agr., and Ph.D.)
Physiology of Reproduction	(M.S., M.Agr., 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. Special equipment available in these laboratories or in readily available facilities, such as at the large Data Processing Center, offer a wide array of opportunities for study and research.

Dairy, beef 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.

Minors or joint majors in such areas as biochemistry and biophysics, economics, genetics and statistics may be readily arranged.

There is no specific foreign language for the Doctor of Philosophy degree. A student's Advisory Committee may require a foreign language or additional course work in an unrelated area beyond the minimum 96 hours required for the Ph.D. degree.

ANIMAL SCIENCE

(An. Sc.)

602. Protein and Energy Nutrition. (3-0). Credit 3. I Study of transformation of dietary protein and energy by homeotherms to provide for organisms nutritive requirements for protein and energy in health and production. Physical, physiological, and biochemical aspects and their application in practice emphasized. Prerequisites: An.Sc. 444; Bi.Ch. 410.

*Graduate Advisor

603. Experimental Nutrition. (1-6). Credit 3. I Laboratory experiments designed to familiarize the student with basic and specialized research techniques, their limitations and applications. Prerequisite: An.Sc. 602, or approval of Department Head.

604. Ruminant Nutrition. (3-0). Credit 3. II Survey of current knowledge and concepts in ruminant physiology and biochemistry, their literature and experimental basis and relation to current and future nutrition practice and investigation. Basis, applications, and limitations of methods and techniques in ruminant nutrition research. Prerequisite: An.Sc. 444, Bi.Ch. 410 or 603 and/or approval of Department Head.

605. Advancements in Beef Cattle Production. (3-0). Credit 3. I, S 1973 Survey of current knowledge and concepts in beef production; the literature, scientific basis and relation to future production practices and investigation. Economic considerations and current production problems of breeding herd operations. Prerequisites: An.Sc. 305, 306 and 406 or approval of Department Head.

606. Advancements in Beef Cattle Production. (3-0). Credit 3. II, S, 1973 Continuation of An.Sc. 605 except emphasis is placed on problems of growing, backgrounding and finishing cattle for slaughter. Prerequisites: An.Sc. 309 and 406 or approval of Department Head.

607. Meat Science and Research Techniques. (2-2). Credit 3. I Emphasizes biochemical, histological, anatomical, and physical factors associated with transformation of muscle cell into meat. Prerequisite: Approval of Department Head.

608. Feedlot Management. (3-0). Credit 3. S Study of current knowledge in the management of commercial feedlots. Disciplines of nutrition, management, breeding, meats, herd health and sanitation will be discussed. Prerequisite: An.Sc. 406.

610. Behavior and Training of Domestic Animals. (2-2). Credit 3. I Study of behavior of domestic species important to agriculture. Review of current literature on normal behavioral patterns and the influence of behavior and training upon the utility of animals. Laboratory will emphasize research techniques.

616. Quantitative Genetics II. (3-0). Credit 3. II Study of theories and methods useful in quantitative genetics research, including estimation of genetic parameters and their precision; genetic discriminant functions; and experimental design and interpretation. Prerequisites: Gen. 613; Stat. 414, 608, 619.

619. Advancements in Sheep and Angora Goat Production. (3-0). Credit 3. I 1972, 1974; S 1973 Review of research relating to various phases of sheep and Angora goat enterprises. Evaluation of research; fitting sheep and Angora goats to whole farm and ranch system. Special attention to over-all economic operation. Prerequisites: An.Sc. 305, 306, 414; or approval of Department Head.

620. Advancements in Sheep and Angora Goat Production. (3-0). Credit 3. II Continuation of An.Sc. 619.

621. Advancements in Swine Production. (3-0). Credit 3. II 1973, 1975; S 1976 Review of research relating to various phases of pork production. Evaluation of research and application of basic principles to efficient management. Special attention to economic requirements and current production problems. Prerequisites: An.Sc. 305, 306, 412; or approval of Department Head.

622. Advancements in Swine Production. (3-0). Credit 3. II 1974, 1976; S 1973 Continuation of An.Sc. 621.

628. Animal Breeding. (2-2). Credit 3. II Basic concepts from Mendelian, population and quantitative genetics and their applications to the genetic improvement of animal productivity. Prequisites: An.Sc. 305, 306 or P.S. 414; Stat. 602.

631. Physiology of Reproduction. (2-2). Credit 3. II 1973; S 1974 Critique of scientific literature on reproduction. Students compile, evaluate, and summarize literature. Current topics are discussed and experimental surgery is conducted in area of reproduction. Prerequisite: An.Sc. 433.

633. Concepts in Reproduction. (3-0). Credit 3. S Research and concepts of reproduction which are directly related to more efficient production of livestock, such as estrous synchronization, sex control, early embryonic mortality, superovulation, and puberty. Prerequisite: An.Sc. 433 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 will be emphasized.

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; major 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 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. Registration by 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 1972,1974 Advanced study of dairy production, feeding, breeding, and management. Prerequisite: D.S. 418.

602. Dairy Production. (2-6). Credit 4 each semester. II 1973, 1975 Continuation of D.S. 601.

605. Chemistry of Foods. (2-3). Credit 3. I 1972, 1974 Advanced study of chemistry of dairy foods and meats relating to their composition and characteristic properties important to their subsequent manufacture into food products. Prerequisite: Bi.Ch. 410 or 603.

606. Microbiology of Foods. (2-3). Credit 3. II Nature and fuction of beneficial and defect-producing bacteria in dairy products, meats, and related foods. Effects of processing, storage, and distribution. Techniques for isolation and identification from foods. Prerequisite: D.S. 326 or approval of Department Head.

608. Seafood Preservation and Processing. (3-2). Credit 4. S 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.

684. Professional Internship. Credit 1 to 4. I, II, S Application of formal training in a commercial operation under supervision of operation manager and designated faculty member. Data will be collected on an investigation of a matter of mutual interest to 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 Study of research methods and review of scientific literature dealing with individually selected problems in production or manufacturing and not pertaining to thesis or dissertation.

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.

DEPARTMENT OF ARCHITECTURE*

C. D. Claycamp, W. W. Harper (Head), C. M. Hix, G. J. Mann, J. H. Marsh, E. J. Romieniec, M. M. Rotsch, W. C. Steward, F. J. Trost, R. E. Vrooman, E. D. Watkins, D. G. Woodcock

*All members of Graduate Faculty listed serve as Graduate Advisors.

The Department of Architecture offers five 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 a program option, based on their academic and professional objectives, from the following: Building Design, Construction Management, Interior Space Design, Systems Development and Urban Design. In addition, the Department provides major coursework and advisory support for those candidates for the degree of Doctor of Environmental Design whose descriptive emphasis is in Architecture.

(Arch.)

601. Environmental Design. (3-9). Credit 6. I, S Advanced course centered on design problems for development of man-made urban environment to meet man's needs. Gives student opportunity to study his design specialization (e.g., architectural design, landscape design, urban design, construction, etc.) in depth and in complexity of environmental problems. Prerequisite: Approval of Department Head.

602. Environmental Design. (3-9). Credit 6. II, S Continuation of Arch. 601. Terminal semester design project of major significance and complexity for the development of the human environment to meet man's need. Prerequisite: Approval of Department Head.

605. Building Design I. (2-4). Credit 3. I Theory and application of architectural programming and design processes using small scale architectural projects as case studies. Interrelated with Arch. 631 and 633. Design experience includes derivation and manipulation of material; structural, mechanical, electrical, external and internal aspects in response to user-owner; site and climatic requirements. Prerequisite: Approval of Department Head.

606. Building Design II. (2-4). Credit 3. I, II, S Aspects of design development, construction planning and scheduling and client communication. Prerequisites: Arch. 605 or approval of Department Head.

607. Building Design III. (3-9). Credit 6. II, S Development of comprehensive professional solutions to contemporary building problems. Practice in architectural services such as program definition, feasibility studies, cost estimating, schematic design and communication, interaction with the client and user, materials selection, design development, production scheduling and construction documentation. Prerequisites: Arch. 606 or approval of Department Head.

608. Building Design IV. (3-9). Credit 6. I, S Individual and team projects assignments will continue from Arch. 607 into Arch. 608. Prerequisites: Arch. 607 or approval of Department Head.

611. Architectural Design. (1-5). Credit 3. I, S Introductory course for non-architects in visual communication utilizing various graphic techniques, methods, and means of drawing and reproduction. Prerequisite: Approval of Department Head.

612. Architectural Design. (1-5). Credit 3. II, S Design course in architecture for engineers and others not having an architectural design background. Studio program will concern aesthetic, special, and general environmental consequences of physical design. Prerequisite: Approval of Department Head.

613. Urban Design I. (2-4). Credit 3. I Theory and application of urban programming and design process to problems of urban context, complexity and scale. Comparative evaluations will be made between traditional and emerging techniques. Prerequisite: Approval of Department Head.

614. Urban Design II. (2-4). Credit 3. I, II, S Explicit and implicit environmental problems in urban areas. Prerequisites: Approval of Department Head.

615. Urban Design III. (3-9). Credit 6. II, S Development of comprehensive professional solutions to contemporary urban problems with guidance and direction of professional consulting faculty. In context of team-structure problems, individual directions and specializations will have social, economic, political and physical emphases. Prerequisites: Arch. 613 or approval of Department Head.

616. Urban Design IV. (3-9). Credit 6. I, S Individual and team project assignments will continue from Arch. 615 into Arch. 616. Prerequisites: Arch. 615 or approval of Department Head.

617. Building Construction Practices I. (3-0). Credit 3. I, S Systems analysis of building construction practices emphasizing conventional building foundations and structures. Prerequisite: Approval of Department Head.

618. Building Construction Practices II. (3-0). Credit 3. II, S Systems approach to innovative construction of building structures. Prerequisites: Arch. 617 or approval of Department Head.

619. Building Construction Practices III. (3-0). Credit 3. I, S The role and relationship of professionals in building construction (architects, engineers, contractors); bidding and construction contract procedures; types of construction contracts and bonds; insurance requirements. Prerequisite: Arch. 618 or approval of Department Head.

620. Building Construction Practices IV. (3-0). Credit 3. II, S Theory and case studies of contracting operations from job initation to project review with special reference to organizational methods employed to control sub-contracts and contingency items. Prerequisite: Arch. 619 or approval of Department Head.

623. Design Methods I. (3-0). Credit 3. I Through program development on specific research projects, fundamental programming skills including PERT, CPM and others will be introduced. Prerequisite: Approval of Department Head.

624. Design Methods II. (3-0). Credit 3. II Actual application of programming techniques to on-going research and development work. Students will develop programs corresponding to assigned sections of an overall group project. Prerequisites: Arch. 623 or approval of Department Head.

625. Building Systems Development I. (3-9). Credit 6. S Total building systems design for various building types as specifically related to the modern technological capabilities of industry. Field trips to research and development organizations will illustrate on-going programs in industry. Prerequisites: Arch. 624 or approval of Department Head.

626. Building Systems Development II. (3-9). Credit 6. I Direct application of building system concepts and principles to actual architectural problem. Individual students will be given specific responsibilities within group working under direct supervision of professional research architect. Prerequisites: Arch. 625 or approval of Department Head.

628. Contemporary and Creative Structures. (2-2). Credit 3. II Studies and analysis of contemporary and creative structures as related to architectural design with emphasis on aesthetic considerations, structural limitations and design, functional use, construction procedures, and estimates of cost.

629, 630. History and Archaeology. (2-0). Credit 2 each semester. I, II Individual problems of study and research in field of American architecture and archaeology.

631. Structural Systems. (3-0). Credit 3. I Methods and practice in 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: Approval of Department Head.

633. Environmental Control Systems. (2-4). Credit 3. I, II Physiological influence of climate and other environmental factors on man; determination of optimum physical environments. Methods of system selection; economics and design of heating, air conditioning, electrical, sanitary, communication, electronic control, vertical transportation and other related electro-mechanical systems. Prerequisite: Approval of Department Head.

637. Architectural History I. (3-0). Credit 3. I Historical study of development of architecture from pre-classic through Greek and Roman Classic, Early Christian, Byzantine, Islamic, Romanesque and Gothic periods. Prerequisite: Approval of Department Head.

638. Architectural History II. (3-0). Credit 3. II Renaissance architecture in Europe and America: sources of contemporary architecture in Europe and America. Prerequisite: Approval of Department Head.

639. Contemporary Architecture. (3-0). Credit 3. I Development of architectural theory from the mid-19th century to present; emphasis on materials, structural systems, social and economic factors as influences in architecture. Discussion and criticism of work and writings of architects and architectural theorists. Prerequisite: Graduate classification.

640. Morphology of Architectural Form. (3-0). Credit 3. II, S Study of forces influencing structure and form of architecture: climate, culture, site, economics, construction methods. Psychological responses to habitable space including emotional reactions. Prerequisite: Graduate classification or approval of Department Head.

641. History of the Urban Environment. (3-0). Credit 3. I Urban and regional environment, urban design and design implementation from prehistory to the present. Function of the city and region in industrialized and pre-industrialized societies. Problems of the high density environments. Prerequisite: Graduate classification.

642. Data Processing in Environmental Design. (2-3). Credit 3. I, II Acquisition, translation and organization of numeric and graphic data; computer aided design and graphics; logical design of multi-variable environmental problems. Prerequisite: Approval of instructor.

643. History of Systems Development. (3-0). Credit 3. I Survey of historical development of various environmental building systems emphasizing methodology of their development and implementation. Prerequisite: Approval of Department Head.

644. Theory of Building Systems Development. (3-0). Credit 3. II General factors in decision making process utilized in research and development of a building system. Prerequisite: Approval of Department Head.

650. Industrialized Building Systems. (3-0). Credit 3. II, S Social, economic, and technological forces determining building systems in both industrially developed and industrially under-developed countries. Detailed examination of selected examples. Prerequisite: Approval of Department Head.

651. Construction Management. (2-4). Credit 3. I, S Organization of construction activities and resources; inter-relationship of time, sequence, material delivery and personnel availability. Methods of construction, project planning, management, cost and time accounting. Prerequisite: Graduate classification.

657. Project Administration. (3-0). Credit 3. I, S Legal and administrative functions; communication between client, owner, and other consultant; supervision and scheduling of construction and installation; office management including business law, estimating trade relations, economics of maintaining an office, and employee-management relations. Prerequisite: Approval of Department Head.

661. Interior Component Selection and Design I. (2-4). Credit 3. I Analysis of standard lines of furniture and accessories; methods of selection; theory and application in designing non-standard components including furniture, accessories and architectural graphics. Prerequisites: Four years of study in architecture or equivalent discipline.

662. Interior Component Selection and Design II. (2-4). Credit 3. II Activities leading to a more thorough understanding of component's relationship to total interior environment. Prerequisites: Arch. 661 or approval of Department Head.

663. Interior Space Design I. (2-4). Credit 3. I 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 Department Head.

664. Interior Space Design II. (2-4). Credit 3. I, II, S Continuation and natural extension of design process to include broader range of control. Empirical design will be used as vehicle to broaden this range. Prerequisites: Arch. 663 or approval of Department Head.

665. Interior Space Design III. (3-9). Credit 6. II, S Development of professional solutions to interior architectural problems on a broad scale, including: feasibility studies, cost estimating, design execution, specifications and construction documents. Prerequisite: Arch. 664.

666. Interior Space Design IV. (3-9). Credit 6. I, S Interior architect's role as consultant. Projects will be organized to require collaboration in team projects and with other design professionals, to simulate professional practice situation. Prerequisite: Arch. 665.

681. Seminar. (1-0). Credit 1 each semester. I, S Review of current work in architecture; original presentation on selected topics.

684. Professional Internship. Credit 1 to 8. I, II, S Credit for practice leading to terminal professional project report by M.Arch. and D.E.D. candidates. This practice may be performed under sponsorship by public agencies and private firms engaged in significant environmental design or planning. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 6. I, II, S Individual problems involving application of theory and practice in design and construction of buildings and groups of buildings.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis.

DEPARTMENT OF BIOCHEMISTRY AND BIOPHYSICS

G. W. Bates, N. R. Bottino, B. J. Camp, C. M. Cater, J. R. Couch, C. R. Creger, H. R. Crookshank, J. W. Dieckert, G. A. Donovan, R. D. Grigsby, A. R. Hanks, R. W. Lewis, H. O. Kunkel, W. A. Landmann (Head)*, E. F. Meyer, J. Nagyvary, R. D. Neff, C. N. Pace*, J. M. Prescott, R. Reiser, E. A. Tsutsui, E. S. Vanderzant

The Department of Biochemistry and Biophysics offers graduate studies leading to the degrees of Master of Science and Doctor of Philosophy. In both programs, emphasis is placed upon the acquisition of a sound fundamental grasp of the student's major and supporting disciplines, and upon the ability to perform research of high quality.

Facilities are available for advanced instruction and student research in various phases of biochemistry and biophysics. Among the specialized items of equipment available are a high resolution mass spectrometer, X-ray diffraction equipment, analytical and preparative ultracentrifuges, and electron microscope, automated gamma ray spectrometers, several types of zone and moving-boundary electrophoresis apparatus, amino acid analyzers, and a spectropolarimeter. There is a wide array of equipment for gas chromatography, spectrophotometry, and for counting radioactive isotopes.

Research is in progress in protein chemistry, lipid chemistry and metabolism, enzymology, intermediary metabolism, nucleic acid chemistry, structural determination of natural products, plant bio-chemistry and microbial genetics.

Students entering into graduate work in biochemistry or biophysics are required to have adequate preparation in chemistry, mathematics, physics and modern biology.

The Department has a foreign language or humanities requirement for the Ph.D. degree, as well as an English requirement for all students, including those seeking the M.S. degree, who have been found to be deficient in writing skills. Detailed information may be obtained from the department office.

HEALTH PHYSICS

An interdisciplinary program is available in health physics, encompassing physics, biology, chemistry, and engineering from the standpoints of radiation

*Graduate Advisor

effects and radiation safety. The curriculum consists of basic courses in radiation physics, radiation biology, and radiation chemistry with provisions for training and research in a student's specialized area of interest.

Students wishing to enter this program should have an undergraduate degree in science or engineering, including mathematics through differential equations, physics through atomic or modern physics, a full year of chemistry, and a full year of biology. Deficiencies may be made up during the summer prior to entering the program or the first semester of participation.

Graduate studies in health physics may also be undertaken in the Department of Nuclear Engineering (see page 180).

BIOCHEMISTRY
(Bi.Ch.)

603. General Biochemistry. (3-0). Credit 3. I Study of the constituents of living cells and their chemical reactions. Particular emphasis is placed on the chemistry of proteins, carbohydrates, lipids, and nucleic acids. The role of enzymes as catalysts in biological reactions is stressed, and the topic of intermediary metabolism is introduced. Prerequisites: Chem. 228, 238, 316, 318.

604. General Biochemistry. (3-0). Credit 3. II Continuation of Bi.Ch. 603, devoted to the dynamic aspects of biochemistry. Emphasis is on intermediary metabolism and biologically important reactions of amino acids, proteins, carbohydrates, nucleic acids, and lipids. Prerequisite: Bi.Ch. 603.

605. Experimental Techniques in Biochemistry. (0-6). Credit 2. I Laboratory course designed to familiarize the student with the properties of biologically important chemical compounds, and with fundamental techniques for the isolation, identification, and quantitative determination of such compounds in natural products. Prerequisite: Bi.Ch. 603 or registration therein.

618. Chemistry and Metabolism of Lipids. (2-0). Credit 2. II Advanced course in lipid chemistry and metabolism. Prerequisite: Bi.Ch. 603.

624. Proteins and Enzymes (3-0). Credit 3. II The chemical and physical properties of proteins and enzymes. Thermodynamics, kinetics, and mechanisms of enzyme catalized reactions. Prerequisites: Bi.Ch. 603; Chem. 324; or approval of instructor.

629. Nutritional Basis of Metabolism. (3-0). Credit 3. II Nutritional and metabolic interrelationship in the utilization of proteins, fats and carbohydrates. The functions of vitamins and mineral elements, particularly at the molecular level. Prerequisite: Bi.Ch. 604.

630. Current Topics in Metabolism I. (2-0). Credit 2. I Departmental staff and a group of internationally prominent visiting professors present their work, with any necessary background, on selected areas of frontiers of biochemical investigations. Different areas are to be covered yearly. Students graded on written review. Prerequisites: Bi.Ch. 604; 8 classification.

631. Current Topics in Metabolism II. (2-0). Credit 2. I Departmental staff and a group of internationally prominent visiting professors present their work, with any necessary background, on selected areas of frontiers of biochemical investigations. Different areas are to be covered yearly. Students graded on written reviews. Prerequisite: Bi.Ch. 630.

640. Clinical Chemistry. (2-6). Credit 4. II, S Study of the quantitative distribution of body constituents and their physiological interpretations. Prerequisite: Bi.Ch. 312 or 410 or 603, or Biol. 433, or V.P.P. 427.

641. Nutritional Mechanisms and Metabolic Regulation in Man. (3-0). Credit 3. II A study of the mechanisms of nutrient digestion, absorption, transport, degradation and intracellular metabolic regulation. Emphasis will be placed on the interrelationships of control systems and their nutritional significance in the normal and diseased states of the human. Prerequisites: Bi.Ch. 411 or 604.

650. Chemistry and Metabolism of Nucleic Acids. (3-0). Credit 3. II An advanced consideration of the chemical, physical, and biological characteristics of nucleic acids. Prerequisite: Bi.Ch. 604.

681. Seminar. (1-0). Credit 1 each semester. I, II Study and discussion of 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. I, II, S Advanced course in biochemical laboratory procedures including preparations and instrumentation. Problems assigned according to experience, interests, and needs of individual student.

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

See Genetics 631 for full description of related course.

BIOPHYSICS
(Bi.Ph.)

621. Interpretation of Organic Mass Spectra. (3-0). Credit 3. I Interpretation of mass spectra including the structures of biologically related molecules. Both low- and high-resolution spectra are discussed in detail. Basic instrumentation is included together with a description of the mechanisms of gaseous-ion formation by electron impact. Prerequisite: Chem. 228 or approval of instructor.

622. Thermodynamics of Biochemical Equilibria. (3-0). Credit 3. II Calculation of equilibrium constants for biochemical reactions. Includes 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 or approval of instructor.

625. Structural Biochemistry. (3-0). Credit 3. I A body of information on the structure of biological molecules at or near atomic resolution is brought to bear on question of biological specificity. Computer aided molecular modeling techniques are employed and information retrieval techniques are developed in order to scan the vast amount of information available in the scientific literature. Prerequisite: Chem. 627.

626. Radioisotopes Techniques. (2-3). Credit 3. I General course on the nature and utilization of isotopes in chemical and biophysical studies. History, general properties of nuclei, nuclear reactions, radiation, health physics and instrumentation. Prerequisites: Math. 122; Phys. 201 and 202 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. I, II Study and discussion of original articles in biophysics and related fields designed to broaden understanding of problems in the field and to stimulate research.

685. Problems. Credit 1 or more each semester. I, II, S Individual problems or research not pertaining to thesis or dissertation.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis.

DEPARTMENT OF BIOLOGY*

See also **ANIMAL PARASITOLOGY** and **PHYSIOLOGY OF REPRODUCTION**

J. W. Anderson, S. O. Brown, W. J. Clark, E. R. Cox, R. Darnell, L. S. Dillon, W. J. Dobson, W. P. Fife, B. G. Foster, J. D. Goeschl, H. L. Gravett, H. W. Harry, S. H. Hopkins, K. Horvath, H. Kleerekoper, W. R. Klemm, G. M. Krise, T. S. Park, S. M. Ray, H. A. Röller, I. V. Sarkissian, J. J. Sperry, M. H. Sweet, W. A. Taber, L. E. Thurston, C. H. M. van Bavel, C. Vanderzant, J. van Overbeek (Head), B. F. Watson, U. G. Whitehouse, W. B. Wilson

*All department members of the Graduate Faculty serve as Graduate Advisors.

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; limnology and biology of algae; various phases of ecology; plant, invertebrate and mammalian physiology; animal parasitology; 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, environmental and wildlife management. The Department recognizes that students are individuals, and strives to develop their inborn 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.

Information concerning the Ph.D. foreign language requirement may be obtained from the departmental office.

(Biol.)

600. Teaching of High School Biology. (2-3). Credit 3. I, S Techniques, exercises, discussions useful in high school biology. Biological principles in the service of mankind. Prerequisite: Approval of Heads of Biology and Education Departments.

602. Biological Electron Microscopy. (2-6). Credit 4. I, S Methods of studying biological material with transmission and scanning electron microscopes; fixation; ultra-microtomy; cytochemistry; dark field and electron diffraction analysis; replica and shadowing; and other biological related procedures. Prerequisite: Approval of instructor received one month prior to registration.

605. Principles and Methods of Systematic Biology. (3-3). Credit 4. I Theoretical and evolutionary basis of systematic biology and methods and rules of nomenclature used in zoological, botanical and bacteriological classification. Practical application of principles and rules in laboratory. Prerequisite: Graduate classification. (Offered in 1974-75 and alternate years thereafter).

606. Organization and Distribution of Terrestrial Ecosystems. (3-3). Credit 4. I Population and community structure and function in organization of terrestrial ecosystems; the worldwide pattern of major terrestrial ecosystems. Representative ecosystems analyzed in laboratory. Prerequisite: Biol. 357 or equivalent. (Offered in 1973-74 and in alternate years thereafter.)

608. Phycology. (3-3). Credit 4. II Morphology, taxonomy, ecology, and physiology of fresh water and marine algae. Reproduction and life cycles. Prerequisite: Biol. 408 or approval of instructor.

610. Immunology. (3-4). Credit 4. I, S Study of immunological reactions as related to the diagnosis of human disease. Both basic immune phenomena and practical laboratory experience will be stressed. Prerequisite: Biol. 351 or equivalent. (Offered in 1974-75 and in alternate years thereafter.)

612. Biology of Estuarine Organisms. (2-3). Credit 3. II, S Experimental study of biological adaptations and ecological interrelationships of estuarine organisms. Prerequisite: Course in physiology or approval of instructor.

615. Cytology. (3-3). Credit 4. I Analysis of structure and ultrastructure of cells; the relationship between structure and function at cellular and sub-cellular levels; the structural and ultrastructural aspects of cell division. Prerequisites: Gen. 301 and Bi.Ch. 410 or 603 or approval of instructor.

617. Ultrastructure of Microorganisms. (3-0). Credit 3. I Electron-microscopic structure of protozoa, algae, viruses, bacteria and the relation of the various cell bodies to the biochemical activities of the cell discussed on a comparative basis to seek out the origins

and possible evolutionary histories of complex cells and their parts. Prerequisite: Graduate classification in a biological or agricultural science.

619. Systematic Botany. (2-6). Credit 4. I, S Study of criteria used in plant identification, classification and phylogeny; floral and vegetative characters of selected orders; families and tribes of flowering plants; application of the rules of botanical nomenclature; summary of major historical developments. Prerequisites: Six hours of biological sciences, including Biol. 101 or 113 or their equivalents.

620. Field Systematic Botany. (1-8). Credit 4. II Field study of species composition of plant communities. Use of floras, manuals and monographs in plant identification and classification. Herbarium techniques. Prerequisite: Biol. 102 or equivalent or approval of instructor.

623. Plant Morphology. (2-6). Credit 4. II Study of anatomical reproductive, and ontogenetic and phylogenetic features of representative vascular plants. Prerequisite: Biol. 327 or equivalent.

627. Helminthology. (3-3). Credit 4. II Study of parasitic worms, especially Trematoda, Cestoda, Nematoda, and Acanthocephala. Prerequisite: Biol. 436 or approval of instructor. (Offered in 1973-74 and in alternate years thereafter.)

628. Scanning Electron Microscopy. (2-6). Credit 4. II Introduction to the principles and techniques of scanning electron microscopy, x-ray analysis, cathode luminescence, and additional systems. Prerequisite: Approval of instructor.

630. Protozoology. (3-3). Credit 4. I Morphology, taxonomy, physiology, reproduction, phylogeny, ecology, and life history of protozoa. Prerequisite: 6 hours of biology or approval of instructor. (Offered in 1973-74 and in alternate years thereafter.)

632. Methods in General Physiology. (2-6). Credit 4. S Methods for quantitative study of metabolism, respiration, circulation, excretion, movement, and other basic physiological phenomena. Recent advances in physiological methods presented on seminar basis. Prerequisite: Biol. 433 or equivalent.

635. Physiology of Microorganisms. (2-6). Credit 4. I Advanced consideration of physiological activities of bacteria with special emphasis on metabolism, regulatory mechanisms, cell composition, and use of 14C-substrates in physiology. Prerequisite: Bi.Ch. 312 or 410. (Offered in 1974-75 and in alternate years thereafter.)

637. Marine Botany. (2-6). Credit 4. S Systematics, morphology, ecology, and economics of marine plants including the algae and flowering plants of the North American coasts. Particular attention is ascribed to Gulf of Mexico and especially Texas coast. Prerequisite: Graduate classification in biology or related science.

640. Neurobiology. (3-3). Credit 4. S Scope includes most aspects of neurobiology, ranging from function of single cells to integrated interactions in spinal cord and brain. Emphasis on present-day research and implications for future research, especially brain research. Prerequisite: Biol. 434 or V.P.P. 427 or equivalent.

647. Industrial Microbiology. (2-6). Credit 4. II Microorganism as basis of industrial processes. Practice includes antibiotic assay; analysis of products of metabolism and fermentation balances. Prerequisite: Bi.Ch. 312 or 410. (Offered in 1973-74 and in alternate years thereafter.)

649. Biology of the Endocrine Glands. (3-3). Credit 4. I Function of endocrine glands and hormone regulatory mechanisms in different animal groups, vertebrates and invertebrates. Mechanisms of action of hormones at the cellular, subcellular and molecular level. Emphasis on recent experimental procedures in lab and lecture; isolation, purification and assay of certain hormones and enzymes regulating hormone biosynthesis. Prerequisite: Course in physiology and approval of instructor.

651. Mycology. (2-6). Credit 4. I Detailed studies of fungi, with emphasis on life cycles of representative forms; genetics and cytology; taxonomy; ecology. Prerequisite: Biol. 353 or approval of instructor (Offered in 1973-74 and in alternate years thereafter.)

652. Human Physiological Response. (3-0). Credit 3. I Function of human body in response to physical exertion and environmental stress. Covers in considerable detail systems of the body which are most affected by heavy exercise or man-made environment. Classroom demonstrations used. Prerequisite: Biol. 220 or 433 or 434 or approval of instructor.

653. Zoogeography. (3-0). Credit 3. II The facts of present distributional patterns, both terrestrial and marine, and continental and insular; the effects of environment, geological history, and evolutionary influences. Stress is placed upon theoretical considerations, approached partly through problem solving. Prerequisites: Twelve hours of biological science, including at least three hours of advanced courses.

654. Radiation Biology. (3-0). Credit 3. I Review of physical theory of ionizing radiations important to living organisms; X-ray, gamma, alpha, beta and neutron. Survey of effects of ionizing radiations on biological systems. Prerequisite: Graduate classification in biological or agricultural science.

655. Mammalian Radiation Biology. (3-0). Credit 3. II Lecture and demonstration on effects of X-ray, gamma, alpha, beta, and neutron radiation on mammalian organisms. Both early and delayed effects emphasized. Prerequisites: Biol. 654; graduate classification.

660. Aquatic Ecology. (2-3). Credit 3. I Advanced consideration of those topics which are currently of major significance in aquatic ecology. Prerequisites: A previous course in ecology, limnology or aquatic biology, or approval of the instructor.

661. Cellular Physiology. (3-0). Credit 3. II Consideration of physiochemical nature of cell and its relationship to environment emphasizing conversion of energy and matter as required by cell as living unit. Prerequisites: Graduate classification in biology or animal or plant science; approval of instructor.

662. Biology of the Mollusca. (3-3). Credit 4. I, II, S Conferences and laboratory work on classification, life history, morphology, physiology, ecology, diseases, parasites, predators and competitors of molluscs, with special reference to oysters. Prerequisite: B.S. degree in biology or related fields, or approval of instructor.

663. Biology of the Crustacea. (3-3). Credit 4. S Lectures, conference, and laboratory work on classification, life history, morphology, physiology, ecology, diseases, parasites, and predators of crustaceans. Economic aspects of crustaceans considered. Study of original literature emphasized. Prerequisites: Biol. 435 or equivalent; graduate classification or approval of instructor.

665. Invertebrate Zoology. (3-3). Credit 4. I Morphology, taxonomy, biology, and phylogeny of invertebrate animals, including an individual project. Special attention to invertebrates (not including insects) of interest to entomologists, wildlife students, and oceanographers, including economic forms. Prerequisite: Six hours of zoology.

666. Aerospace-Hydrospace Physiology. (3-0). Credit 3. S Study of the physiological systems most affected by changes experienced by the body both in aerospace and underwater existence. Emphasis placed on overcoming physical hazards such as decompression, heat loss, fire, explosion. Consideration given to 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. I Physiology and biochemistry of parasites, environmental conditions under which parasites are living and integration of the parasite and the host into functional host-parasite complex. Prerequisite: Course in physiology or biochemistry or approval of instructor. (Offered in 1974-75 and in alternate years thereafter.)

668. Biology of Invertebrate Symbioses. (3-2). Credit 4. II, S Review of physiology, ecological relations, and populations significance of various types of symbiotic associations with emphasis on parasitism and mutualism. Prerequisite: 6 hours of biology or approval of instructor. (Offered in 1974-75 and in alternate years thereafter.)

669. Quantitative Electron Microscopy. (2-6). Credit 4. II, S An interdisciplinary course in the statistical and quantitative evalution of electron micrographs, diffractographs, electron energy, electron microprobe analysis, scanning electron micrographs, and related data. Theory and practice for all technical fields. Prerequisite: Biol. 430 or approval of instructor.

681. Seminar. (1-0). Credit 1. I, II Detailed reports on specific topics in field chosen. Prerequisite: Graduate classification in appropriate field.

685. Problems. Credit 1 to 6 each semester. I, II Limited investigations in fields other than those chosen for thesis or dissertation.

690. Theory of Biological Research. (2-0). Credit 2. I, II, S The 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. I, II Research for thesis or dissertation. Prerequisite: Approval of ranking professor in field chosen.

DEPARTMENT OF BUSINESS ANALYSIS AND RESEARCH

F. P. Buffa, R. A. Cossaboom (Head)*, N. H. Erb, J. E. Pearson, W. W. Saitta, E. B. Smith

Two Master of Business Administration programs are administered by the Department: the M.B.A. in Business Computing Science and the M.B.A. in Business Statistics. These programs are interdisciplinary between the department and the Department of Industrial Engineering in the Business Computing Science professional concentration; and between this department and the Graduate Institute of Statistics in the Business Statistics professional concentration.

The Department also provides graduate work in quantitative and computing business tools and concepts for students with professional concentrations in accounting, finance, marketing and management.

Students in M.B.A. and Business Administration doctoral programs, and those in programs of colleges other than Business Administration who meet the prerequisites, may take graduate courses in the Business Analysis and Research Department to understand business research designs and methodologies.

(B.Ana.)

617. Automated Business Systems. (2-3). Credit 3. I, II, S A study of business data processing emphasizing concepts of why and how the business community utilizes computing techniques. Selected business applications will be utilized.

620. Systems Analysis for Business Data Processing. (3-0). Credit 3. I Introduces the concepts of planning, development, implementation, and operation required in major business data processing systems. Prerequisite: B.Ana. 617 or equivalent.

622. Corporate Information Planning. (3-0). Credit 3. II Emphasis on cost/benefit analysis of business information systems and the relationship of this to organizational functions. Prerequisite:B.Ana. 617 or equivalent.

646. Business Trends, Fluctuations, and Measurements. (3-0). Credit 3. I, S Study of business trends and economic fluctuations, theory, causes and control cyclical behavior, analytical forecasting, economic and statistical services. Prerequisites: Graduate classification; approval of graduate advisor.

666. Quantitative Analysis for Business Decisions. (3-0). Credit 3. I, II, S A study of the conceptual foundations of business research, formulation and structuring of business problems, and selected quantitative techniques. Investigation of prior research and formulation of specific problems. Prerequisite: Graduate classification in business administration; approval of graduate advisor.

681. Seminar. (1-0). Credit 1 each semester. I, II Critical examination of subject matter presented in current periodicals, recent monographs and bulletins in field of quantitative methods applied to business.

685. Problems. Credit 1 to 3 each semester. I, II, S Directed study on selected problems using recent developments in business research methods. Prerequisites: Graduate classification; approval of instructor.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

*Graduate Advisor

DEPARTMENT OF CHEMICAL ENGINEERING

R. G. Anthony, R. Darby, R. R. Davison, L. D. Durbin, P. T. Eubank*, D. T. Hanson, W. B. Harris, W. D. Harris, C. D. Holland (Head), W. W. Meinke, E. A. Schweikert, R. E. Wainerdi

The graduate program in chemical engineering is designed to give the student a well-rounded training in the fundamentals of chemical engineering and in research methods. The courses given cover various unit operations and chemical engineering thermodynamics, economics, transport phenomena, and process control. The applications courses utilize mainly petroleum and other hydrocarbon process data to develop examples of methods which are of general applicability. Courses devoted to specialized industrial technology are given, but the major emphasis is on fundamentals.

Research is an integral part of the work leading to an advanced degree. The department specializes particularly in research on heat transfer, solar heating, rheology, thermodynamics, distillation, extraction, process control, water purification, microbiological transformations, electrochemistry, energy conversion, chemical reactor design and optimization, chemical engineering kinetics and catalysis, activation analysis, chemurgic research, and environmental research.

The research facilities include, in addition to standard laboratory equipment, several precision analytical distillation columns, vapor-phase chromatograph, ultraviolet and infrared spectrometers, high-speed movie and other photographic equipment, Burnett P-V-T apparatus, high-speed recorders, digital data logging equipment, a medium size electronic analog computer, a Weissenberg Rheogoniometer, other rheological research equipment, and an experimental fuel cell system. Many other specialized pieces of equipment are contained in the laboratories where the work in the areas of specialization is performed. In addition, the facilities of the Data Processing Center are available for use in the correlalation of experimental results and for the analysis of mathematical models of chemical processes.

The Department of Chemical Engineering requires nine hours of non-technical or collateral courses which may include language or technical writing at the discretion of the committee of the student.

(Ch.E.)

605. Chemical Engineering Economics. (3-0). Credit 3. I Advanced calculations involving process design and process control as limited by least cost or maximum profit. Problems based on various unit operations and unit processes. Prerequisite: Ch.E. 424.

606. Unit Operations. (3-0). Credit 3. II 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. I 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. 424.

612. Distillation. (3-0). Credit 3. I Process and process design calculations involving distillation of multicomponent and complex systems. Extractive and azeotropic distillation covered. Prerequisite: Ch.E. 424.

613. Unsteady State Processes. (3-0). Credit 3. II 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. I 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. 323, 324.

623. Applications of Thermodynamics to Chemical Engineering. (3-0). Credit 3. II Study of application of thermodynamics to chemical engineering operations and processes. Prerequisite: Ch.E. 354.

624. Chemical Engineering Kinetics I. (3-0). Credit 3. I Study of rates and mechanisms of chemical reactions. Thermal and catalytic reactions both homogeneous and heterogeneous are considered. Prerequisite: Ch.E. 464.

625. Chemical Engineering Kinetics II. (3-0). Credit 3. II Study of physical factors affecting chemical reaction rates and of methods for design of reaction equipment. Prerequisite: Ch.E. 624.

629. Transport Phenomena. (3-0). Credit 3. I Principles of transfer of momentum, energy, and mass studied by application to advanced chemical engineering problems. Theoretical analogy of these three modes of transfer will be emphasized. Prerequisite: Ch.E. 424, or approval of instructor.

630. Activation Analysis. (1-3). Credit 2. II The theoretical and practical bases of nuclear activation analysis are developed. Applications of the method in the physical and life sciences are presented. Prerequisites: Graduate classification in the sciences or engineering and one appropriate course in nuclear engineering or nuclear chemistry.

631. Process Dynamics I. (3-0). Credit 3. I Study of 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.

632. Process Dynamics II. (3-0). Credit 3. II Continuation of Ch.E. 631. Theory and application of discrete, nonlinear, and stochastic dynamic analysis and optimal design policies to processes in chemical and allied fields. Prerequisite: Ch.E. 631.

633. Theory of Mixtures. (3-0). Credit 3. I Basic relations of statistical thermodynamics, intermolecular forces, the liquid state, theory of mixtures, the critical state, theory of conformal solutions, new theory of Flory for chain molecules, 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. II Principles of stress, deformation and flow with emphasis on vector and tensor equations of fluid mechanics. Behavior of Newtonian, non-Newtonian, and viscoelastic fluids stressed. Prerequisites: Ch.E. 629; Math. 601.

641. Introduction to Bioengineering. (3-0). Credit 3. II Application of principles of mass, energy and momentum transport to the characterization of biological systems. Ability to represent behavior of biological systems in terms of measurable properties of biomaterial and measurable environmental factors demonstrated. Prerequisites: Graduate classification; Ch.E. 424.

650. Electrochemical Processes. (3-0). Credit 3. I Fundamentals of reversible and irreversible electrode processes with emphasis on energy conversion devices. The interaction between mass transport and kinetic mechanisms, industrial applications and corrosion considered. Prerequisites: Ch.E. 424 or approval of instructor.

681. Seminar. (1-0). Credit 1. I, II Graduate students will be required to attend one hour per week to discuss problems of current importance in connection with their research.

685. Problems. Credit 1 to 6. I, II, S The work covers one or more of numerous problems in chemical engineering processes and operations. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S 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, D. W. Brooks, D. C. Conway, F. A. Cotton, J. H. Fendler, C. S. Giam, K. A. Gingerich, T. A. Giudici, J. K. Gladden, G. I. Glover, J. S. Ham, K. E. Harding, E. E. Hazen, R. M. Hedges, C. J. Hoeve, K. J. Irgolic, A. F. Isbell, H. Kaye, J. Laane, R. A. Levenson, H. A. Liebhafsky, J. H. Lunsford*, R. D. MacFarlane, P. S. Mariano, A. E. Martell (Head), E. A. Meyers, J. B. Natowitz, D. H. O'Brien, A. S. Rodgers, T. L. Rose, M. W. Rowe, P. C. Scholl, E. A. Schweikert, B. L. Shapiro, F. Sicilio, T. T. Sugihara, Y. N. Tang, R. L. R. Towns, M. Tsutsui, R. L. Watson, R. C. Wilhoit, R. A. Zingaro, B. J. Zwolinski

Graduate work in chemistry is offered at both the Masters and Doctorate 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 has the opportunity to spend more of his time in research. The dissertation which results from this research must satisfactorily demonstrate (1) that the student is capable of independent and creative research in a specialized area of chemistry and (2) that the student has a superior knowledge and understanding of the area in which his research activities were performed. In addition, the student must demonstrate that he 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 six semesters as part of his 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 and analytical chemistry. There is also considerable Departmental research activity in various interdisciplinary areas such as nuclear chemistry, theoretical chemistry, x-ray crystallography, biophysical, bioorganic, and bioinorganic chemistry. Seven nuclear-related faculty, including five members of the Cyclotron Institute, provide one of the best graduate nuclear chemistry programs available in this country. The Thermodynamics Research Center has an international reputation for excellence. The Polymer Research Center cuts across divisional lines and offers research problems in all subfields of chemistry. The Department also offers strong research programs in heterogeneous and homogeneous catalysis, analytical instrumentation, coordination, chemistry, high temperature chemistry, organic photochemistry, and organometallic chemistry. Highly relevant research problems are available in pollution control and environmental chemistry, under the direction of faculty members specializing in coordination chemistry, heterogeneous catalysis, photochemistry, and heterocyclic chemistry.

*Graduate Advisor

Major scientific equipment required for modern chemical research is available in the Department for the use of graduate students, including x-ray diffractometers, nmr and epr spectrometers, mass spectrometers, infrared, ultraviolet, optical rotatory and circular dichroism spectrophotometers. A new building brings the total space available for the work of the Department to over 150,000 sq. ft. For further details about programs, faculty, facilities, and financial aid, write to Arthur E. Martell, Head of the Department, for a descriptive brochure.

(Chem.)

600. Survey of Chemistry. (2-3). Credit 3. I Survey course designed for teachers of high school chemistry. Prerequisites: Graduate classification; approval of Head of Department of Chemistry and Dean of College of Education.

608. Qualitative Organic Analysis. (1-6). Credit 3. I Analysis of organic compounds and application of techniques of chemistry in the laboratory. Prerequisite: Chem. 228.

609. Theory of Organic Chemistry. (3-0). Credit 3. II Development and application of chemical theories to organic compounds. Prerequisite: Chem. 646.

610. Organic Reactions. (3-0). Credit 3. II Relatively detailed study of organic reactions, not only those commonly described in undergraduate course but also the less well known but equally useful reactions. Advantages and limitations of these reactions in organic syntheses. Prerequisites: Chem. 609, 646 or their equivalent.

611. Principles of Physical Chemistry. (3-0). Credit 3. I Study of general principles of chemistry from quantitative standpoint. Discussion of gases, liquids, and solutions. Prerequisite: Graduate classification.

616. Statistical Chemistry and Chemical Dynamics. (3-0). Credit 3. I Advanced treatment of statistical mechanics and chemical dynamics including properties of real gases, non-equilibrium phenomena, and microscopic chemical dynamics. Prerequisites: Chem. 621, 631.

619. Analytical Absorption Spectroscopy. (3-0). Credit 3. II Theory, principles, and applications of absorption techniques to modern problems of analytical chemistry. Topics covered include visible, ultraviolet, polarimetry, optical rotatory dispersion, circular dichroism, atomic absorption, flame and emission spectroscopy. Prerequisite: Chem. 620 or approval of instructor.

620. Principles of Chemical Analysis. (3-0). Credit 3. II Advanced survey of principles of chemical analysis with special emphasis on newer developments in field of analytical chemistry. Prerequisite: Chem. 317.

621. Chemical Kinetics. (3-0). Credit 3. II Study of some of present theories about chemical reaction rates and mechanisms. Prerequisite: Chem. 324.

624. Physico-Organic Chemistry. (3-0). Credit 3. I Mathematical and quantitative investigation of organic chemical phenomena. Prerequisite: Chem. 609 or approval of instructor.

626. Thermodynamics. (3-0). Credit 3. I Theory and applications of classical thermodynamic functions. Prerequisite: Chem. 324.

627. Diffraction Methods. (3-0). Credit 3. II Introduction to use of diffraction methods for determination of molecular structure. Major emphasis placed on results of diffraction of X-rays by crystals, but related methods are also discussed. Prerequisites: Chem. 324; Math. 601 or equivalent; approval of instructor.

629. Chemistry of the Regular Elements. (3-0). Credit 3. I 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. II Introduction to methods of statistical mechanics based primarily on Boltzmann statistics. Approach to thermodynamics through partition function. Statistical concept of entropy. Prerequisite: Chem. 626.

634. Ligand Field Theory. (3-0). Credit 3. II Study of electronic structures of transition metal complexes. Emphasis on the student obtaining a firm theoretical understanding by working on a detailed problem set on the material to be covered. Electronic spectra of

pertinent compounds will be examined and interpreted in terms of the ideas presented. Prerequisites: Chem. 461 or equivalent; approval of instructor.

635. Heterocyclic Compounds. (3-0). Credit 3. I Structure, preparation, and properties of heterocyclic compounds with special emphasis on those with biological activity. Prerequisite: Chem. 228.

636. Electrochemistry. (3-0). Credit 3. I Advanced treatment of conductivity, electrochemical thermodynamics, galvanic cells, electrodeposition, and corrosion. Prerequisite: Chem. 324.

637. Electroanalytical Chemistry. (3-0). Credit 3. I Advanced survey of modern electroanalytical methods including potentiostatic, galvanostatic, sweep, and periodic techniques. Prerequisite: Chem. 620 or approval of instructor.

638. Chemical Instrumentation. (2-3). Credit 3. S Introduction to electronic instrumentation of importance to the chemist in the generation, detection, amplification, modification, and presentation of chemical information. Typical modern instruments studied from design and operational standpoints after an introduction to electronics and electrical measurements. Prerequisite: Approval of instructor.

639. Instrumental Methods of Analysis. (2-3). Credit 3. I Study of theory and practice of modern techniques of chemical analysis. Laboratory work illustrates use of these instruments for routine analytical work and as research tools. Prerequisite: Chem. 317.

640. Transition Metal Chemistry. (3-0). Credit 3. II Chemistry of the subgroup B elements of the periodic table including the lanthanides and actinides. Special emphasis on coordination compounds. Prerequisite: Chem 641.

641. Structural Inorganic Chemistry. (3-0). Credit 3. I Introduction to chemical bonding; valence bond and molecular orbital theory, ionic bonding, the hydrogen bond, and introduction to ligand field theory. Prerequisite: Chem. 462.

645. Organometallic Chemistry of Transition Metals. (3-0). Credit 3. I 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. I, II Systematic and thorough presentation of organic chemistry on advanced level. Prerequisite: Chem. 228.

647. Spectra of Organic Compounds. (3-0). Credit 3. I 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. I Brief review of 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. II 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. II 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. S 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 its equivalent; approval of instructor.

652. Recent Topics in Analytical Chemistry. (2-0). Credit 2. S Recent advances and special methods in field of analytical chemistry. Methods will be discussed in terms of their basic theory, particular advantages, limitations, and required instrumentation. Prerequisite: Chem. 620.

653. Recent Topics in Organic Chemistry. (2-0). Credit 2. S 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.

654. Recent Topics in Inorganic Chemistry. (2-0). Credit 2. S Discussion of topics such as boron hydrides, crystal field theory, inorganic reaction mechanisms, organometallic chemistry and nuclear chemistry. Prerequisite: Chem. 641.

655. Polymer Science I. (3-0). Credit 3. I 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. II Selected topics in polymer synthesis, solution, and solid state properties. Prerequisite: Chem. 655.

657. Magnetic Resonance Spectroscopy. (3-0). Credit 3. II Principles of magnetic resonance and of 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. I 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. II Fundamentals of 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.

662. Crystal Chemistry. (3-0). Credit 3. I Introduction to chemistry of crystals, their properties and structures. Discussion of types of crystals with special emphasis upon the bonding present and its influence upon chemical and physical properties. Prerequisite: Approval of instructor.

663. X-Ray Absorption and Emission in Analysis. (3-0). Credit 3. I 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. II Synthesis, reactivities, structures, and applications of organometallic compounds of the main group elements studied. Correlation between physical and chemical properties of organometallic compounds and position of the central metal atom in the periodic system emphasized. Prerequisites: Chem. 641, 646.

665. Biophysical Chemistry. (3-0). Credit 3. II The physical chemistry of macromolecules of biological importance. Methods applicable to solids and solutions will be considered, such as x-ray diffraction and scattering, osmometry, sedimentation equilibrium, electrophoresis and other thermodynamic and transport methods. Prerequisite: Chem. 324.

670. Chemistry of Proteins. (3-0). Credit 3. I, II, Chemical synthesis and degradation of proteins, chemical modification of proteins, primarily specific reactions with affinity labeling reagents. Applications of chemical modification. Prerequisites: Bi.Ch. 603, Chem. 646 or approval of instructor.

672. Bioorganic Reaction Mechanisms. (3-0). Credit 3. II The study of proposed mechanisms of action of various enzymes and coenzymes from the "model systems" approach. Will cover new proposals, theory and established mechanisms. Prerequisite: Bi.Ch. 624 or Chem. 670; Chem. 646.

673. Symmetry and Group Theory in Chemistry. (2-0). Credit 2. The applications of symmetry and group theory to various types of chemical systems will be discussed. The classification of molecules into symmetry point groups and the use of character tables will be emphasized. Prerequisite: B.S. or B.A. in Chemistry.

674. Mechanisms of Photo- and Radiation Biochemistry. (3-0). Credit 3. II The nature of the chemical reactions occurring in organic chemical and biological systems as the result of high energy radiation are examined critically. Prerequisite: Bi.Ch. 603 or Chem. 228 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. I, II Oral presentations and discussions of recent advances in chemistry.

685. Problems. Credit 1 to 6. I, II, S 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.

690. Theory of Chemical Research. (2-0). Credit 2. I, II, S 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. I, II, S Research for thesis or dissertation.

DEPARTMENT OF CIVIL ENGINEERING

D. R. Basco, F. J. Benson, A. Cetiner, H. M. Coyle, R. F. Dominguez, C. L. Dudek, W. A. Dunlap, J. A. Epps, H. L. Furr, B. M. Gallaway, R. W. Hann, Jr., J. B. Herbich, T. J. Hirsch, R. M. Holcomb, D. L. Ivey, W. P. James, M. D. Jones, C. J. Keese, D. R. Knowles, A. H. Layman, W. B. Ledbetter, L. L. Lowery, R. L. Lytton, J. E. Martinez, C. J. Messer, A. H. Meyer, R. M. Olson, R. O. Reid, T. D. Reynolds, N. J. Rowan, H. E. Ross, Jr., C. H. Samson, Jr. (Head), R. A. Schapery, R. E. Schiller, Jr., F. H. Scrivner, M. Shelby, R. M. Sorensen, V. G. Stover, L. J. Thompson, R. D. Turpin*, H. W. Wolf, D. L. Woods

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, programs in coastal and ocean engineering; construction engineering; environmental engineering; forest engineering (in cooperation with 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.

(C.E.)

601, 602. City Management. (3-0). Credit 3 each semester. I, II 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. Stream Quality. (3-0). Credit 3. I 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 standing in engineering or approval of instructor.

604. Introduction to Unit Operation Theory. (3-0). Credit 3. I 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. Prerequisites: C.E. 402 or approval of instructor.

605. Experimental Analysis in Environmental Engineering. (1-6). Credit 3. I, S Theory and practice of analytical methods used in the environmental engineering field. Wet chemistry techniques for organic and nonorganic determinations; Warburg and Gilson respirometers; infra-red, ultra-violet, and visible light spectrophotometry; gas chromatography; polarographic techniques for pH and dissolved gases and continuous field monitoring techniques. Prerequisite: Graduate classification in engineering or approval of instructor.

*Graduate Advisor

606. Design of Waste Water Treatment Systems. (1-6). Credit 3. II 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.

607. Environmental Analysis for Urban Areas. (3-0). Credit 3. I Analysis of urban problems, including air pollution and environmental engineering, problems affecting urban and suburban areas; evaluation of administrative and financing problems, legal probleems, government assistance programs and aspects affecting development of overall environmental engineering plan for a city. Prerequisite: Graduate classification in engineering or approval of instructor.

608. Environmental Design for Urban Areas (1-6). Credit 3. II Design or environmental engineering projects related to urban problems including air pollution and environmental problems affecting urban and suburban areas. Prerequisite: C.E. 607 or approval of instructor.

609. Simulation of Water Resources Systems for Numerical Analysis. (3-0). Credit 3. II, S Digital methods for simulating runoff from river basins. Numerical evaluation of stream quality variations, flow augmentation requirements, waste assimilation capacities and optimum waste loadings. Evaluation of velocity and salinity patterns in streams, impoundments, and estuaries. Prerequisites: Aero. 320; C.E. 603 or equivalent.

610. Industrial Wastes. (2-3). Credit 3. II, S 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 equivalent.

611. Design of Potable and Industrial Water Systems. (1-6). Credit 3. II, S Application of theories of unit operations and unit processes to design systems for treatment of water for domestic and industrial uses. Prerequisites: C.E. 603, 604, or equivalent.

612. Transportation in City Planning. (2-2). Credit 3. I Importance of transportation in urban development and planning. Role of engineer in planning. Urban transportation planning studies; design, organization, analysis and modeling techniques. Site development of residential, commercial, and industrial areas related to transportation.

613. Urban Engineering. (3-0). Credit 3. II, S 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. I, S Theory of mechanical and chemical stabilization of soils and soil-aggregate systems.

615. Structural Design of Flexible Pavements. (2-0). Credit 2. I Characteristics of pavement loads, stress analysis in flexible pavements, design practices, construction and maintenance. Prerequisite: C.E. 307.

617. Traffic Engineering: Characteristics. (2-3). Credit 3. I Advanced theory and practice of engineering studies of traffic characteristics. Methods of traffic administration. Prerequisite: C.E. 457.

618. Traffic Engineering: Operations. (2-3). Credit 3. II Advanced theory and application of traffic control and design of traffic facilities. Traffic regulations. Prerequisite: C.E. 617.

619. Highway Problems Analysis. (2-3). Credit 3. II Advanced techniques in statistics, aerial photogrammetry, and data processing in solution of problems in highway and traffic design and research. Students should have knowledge of computer programming and basic statistics. Prerequisites: C.E. 617; I.En. 414.

620. Structural Design of Rigid Pavements. (2-0). Credit 2. II Theory of rigid pavement design, design practices, maintenance, and construction. Prerequisite: C.E. 307.

621. Advanced Reinforced Concrete Design. (3-0). Credit 3. I Flat slabs, continuous building frames, torsion, deep beams, bulk storage structures, creep and temperature change effects. Prerequisite: C.E. 344.

622. Hydraulics of Drainage Structures. (2-3). Credit 3. II Hydraulics of open channels, bridge openings, culverts, head walls, surface street drainage, storm sewers, gutters, drop inlets and spillways. Theory of model studies as applied to drainage of highways, streets, and freeways. Prerequisite: C.E. 338 or equivalent.

623. Properties of Concrete. (3-0). Credit 3. I Physical and chemical properties of aggregate, cement, and concrete. Selected topics including chemistry of cement, synthetic aggregate and concrete. Failure analysis; bond, creep, elasticity, and volume changes in concrete; admixes; special concretes. Prerequisite: Graduate classification or approval of instructor.

624. Design of the Driving Environment. (2-0). Credit 2. S 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, roadway lighting and roadside beautification consideration are included. Prerequisite: Graduate classification.

625. Geometric Design of Highways. (2-3). Credit 3. I Advanced theory and practice in highway design. Design controls and criteria, elements of design, design of alignment, cross section, intersections and interchanges, multilane expressways, and drainage structures. Prerequisites: C.E. 307, 365.

626. Roadside Safety Design. (3-0). Credit 3. II Fundamental concepts of designing safety into roadways. Designs of safety devices are treated in detail and recommendations regarding safety provisions are made. Topics include breakaway signs and luminares, attenuation devices, guardrails. Prerequisite: C.E. 623.

627. Hydrology. (3-0). Credit 3. I Precipitation, stream gauging methods, evaporation and transpiration, ground-water, hydrograph analysis, flood hydrographs from rainfall and snow, snow melt. Stream flow routing, frequency and duration. Sedimentation, storage reservoir design, graphical correlation, and airfield drainage. Prerequisite: Approval of instructor.

628. Hydraulic Engineering. (3-0). Credit 3. I Gradually and rapidly varied flow in open channels. Hydraulic design criteria for reservoirs, spillways, outlet works, transition structures and energy dissipators. River hydraulics and flood routing. Hydraulic models. Surges. Case studies of existing multi-purpose water resources projects. Prerequisite: C.E. 338, 458 or approval of instructor.

629. Hydraulics of Open Channels. (3-0). Credit 3. I, S Advanced topics in uniform and non-uniform flow in open channels. Computation methods for uniform, critical, and gradually-varied flows. Design of erodible channels. Boundary layer and roughness concepts. Flows in channels of non-linear alignment and non-prismatic section. Prerequisite: Approval of instructor.

632. Advanced Design in Metals. (2-3). Credit 3. II Properties of high-strength and other special materials. Stress concentrations and fatigue. Design of complex members and connections such as curved columns, fixed bases, and rigid-frame knees. Prerequisites: C.E. 483; M.M. 467.

633. Advanced Mechanics of Materials. (4-0). Credit 4. S Stresses and strains at a point, torsion of noncircular cross sections, beams with combined axial and lateral loads, built-up columns, lateral buckling of beams, torsional buckling of centrally loaded columns, bending of thin plates and shells. Prerequisites: Aero. 306 or C.E. 306; Math. 308.

634. Airport Planning and Design. (2-2). Credit 3. II Planning and design of the airfield, study of functional terminal configurations and adjacent area land use problems. Airport siting, runway orientation, runway capacity, surface drainage, runway pavement design, terminal orientation, and ground access considerations are stressed.

636. City Street Design. (2-0). Credit 2. S Street classification and function. Design of city streets, intersections, access drives, and pavements. Street drainage. Financing city street improvements. Prerequisite: C.E. 307.

637. Pipeline Construction. (2-0). Credit 2. II Study of cross-country pipeline construction. Although emphasis will be on pipeline construction methods and equipment, general information will be presented on pipeline design, automation, corrosion control, and shore installations for marine terminals. Underground and general utility construction also considered. Prerequisite: C.E. 478 or approval of instructor.

638. Building Construction. (2-0). Credit 2. I Take-off of quantities, compilation of estimate, pricing and checking of estimate, building construction equipment and methods. Prequisites: C.E. 473, or approval of instructor.

639. Highway Construction. (2-0). Credit 2. II Methods of locating and procuring highway aggregates; design and operation of crushing, hot-asphalt, concrete, and grading equipment. Highway estimating and construction methods. Prerequisites: C.E. 365, 473; Geol. 441, or approval of instructor.

640. Freeway Design and Operation. (2-0). Credit 2. S Characteristics of traffic flow on controlled access facilities. Advanced theory and practice in operation on freeways and related street systems. Freeway traffic control. Material based on advanced research of Texas Transportation Institute. Prerequisite: C.E. 618.

641. Construction Engineering Systems. (3-2). Credit 4. S Fundamentals of systems engineering theory and methodology; application of systems theory to construction situations and problems; case history studies of complex construction problems and group action. Design and reporting of construction system projects. Prequisites: C.E. 348, 404, 473; or approval of instructor.

642. Construction Engineering Management. (3-0). Credit 3. I Applied management aspects of construction. Construction company organization and management, project planning, critical path techniques, and computer methods. Prerequisites: C.E. 348, 404, 473; or approval of instructor.

643. Plastic Analysis and Design in Steel. (3-0). Credit 3. I, S 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. (2-0). Credit 2. I Study of engineering behavior of rocks, stability of slopes, tunnels and protective structures, wave propagation in rock, and excavation methods. Prerequisite: Graduate classification in engineering or approval of instructor.

645. Scientific Methods in Urban Engineering and Management. (2-3). Credit 3. II Mathematical models for managerial decision-making in the urban situation, emphasis on subjects such as 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: Aero. 320 or equivalent; Math. 308.

648. Design and Analysis of Earth Structures. (2-0). Credit 2. II 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. I Introduction to physico-chemical properties of soils; soil structure; soil classification; permeability; principle of effective stress; stress-deformation and strength characteristics; expansive and collapsing soils; soil compaction; site investigation; testing procedures. Prerequisites: C.E. 365, 435 or approval of instructor.

650. Soil Mechanics. (3-3). Credit 4. II 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. II Review of the 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. Prerequisites: C.E. 649; Math. 601 or the equivalent.

652. Soil Dynamics. (3-0). Credit 3. II Study of behavior of soils during 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 earth quakes. Prerequisite: Graduate classification in engineering or approval of instuctor.

653. Bituminous Materials. (2-3). Credit 3. II Production, specifications, and tests of bituminous materials; design and evaluation of asphaltic concrete construction maintenance; inspection control of street, parking, and highway paving surfaces. Prerequisite: Graduate classification in engineering.

656. Concrete Structures Testing Laboratory. (1-3). Credit 2. II Methods and equipment used in testing reinforced concrete structures, and elements of structures. Observations of behavior in compression, flexure, shear, torsion, and combinations thereof. Correlations with theory, both elastic and plastic. Prerequisite: C.E. 621.

657. Dynamic Loads and Structural Behavior. (3-0). Credit 3. I 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.

659. Folded Plates and Shells. (3-0). Credit 3. II General theory and design procedures for thin-shell and folded-plate structures. Characteristics, use, construction, problems, and economic factors. Membrane theory for shells. Edge effects and effects of unsymmetrical loading. Prerequisite: M.M. 468 or equivalent or approval of instructor.

660. Photogrammetry. (3-0). Credit 3. I 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. 121; graduate classification; approval of instructor.

661. Photo Interpretation. (3-0). Credit 3. II Photographic processes related to interpretation; principles, methods, and techniques of photo interpretation; applications in agriculture, forestry, soils, engineering materials, geology, geomorphology, water resources, transportation, and urban planning. Prerequisites: Graduate classification; approval of instructor.

662. Engineering Applications of Map Projections. (3-0). Credit 3. I Types and characteristics of maps and map projections; mathematical considerations of selected map projections, with emphasis on the Lambert conformal conic, Mercator, transverse Mercator, and polyconic projections; map production. Prerequisites: Math. 121; graduate classification; approval of instructor.

663. Geodetic Surveys. (3-0). Credit 3. II Triangulation, trilateration, adjustment computations, first-order leveling, electronic distance measuring, field astronomy, size and shape of the earth. Prerequisites: Math 121; graduate classification; approval of instructor.

664. Water Resources Development. (3-0). Credit 3. II Conservation and utilization of water resouces with emphasis on legal, social and economic phases of watershed planning and multipurpose projects. Prerequisites: Graduate classification; approval of Department Head.

666. Foundation Structures. (2-3). Credit 3. II Spread footing, combined footings, and raft foundations. Retaining walls, piles, and pile foundations. Sheet-pile structures, cofferdams, wharves, and piers. Bridge piers and abutments. Prerequisites: C.E. 365 or equivalent; graduate classification in civil engineering.

667. Highway Structures. (3-3). Credit 4. I Structural analysis and design of bridges, grade separation structures, retaining walls, and culverts. Loads materials, comparisons of different types, and economic proportions. Current standards, new developments, and current cost information. Prerequsites: C.E. 483, 625.

669. Bituminous Technology. (2-0). Credit 2. I Methods and techniques used in evaluating chemical, physical, colloidal and rheological properties of asphaltic materials. Available data will be discussed and a study made of methods for evaluating durability of asphalt. Prerequisite: C.E. 417 or equivalent.

673. Urban Transportation. (2-2). Credit 3. II Planning urban transportation facilities; special emphasis on trip generation, trip distribution and traffic assignment. Transportation system planning and evaluation; characteristics, cost, and application of all modes of transportation.

674. Flow Through Porous Media. (3-0). Credit 3. II Development of Darcy's Law; non-Darcy flow; survey of potential flow theory and flow patterns; boundary conditions; flow nets; multilayered and anisotropic soils; models, analogs and special techniques; well flow; seepage through earth structures. Prerequisite: Approval of instructor.

675. Coastal Engineering I. (3-0). Credit 3. I Review of small amplitude and finite amplitude wave theories and applications to engineering problems. Wave forces on coastal structures. Wave run-up on uniform and composite beaches. Design of seawalls and breakwaters. Prerequisite: Approval of instructor.

676. Ocean Engineering. (3-0). Credit 3. I Review of wave and tide theories; wind and ocean current forces; storm surge; ocean survey equipment; diffusion processes and marine outfall design; ocean mooring; oil spill containment and collection. Prerequisite: Approval of instructor.

677. Coastal Engineering II. (3-0). Credit 3. II Applications of wave theories to engineering problems; tidal dynamics; sediment transportation along coast and in estuaries; dredging; coastal and estuarine models. Prerequisite: C.E. 675 or approval of instructor.

678. Hydromechanics. (3-0). Credit 3. II Continuity; stream and potential functions; irrotational flow; Laplace, Euler and Navier-Stokes equations; standard patterns of flow; conformal transformations; Schwarz-Cristoffel theorem; vortex motion; gravity wave theory. Prerequisite: Approval of instructor.

679. Theory of Fluid Mechanics Models. (2-0). Credit 2. I, S Dimensional analysis; model laws; mathematical techniques; applications to fluid mechanics and hydraulic models; fixed-bed; movable-bed, geometric, and distorted models. Prerequisite: Approval of instructor.

680. Civil Engineering Computer Systems. (2-3). Credit 3. II, S Evaluation of role of computer hardware and software systems in civil engineering problem solving environment. Use of numerical analysis techniques and existing problem oriented computer languages, including the ICES System to solve civil engineering problems. Development of problem oriented languages for civil engineering analysis and design. Prerequisites: Aero. 320, C.S. 458, or Math. 417.

681. Seminar. (0-2). Credit 1. I, II, S 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. Prerequisite: Graduate classification.

682. Coastal Sediment Processes. (3-0). Credit 3. II, S Review of pertinent wave topics; coastal sediment sources, properties and basic transport concepts: beach scour, accretion and profile changes; mechanical bypassing; littoral inlets; effect of structures; sediment tracing; wind transport. Case studies. Prerequisites: Graduate classification; approval of instructor.

683. Estuary Hydrodynamics. (3-0). Credit 3. I Review of equations for tidal dynamics as applied to real estuaries. Storm surge, stratification, diffusion, sedimentation and model similitude laws. Model studies. Pollution effects in tidal estuaries. Prerequisites: Graduate classification; approval of instructor.

685. Problems. Credit 1 to 6 each semester. I, II, S 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. II Review of fundamental analysis and design techniques; offshore platforms; causeways, docks and wharves; underwater storage tanks; mooring and anchorages; underwater habitats. Prerequisites: Graduate classification; approval of instructor.

687. Marine Foundation Engineering. (2-2). Credit 3. II Study of foundation engineering problems associated with a marine environment. Emphasis placed on settlement and bearing capacity analysis of near-shore and off-shore foundations. Computer programs used to analyze axially loaded piles, laterally loaded piles, and sheet-pile walls. Prerequisites: C.E. 365, graduate classification and approval of instructor.

688. Marine Dredging. (3-0). Credit 3. II Dredge pump design and 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. Prerequisites: Graduate classification; approval of instructor.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

(The Civil Engineering courses in applied mechanics such as elasticity, plasticity, continuum mechanics, etc., are listed in the section entitled Mechanics and Materials under Interdisciplinary Engineering.)

DAIRY MANUFACTURING

A new Master of Agriculture degree program in the College of Agriculture has been tailored specifically to prepare students for a professional career in Dairy Manufacturing. Management training is essential to provide leadership of the highest quality. Entrance requirements and academic standards are the same as required for other graduate programs. A Professional Internship program is required in cooperation with some major company. The student's committee will determine the length of the program. While the student is actively engaged in the Professional Internship program, under the supervision of his committee chairman, he will register for 4 hours of D.S. 684 each semester and 2 hours for each summer term. Students prepare a professional paper instead of a thesis. The curriculum is sufficiently flexible to fit individual needs.

DAIRY PRODUCTION

A fast-growing dairy industry in Texas is creating excellent opportunities for competent management personnel. The new Master of Agriculture degree program in the College of Agriculture offers a program tailored to prepare students for a professional career in large dairy herd management. Other requirements are the same as stated for Dairy Manufacturing. The Professional Internship program will be in cooperation with an approved dairy.

DEPARTMENT OF ECONOMICS

W. R. Allen, R. L. Basmann, A. F. Chalk, A. S. DeVany, R. B. Ekelund, Jr., R. J. Freund, E. G. Furubotn, W. P. Gramm, M. L. Greenhut, H. O. Hartley, I. O. Linger, S. C. Maurice, W. D. Maxwell, T. R. Saving, A. R. Waters*, C. V. Wootan

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. To minor in economics, the student should submit a minimum of 12 semester hours of undergraduate credit in economics. Up to 6 semester hours of prerequisites in economics for majors and minors may be granted for undergraduate courses in statistics, corporation finance, business cycles, and other closely related work in business administration or agricultural economics.

*Graduate Advisor

(Econ.)

601. History of Economic Thought. (3-0). Credit 3. I Survey of the period 1776-1848. Special attention devoted to original works of Smith, Malthus, West, Ricardo and Mill. Prerequisite: Approval of Department Head.

602. History of Economic Thought. (3-0). Credit 3. II Primary emphasis given to the emergence of marginal utility theory and to other British and Continental developments in neoclassical analysis. Prerequisite: Approval of Department Head.

606. Economics of Labor. (3-0). Credit 3. II Survey of theories of labor movement followed by analysis of wage and employment theories, effect of union policies and practices upon wages and employment, and role of unionism in economic stability. Prerequisite: Approval of Department Head.

607. Foundations of Microeconomic Theory. (3-0). Credit 3. II A systematic presentation of microeconomic theory which focuses on the role of prices in directing the actions of individuals and groups of individuals in the processes of production, exchange, and consumption of goods and service. Prerequisite: Approval of instructor.

609. Human Resource Economics I. (3-0). Credit 3. I Study of the valuation and allocation of human resources. Topics: labor supply of households, labor supply over the life-cycle, determination of wages, income distribution, human capital, migration, education, labor markets, and population. Use of the testable implications of theory and of evidence to explain observed labor market behavior is emphasized. Prerequisite: Econ. 607 or equivalent.

610. Human Resource Economics II. (3-0). Credit 3. II Analysis of selected topics and labor markets including unemployment, earnings differentials, effects of occupational licensing, employment problems of ex-convicts, 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. Emphasis is on developing and analyzing empirical problems. Prerequisite: Econ. 609.

611. Foundations of Macroeconomic Theory. (3-0). Credit 3. II, S Development of modern static national income analysis from general equilibrium system. Roles of fiscal and monetary policy in promoting economic stability are examined. Prerequisites: Econ. 323, 410.

612. Fiscal Theory and Policy. (3-0). Credit 3. II Analysis of consumption, investment and government spending, and the influence on the above taxes. Emphasis on total economy, with attention to the differential impact on the subsectors of the economy of changes in governmental expenditures and taxes. Prerequisite: Econ. 410.

613. International Economic Policies. (3-0). Credit 3. I Critical examination of governmental policies toward international trade. Export and import controls, exchange controls, tariff and rehabilitation policies in relation to foreign trade. Prerequisite: Econ. 321.

615. The American Economy I. (3-0). Credit 3. I Brief survey of development of competitive economic system. Analysis of market system with particular reference to behavior of both individual and firm. Study of fluctuations in level of economic activity and macro analytical tools required for understanding causes of such fluctuations. Prerequisite: Graduate classification and approval of Department Head.

616. The American Economy II. (3-0). Credit 3. II Policy course which entails application of micro and/or macro analytical tools to the following problem areas: public finance, international trade and finance, capital markets, labor markets, and social control of business. Prerequisite: Approval of department head.

619. Theory of the Firm in Economic Space. (3-0). Credit 3. I Examination of impacts of distance on classical economic markets and the theory of the firm. Prerequisite: Econ. 323.

621. Regional Science I. (3-0). Credit 3. I A survey of regional economic analysis including industrial and residential location analysis; regional delineation; factor mobility and commodity movements; interregional input-output models; and regional economic growth. Prerequisite: Approval of Department Head.

622. Regional Science II. (3-0). Credit 3. II Additional study of regional economic analysis including regional income accounting, balance of payments, gravity models, industrial

complex analysis, cost-benefit analysis, interregional programming, regional economic planning, interregional trade, and economic base analysis. Prerequisite: Econ. 621.

623. Theories of Economic Development I. (3-0). Credit 3. I Survey of nature and extent of economic development issues, review of theories that facilitate analysis, and examination of specific problems confronting less developed nations. Prerequisite: Econ. 330 or approval of instructor.

624. Regional Income Accounting. (3-0). Credit 3. I Different types of regional accounting systems and their basic problems: income and product accounting, input-output accounting, flow of funds analysis, balance of payments, and the regional balance sheet. Regional and interregional input-output accounting, flow of funds analysis, and balance of payments, the regional balance sheet. Regional and interregional input-output analysis and application to policy problems. Prerequisite: Approval of Department Head.

625. Regional Resource Management. (3-0). Credit 3. II Goals relevant for resource management. Conditions of optimal allocation of resources in a spatial setting. Necessity of regional resource management in a market economy. Analysis of resource base and its development. Activity analysis. Decision models and criteria for regional resource management. Problem areas. Role of planning. Prerequisites: Approval of Department Head.

626. Economic Planning. (3-0). Credit 3. II Theory and policy of regional planning, beginning with consideration of general theory of regional economics, proceeding to analysis of investment planning, manpower planning, and government planning, ending with selected case studies. Prerequisite: Approval of Department Head.

627. Transport Systems Economics. (3-0). Credit 3. I Study of economic structure of primary transport systems with emphasis on impact of transportation on regional development. Examines alternative methodologies for evaluating public policy with respect to investment in and management of transport sector. Prerequisite: Econ. 323 or 330; or approval of instructor.

628. Urban Economics. (3-0). Credit 3. II Economic analysis of structure, functions, and problems of urban areas with particular emphasis on 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. I 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: Econ. 323.

630. Microeconomic Theory II. (3-0). Credit 3. II 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. I Study of basic concepts and propositions of welfare theory. Consideration of such topics as: 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.

632. Theories of Dynamic Economic Equilibria. (3-0). Credit 3. II Study of basic concepts of intertemporal economic behavior. Consideration of such topics as: intertemporal utility maximization, intertemporal profit maximization, dynamic consumer demand theory, and theory of investment. Prerequisites: Econ. 629, Ecmt. 660.

633. Theories of Economic Development II. (3-0). Credit 3. II Continuation of Econ. 623 with emphasis on formal growth models and modern techniques of development planning. Prerequisite: Approval of instructor.

634. Economic Fluctuations. (3-0). Credit 3. II Study of major theories of and factors affecting general economic relationships. Primary emphasis on empirical studies, including special analysis of economic fluctuation. Impact of fluctuations on inventories, capital spending, money stocks, governmental revenues and expenditures, and economic growth. Prerequisite: Econ. 611.

635. Monetary Theory. (3-0). Credit 3. I Traditional as well as modern theories of money. Major emphasis on general equilibrium systems and role of money in determination of

prices, interest rates, income, and employment. Factors influencing demand for money as well as its supply. Prerequisites: Econ. 636.

636. Macroeconomic Theory. (3-0). Credit 3. II, S Attention given to selected problems arising from Keynesian and post-Keynesian income and employment theory. Theoretical and conceptual aspects of the analysis are stressed. Prerequisite: Econ. 410 or 611.

637. Monetary Policy. (3-0). Credit 3. II Analysis of effect of monetary policy on aggregate economic activity and distribution of resources. Evaluation of the effectiveness of various policies and discussion of optimal policy in light of various institutional restrictions that exist. Prerequisite: Econ. 635.

638. Capital and Interest Theory. (3-0). Credit 3. II Development of neoclassical capital theory from Bohm-Bawerk to present time, with emphasis upon the critics of neoclassical theory. Both production and time-preference approaches studied. Prerequisite: Econ. 630.

639. Economic Analysis of Regulated Enterprise. (3-0). Credit 3. I Explore scope of governmental regulation in economy of United States, its evolution and development. Particular emphasis given to application of tools of economic analysis to problems posed by regulated enterprise. Prerequisite: Econ. 424 or approval of Department Head.

640. Economics of Labor. (3-0). Credit 3. II Critical evaluation of existing wage theories; application of these theories to employer wage and employment decisions; analysis of effect of changes in wages, productivity, and prices on level of economic activity; review of current methods for forecasting supply of and demand for labor; development of manpower policy to achieve full utilization of human resources. Prerequisite: Econ. 318.

641. Comparative Economic History. (3-0). Credit 3. I Application of statistical inference and computer analysis to selected problems in comparative economic history. Prerequisites: Econ. 319, 320 or approval of Department Head.

642. Comparative Economic Systems. (3-0). Credit 3. II Historical and modern theories of capitalism, socialism, and communism. Presentation of general analytical framework and its applications to selected case studies. Prerequisite: Approval of Department Head.

649. Industrial Organization and Economic Regulation. (3-0). Credit 3. II Evolution and development of government regulation of economic activity analyzed in light of prevailing theories of microeconomics. Prerequisite: Econ. 607 or 629 or approval of Department Head.

651. International Economic Policy. (3-0). Credit 3. I Emphasis is on interpretation of the balance of payments and the adjustment to national and international equilibria, through changes in price levels, exchange rates, and national incomes. Other topics include: making international payments, determination of exchange rates under various monetary standards, capital movements, exchange controls, and international monetary organization. Prerequisite: Econ. 607 or equivalent.

652. International Trade Theory. (3-0). Credit 3. II Emphasis is on the classical and neoclassical models of international trade. Topics include: 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 commerical policy.

685. Problems. Credit 1 to 3 each semester. I, II, S Individual problems not related to thesis or dissertation. Prerequisites: Graduate classification with major or minor in economics; approval of Department Head.

690. Theory of Economic Research. (3-0). Credit 3. I, II, S The design of research experiments in various subfields of economics, and the evaluation of research results with the aid of examples taken from the current scientific literature.

691. Research. Credit 1 or more each semester. I, II, S Thesis research.

See Agricultural Economics 603 and 633 for description of related courses.

ECONOMETRICS
(Ecmt.)

660. Mathematical Economics. (3-0). Credit 3. I, S Review of use of selected types of mathematical tools in economic theory. Prerequisites: Econ. 323.

661. Mathematical Economics. (3-0). Credit 3. II Examination of fundamental properties of vectors and matrices, 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. I 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. I 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. II Principal statistical techniques in the analysis of economic phenomena including classical linear regression, extensions of linear regression, and linear regression with stochastic regressors, and estimation of simultaneous equation systems. Prerequisites: Ecmt. 662 and two semesters of differential and integral calculus, or Ecmt. 660 and approval of instructor.

665. Econometric Theory and Programming. (3-0). Credit 3. I A study of stochastic and non-stochastic model formulation, identification, methods of solution, and interpretation of results; applications of theory and methods to significant economic problems. Prerequisites: Ecmt. 664; or approval of Department Head.

666. Model Building in Econometrics. (3-0). Credit 3. I Further intensive study of 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. Prerequisites: Ecmt. 664, 665.

667. Case Studies in Econometrics. (3-0). Credit 3. II Primary emphasis given to extensions of dynamic theory and applications of theory and methods to significant dynamic economic problems. Prerequisites: Ecmt. 664, 665.

668. Production Functions. (3-0). Credit 3. II Study of leading production models employed in economic theory. Consideration given to conceptual basis of production function and to particular expressions of the function as found in neoclassical, programming, stock-flow, learning, and dynamic production models. Special emphasis on problems of reconciling empirical production functions with models of pure theory. Prerequisites: Econ. 607, or approval of instructor.

669. Microeconomics and Activity Analysis. (3-0). Credit 3. II Evaluation of effectiveness of free enterprise system via decision theory, linear and nonlinear programming, and matrix alegebra. Prerequisites: Econ. 619; Math. 121 or 209.

DEPARTMENT OF EDUCATIONAL ADMINISTRATION*

A. G. Ashburn, R. I. Berridge, R. A. Felenz, H. L. Hawkins, (Head), P. R. Hensarling, F. W. R. Hubert, L. S. Richardson, D. F. Seaman, R. Terrell

Graduate courses in educational administration are designed to advance knowledge and competence in school administration. Planned programs lead to the Master of Education, Master of Science, or Doctor of Philosophy degrees, and the professional certificate for the all-level school administrator. Professional programs for the certificate are subject to the requirements of the Texas Education

*All department members of the Graduate Faculty serve as Graduate Advisors.

Agency, state accrediting agency. Course work is designed to prepare students to become administrators and to assist practicing administrators to improve their professional efficiency.

The department offers special graduate programs in Public Relations, School Business Management, Higher Education and Community Education. An adjunct of the department is major participation in an interdisciplinary program in Adult Education.

Members of the faculty have had successful teaching and administrative experiences in the fields related to the courses they are assigned to teach. Emphasis is given to counseling the graduate student and to supervising his program of study.

Information concerning the Ph.D. foreign language requirement may be obtained from the departmental office.

*All department members of the Graduate Faculty serve as Graduate Advisors.

(Ed.Ad.)

606. Administration of Elementary and Secondary Schools. (3-0). Credit 3. I, S Study of the organization and administration of elementary and secondary schools. Administration and supervision of curriculum and instruction. Prerequisite: Twelve hours of Education or approval of Department Head.

608. School Finance and Business Management. (3-0). Credit 3. I, S Study of 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. 606, 615 or approval of Department Head.

609. Public School Laws. (3-0). Credit 3. II, S Constitutional provisions, statutory laws, court decisions, and regulations governing public schools with special reference to Texas and federal relationships. Prerequisite: Ed.Ad. 606 or approval of Department Head.

613. The School Plant. (3-0). Credit 3. I, S Study of plans for determining extent and character of present and future building and equipment needs of school unit; efficiency of present plant, operation and maintenance, planning building program. Prerequisites: Ed. Ad. 606, 615 or approval of Department Head.

615. The School Superintendency. (3-0). Credit 3. II, S Organization and administration of systems of schools and their relationships on federal, state, intermediate, and local levels. Also private, parochial, and adult education. Prerequisites: Ed.Ad. 606, 616, or approval of Department Head.

616. Administration of Staff Personnel. (3-0). Credit 3. I, S Analysis of personnel organization and administration in school systems. Relationship of positions. Ethics, welfare, security, and professional improvement. Prerequisite: Ed.Ad. 639 or approval of Department Head.

620. Educational Program Evaluation. (3-0). Credit 3. I, II, S A study of the theory and practice of evaluation of instructional programs, management and support services, and project operations, with special emphasis on the nature and preparation of evaluation designs and management of educational evaluation functions.

635. Administration of Special Services. (3-0). Credit 3. I, S To help administrators, counselors, supervisors, and teachers develop an understanding of functions, operation and evaluation of special services which support the educational program.

639. Processes in Educational Leadership. (3-0). Credit 3. I, II, S Analysis of skills and techniques of administrator in modern school, emphasizing democratic leadership, teacher-administrator relationships, group processes, and evaluation of administrative programs.

640. School-Community Relationships. (3-0). Credit 3. II, S Systems of interpretation of schools to community publics. Promotion of effective school-community relations through media of communication.

641. Community Education. (3-0). Credit 3. II, S Will familiarize the student with the structure, purpose and strategies of community education with particular emphasis on the community school.

643. Internship in Community Education. (0-9). Credit 3. I, II, S To give the prospective community education coordinator, administrator and teacher on-the-job experience under the guidance of a trained community education coordinator and under supervision of a department faculty member. Prerequisites: Ed.Ad. 641; approval of instructor.

644. Practicum in Educational Public Relations. (0-9). Credit 3. I, II Designed to give the prospective specialist in public relations on-the-job experience under the guidance of practicing specialists in various areas of public relations. To be supervised by a department faculty member. Prerequisites: Ed.Ad. 640, plus six related semester hours to be approved; Jour. 405.

645. Practicum for the College Administrator. (0-9). Credit 3. I, II Designed to give the prospective college administrator on-the-job training under the guidance of practicing college administrators and the supervision of a department faculty member who has had experience as a college administrator. Prerequisites: Ed.Ad. 655 plus nine semester hours in Educational Administration to be approved.

646. Internship for the School Principal. (0-9). Credit 3. I, II Designed to give prospective school principal on-the-job training under guidance of successful, experienced, practicing public school administrator and supervision of member of university staff. Certification requirement for principalship.

647. Internship for the School Superintendent. (0-9). Credit 3. I, II Designed to give prospective school superintendent on-the-job training under guidance of successful, experienced, practicing public school administrator and supervision of member of university staff. Certification requirement for superintendency.

648. Internship for the School Business Administrator. (0-9). Credit 3. I, II Internship designed to give prospective school business administrator on-the-job training under guidance of successful, experienced, practicing public school administrator and supervision of members of university staff. Prerequisite: Approval of Department Head.

649. Accreditation of Educational Systems. (3-0). Credit 3. S Principles and procedures governing accreditation of local school systems by state educational authorities; regional and special purpose accrediting associations. Includes study of historical bases for accreditation and analysis and use of contemporary evaluative instruments.

651. Orientation in Business Principles and Procedures. (3-0). Credit 3. I, S Interdisciplinary survey course utilizing various fields in business to broaden knowledge of school superintendent and school business official. Case studies. Field studies. Prerequisite: Approval of Department Head.

652. Educational-Governmental Relationships. (3-0). Credit 3. II, S Interdisciplinary survey course utilizing various fields in political science, comparative government, American and state history. Interrelationships of educational administration to political organizations. Prerequisites: Master's degree; approval of Department Head.

653. The Nature and Problems of Administrative Behavior. (3-0). Credit 3. I, S Interdisciplinary survey course utilizing case study method. Designed to enhance understanding of organizational theory and the appropriate techniques in decision making, communication, and personnel relations required by the educational administrator. Prerequisites: Master's degree; approval of Department Head.

654. Teacher Education and Professional Standards. (3-0). Credit 3. I, II, S Relationships between teacher education and professional standards and teaching as a profession. Topics consist of cluster of broad problems which teachers in public school encounter repeatedly. Includes criteria of profession, theory of professional standards, standards of practice, and orientation to current guidelines and legal sanctions. Prerequisite: Approval of Department Head.

655. Administration of Higher Education. (3-0). Credit 3. II, S Survey of management principles in higher education. Functions in delegation, direction, operation, evaluation, and financial management applied to college and university administration. Prerequisite: Ed.C.I. 601 recommended but not required.

656. Administration of Supervisory Personnel. (3-0). Credit 3. I, S The administration of public school supervisory programs; the roles of administrators in the management of supervision; organization of the supervisory staff in small and large schools. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1. I, II, S Problems pertinent to superintendent and principal. Recent developments and research in different areas. Prerequisites: Twelve hours of advanced education; approval of Department Head.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problem in field of administrative education. Prerequisite: Graduate classification in education.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis.

DEPARTMENT OF EDUCATIONAL CURRICULUM AND INSTRUCTION

J. K. Campbell*, D. W. David*, J. Ilika*, D. Janke*, G. R. Johnson (Head)*, J. H. Rollins*, R. E. Shutes*, W. F. Stenning*

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, and Doctor of Philosophy degrees.

The department offers specializations in elementary, secondary, and higher education, in general curriculum and instruction, in reading, and in a variety of subject matter fields, including mathematics, science, language arts, and social studies. Degree programs are 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 they 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 course contents.

Information about prerequisites, research, or language requirements can be obtained from the departmental office. Requirements will be determined by the student's Advisory Committee.

(Ed.C.I.)

601. College Teaching. (3-0). Credit 3. I, II, S Conceptions of higher education underlying typical programs including general education, learning process, and effective use of techniques and instrumentalities of classroom instruction.

602. Cultural Foundations of Education. (3-0). Credit 3. II, S Contributions of social and cultural foundations applied as analytic tools in solving problems of curriculum and instruction.

604. Reading Diagnosis. (2-3). Credit 3. I, S Appraisal and diagnosis of reading problems. Practicum in administration and interpretation of individual reading inventories. Prerequisite: Approval of Department Head.

605. Creative Application of Technology to Education. (2-3). Credit 3. II, S Identification and solution of learning problems utilizing a learning systems approach; creative application

*Graduate Advisor

of educational technology (programmed instruction, single-concept films, television, electronic carrels, etc.)

607. Programs and Procedures in Supervision. (3-0). Credit 3. II,S Designed for teachers, supervisors, and administrators. Philosophy, organization, and administration of supervision of both elementary and secondary schools.

618. Teaching Elementary School Mathematics. (3-0). Credit 3. II, S New approaches to teaching numeration presented, emphasizing importance of place value and decimal system with consideration of systems of natural numbers.

619. Teaching Basic Concepts of Mathematics. (3-0). Credit 3. II, S Following review of number systems of elementary school mathematics, teaching use of numbers for quantifying geometric configurations is considered. Study of measurement with emphasis on nature of approximation precedes treatment of relation and function in cartesian frame of reference.

620. Teaching Secondary School Algebra. (3-0). Credit 3. S Techniques in teaching properties of real numbers and of order relations, factors, radicals, and polynomial expressions. Emphasis on techniques of presenting concepts at various levels of complexity. Prerequisites: Six hours of calculus or certification in secondary school mathematics.

621. Teaching Secondary School Geometry. (3-0). Credit 3. II Techniques in teaching point-set geometry are presented, including coordinates on a line, congruence, parallelism, similarity, and coordinates in planes, and in space. Emphasis on techniques of presenting concepts at various levels of complexity. Prerequisites: Six hours of calculus or certification in secondary school mathematics.

637. Advanced Elementary School Methods. (3-0). Credit 3. II Study of teaching methods, devices, and techniques of learning-teaching situations on elementary school level. Prerequisites: Twelve hours in elementary education or an elementary school certificate.

638. Trends in Curriculum and Instruction. (3-0). Credit 3. I, II, S Recent research and development in theories and practices of curriculum and instruction. Special attention given to programmed subject content and new instructional media. Prerequisite: Twelve hours of education or approval of Department Head.

642. Clinic Teaching in Reading. (1-6). Credit 3. II, S 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.CI 351; Psy. 307, 624, or 634; or equivalent approved by Department Head.

643. Current Issues in Elementary Education. (3-0). Credit 3. I, S Current educational issues affecting curriculum and organization of elementary school. Organizing instruction to meet individual differences, including gifted and disadvantaged student. Prerequisites: Twelve hours in advanced education or equivalent.

644. Curriculum Development. (3-0). Credit 3. I, II, S Analysis of curriculum development. Bases of curriculum design. Study of problems of balance, scope, organization, sequence, selection, and articulation.

645. Society and Education in World Perspective. (3-0). Credit 3. S Advanced study of comparative education with emphasis on the interrelationships among societal institutions and the particular roles that education plays in different cultures and political systems. Prerequisites: Ed.C.I. 402, 421 recommended.

646. Instruction Theory. (3-0). Credit 3. II, S Theoretical basis for research and training in instruction. Systematic study of existing research on key factors influencing instructional effectiveness. Exploration of interaction among modes of instruction. Prerequisite: Ed.C.I. 675.

647. Curriculum Theory. (3-0). Credit 3. II, S The theoretical basis for curriculum conceptualization, development, evaluation and implementation. The 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. I, S Basic principles of reading instruction; nature and scope of total reading program; methods, materials, and organization of the developmental, corrective, and speed-reading programs in high school and college.

650. Foundations of Reading Instruction. (3-0). Credit 3. I, II, S Psychological, linguistic, and physical factors related to reading performance; implications for content and teaching methods; appraisal of current materials and related reading for teachers, supervisors, and reading specialists. Prerequisite: Approval of Department Head.

662. Philosophical Theories of Education. (3-0). Credit 3. II, S Study in depth of selected historical theories of education from Plato to Skinner. Emphasis on evaluating educational ends and means, with stress on the nature of knowledge, its acquisition, and transmission. Prerequisite: Graduate classification in Educational Curriculum and Instruction.

670. Social Studies in Elementary and Secondary Education. (3-0). Credit 3. I, S Methodology course focusing upon the implementation, both practical and theoretical, of the objectives of social studies: current trends, resource materials, demonstrations of teaching methods.

671. Creative Art Education: Sculpture. (2-3). Credit 3. S Advanced course in teaching the techniques of sculpture in various media with particular emphasis on stimulating creative thought and skills.

672. Curriculum and Methodology of Language Arts. (3-0). Credit 3. II, S Advanced methodology course for teachers of language arts courses and their supervisors. Emphasis on total curriculum development, attitudes and procedures for fostering developmental skills and creativity.

673. Analysis of Teaching Behavior. (3-0). Credit 3. I, II, S Methods of gathering teaching behavior data. Use of computer for analyzing and interpreting data collected. Video-tape recording micro-teaching lessons.

674. Developmental Reading in the Elementary School. (3-0). Credit 3. II, S Analysis of methods and materials of reading instruction in the elementary grades. Includes study of past, present, and emerging programs; organization and administration of programs and classroom management; linguistics and psychological factors; teaching reading to special groups; issues in reading; reading research.

675. Teaching Strategies: Patterns of Learning. (3-0). Credit 3. I, S Learning and teaching theory and research applied to development of teaching strategies appropriate for various contents, objectives, and instructional situations. Systematic analysis of variables influencing learner behavior and of approaches to optimization of teacher behavior. Prerequisite: E.Psy. 602 or 673 or approval of Department Head.

676. Teaching Strategies: Critical Problems. (3-0). Credit 3. II, S Analysis of critical teaching problems confronting teachers. Enrollees simulate role of classroom teacher and are required to make decisions regarding alternative courses of action they might take in each critical teaching situation. Critical problems have been identified through research studies and surveys. Prerequisite: Approval of Department Head.

677. Strategies for Teaching the Disadvantaged. (2-2). Credit 3. II Development of teaching strategies for disadvantaged students in elementary and secondary school classes; rationales for modes of learning in various curriculum subjects; relation of materials and methods to affective and cognitive aspects of learning for disadvantaged students; laboratory exercises with disadvantaged students.

681. Seminar. (1-0). Credit 1. I, II, S Problems pertinent to counselor, supervisor, and teacher. Recent developments and research in different areas. Prerequisites: Twelve hours of advanced education, approval of Department Head.

684. Professional Internship. Credit 1 to 6 each semester. I, II, S 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. Prerequisites: Approval of Department Head; approved degree plan on file.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problems in the field of education.Prerequisite: Graduate classification in education.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis.

DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

C. R. Anderson*, D. G. Barker*, C. A. Borman*, L. H. Hope*, S. A. Kerley, C. E. McCandless, C. J. Martin*, W. R. Nash, R. R. Reilley*, A. J. Roach (Head)*, S. D. Smith, W. F. Stenning*, W. R. Thomas.

The Department of Educational Psychology offers the M.Ed., M.S. and Ph.D. degrees in Educational Psychology. Within each of these degree structures the department offers specializations in college student personnel work, counselor education, counseling psychology, psychological foundations of education and special education. Students seeking admission to the various programs are expected to have suitable background work in the behavioral sciences. They are also asked to visit the campus for a personal interview with appropriate faculty members, if at all possible.

The doctoral degree is an interdisciplinary degree which requires extensive work in statistics, psychology, sociology or other related areas of study. There is a foreign language requirement for the doctoral degree. Additional information on doctoral programs may be obtained from the department office.

The department offers preparation in counseling in three areas of specialization. To foster quality preparation, these counseling programs operate a modern laboratory training facility in which practicum experiences are provided.

The Counselor Education Program prepares students for state certification as guidance associates and school guidance counselors. Preparation may emphasize elementary, secondary, vocational or special education applications.

The Counseling Psychology Program prepares students to work as counselors in colleges and universities. Students preparing to work in a variety of social service agencies may also pursue training in this program.

The College Student Personnel Program prepares students for such positions as deans, directors of or specialists in counseling, admissions, financial aids, placement, residence halls, student union and activities programs and related services. Preparation is available for students planning to serve in two-year institutions, senior colleges or universities.

The Special Education Program currently emphasizes preparation for working with learning-disabled children and for diagnosis of learning disabilities (psychometry). It also prepares generic special education workers. The Special Education Program operates the Psychological Services Laboratory which serves the public and its schools. Through its services graduate students are given appropriate training in various aspects of special education under qualified supervision.

The Psychological Foundations of Education Program prepares specialists in the educational applications of human learning and development as well as in measurement and research methodology. In conjunction with this program, the department operates the Human Learning Research Laboratory as an endeavor for discovery of basic knowledge concerning human learning processes and as a vehicle for training research specialists in human learning.

Preparation as a professional in the various specialties offered in the department requires attention to personal characteristics of the individual 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 pursuing certificate or degree programs satisfy the demands of the appropriate screening committees for the various specializations. These committees may rightfully expect

*Graduate Advisor

that students submit personal references, complete selected tests and be interviewed by appropriate faculty members. Formal admission is contingent upon the screening committee's decision concerning the individual's total fitness and promise as a professional person in the specialization for which application is made. Students in all programs will periodically have their total progress in professional development reviewed by a faculty committee to determine whether or not they shall be permitted to continue.

All new certificate or degree students are required to enroll in a one-hour orientation and self-awareness seminar. They should do so during their first full semester of studies or prior to completion of 9 hours of work.

Field experiences or internships in appropriate school, college or social agencies are required in most programs. Students completing degrees in this department are eligible to apply for certification with the Texas State Board of Psychological Examiners.

(E.Psy.)

602. Educational Psychology. (3-0). Credit 3. I, II, S Study of scientific concepts of learning and the principle influences in learning process. Consideration of effects of development, aptitude, emotional and social maturation, and environment on learning.

611. Learning Characteristics of Exceptional Children. (3-0). Credit 3. I, S Designed to explore learning behavior of exceptional children. Educational, psychological and medical information interpreted as it is relevant to the learning-disabled in public schools. Educationally relevant conceptual models will be used.

612. Individual Assessment in Education. (3-0). Credit 3. II Theory and educational applications of individual assessment. Instruments studied include 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 or Psy. 623, 624.

613. Individualized Teaching of Exceptional Children. (3-0). Credit 3. II, S Traditional and experimental teaching strategies for exceptional children. A systems model will be presented for the management of educational data on individual pupils. Emphasis will be placed upon collection, analysis, teacher interpretation of data and formulation of recommendations for educational change.

614. Laboratory in Educational Assessment and Diagnosis. (1-6). Credit 3. I, II, S Evaluation of student test administration competencies and supervised experience in the administration, analysis and reporting of individual diagnostic instruments. Prerequisite: E.Psy. 612.

615. Individual Instruction Programming. (1-6). Credit 3. I, II, S Laboratory experiences in developing prescriptions for individual teaching of learning-disabled children. Translation of diagnostic test results into programs of individual instruction. Prerequisite: E.Psy. 613.

616. Field Experiences in Special Education. (1-6). Credit 3. I, II Participation in an approved special education program. Field experiences are supervised by the course professor and a certified professional in special education. Ninety hours of scheduled, supervised experience, a daily log of pertinent activities and an in-depth case study are required. Prerequisite: E.Psy. 410.

622. Measurement and Evaluation in Education. (3-0). Credit 3. I, II, S Principles of psychological testing applied to education. Uses and critical evaluation of achievement and aptitude tests and performance in educational settings.

625. Test Construction. (3-0). Credit 3. II Planning, construction, analysis, and evaluation of written and performance test. Test item analysis, reliability studies, and validity studies. Development of test norms, score transformations, and equivalent forms of tests. Prerequisite: E.Psy. 439 or equivalent.

629. Counseling Practicum I. (2-3). Credit 3. I, II, S Supervised experience in individual counseling. Cases to be assigned in the counseling laboratory on campus. Off-campus counseling in schools and various agencies may also be assigned at the supervisor's

discretion. Prerequisites: E.Psy. 631, approval of Department Head and application six weeks prior to registration.

631. Techniques of Counseling. (3-0). Credit 3. I, II, S Methods of gathering, analyzing, and interpreting case data in counseling. Analysis of dynamics of counselor-counselee relationship. Interviewing techniques. Use of test results in counseling. Prerequisites: E.Psy. 622, 660, Psy. 634, and approval of Department Head.

632. Educational and Occupational Information. (3-0). Credit 3. II, S 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. Methods of Group Guidance. (3-0). Credit 3. I, S Group aspects of student personnel work for counselors, administrators, and other professionals dealing in services where group counseling is provided. Theory and practice of group procedures.

636. Techniques of Research. (3-0). Credit 3. I, II, S 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. I Designed to provide preparation in experimental research design in educational studies emphasizing the application of statistical methods in these designs. Prerequisite: Six hours of statistics.

660. Foundations of Guidance. (3-0). Credit 3. I, S Philosophical, psychological and sociological concepts fundamental to guidance and related helping professions.

661. Operation of Guidance Services. (3-0). Credit 3. S Management of guidance and related personnel services. Considerations and procedures in the organization, administration and evaluation of these services at various educational levels and in various situations. Prerequisite: E.Psy. 660.

662. Issues and Trends in Guidance. (3-0). Credit 3. II, S Recent research and developments affecting guidance as a profession. Special attention to ethical considerations, professional relationships, emerging trends and issues. Prerequisite: Twelve graduate hours in guidance.

663. Field Experiences in Guidance. (1-6). Credit 3. I, II, S Supervised participation in various phases of established guidance programs. Application of guidance techniques in settings appropriate to the student's proposed level of specialization. Prerequisite: E.Psy. 629, approval of Department Head, and application six weeks prior to registration.

664. Counseling Practicum II. (1-6). Credit 3. I, II, S Supervised experience in individual and group counseling requiring advanced technical skills. Stresses the use of modern technology in improving continuing counseling relationships with various, selected subjects. Prerequisites: E.Psy. 629, approval of Department Head and application six weeks prior to registration.

666. Practicum in Counselor Supervision. (1-6). Credit 3. I, II, S Supervised experience in directing couseling 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.

667. Guidance in Elementary School. (3-0). Credit 3. I, S Examination of the role of guidance in the elementary school with emphasis on the unique aspects of elementary guidance which differentiate it from guidance in other situations. Intended for teachers, school administrators, and prospective counselors.

668. Early Childhood Behavioral Development. (3-0). Credit 3. I, S Social and individual factors affecting child development during the period from conception to age 6 and their consequences to the socialization and learning processes of the individual. Observation, research and case studies will augment the theoretical framework. Prerequisite: Approval of Department Head.

669. The College Student. (3-0). Credit 3. II, S Nature, needs and characteristics of American college student, focusing on developmental tasks, peer group relations and impact of college environment on student development. Research from behavioral sciences will be considered. Prerequisite: Graduate classification.

670. Student Personnel Work in Higher Education. (3-0). Credit 3. I, S Survey of student personnel services in higher education emphasizing principles, philosophy, and major theoretical issues. Organization and administration of specialty areas. Prerequisite: Graduate classification.

672. Theories of Counseling. (3-0). Credit 3. I, S Comprehensive and intensive study of major theoretical positions in counseling, stressing implications for research and practice. Prerequisites: E.Psy. 631 or approval of Department Head.

673. Learning Theories for Educators. (3-0). Credit 3. I, S Comprehensive study of classical and current learning theories emphasizing their significance to modern education. Prerequisite: Graduate classification.

674. Verbal Learning and Verbal Behavior. (3-0). Credit 3. II Examination of current research dealing with the methodologies used in the study of verbal processes in children and adults; variables influencing verbal learning. Research on special language problems encountered by handicapped and culturally different children. Application of research findings to educational programs involving verbal learning. Prerequisite: E.Psy. 673.

675. Seminar in Developmental Counseling. (3-0). Credit 3. II An in-depth study of the counseling process to prepare students for conducting research in this area. Study of the major research efforts in counseling psychology. Key problems in counseling research. Review of research pertinent ot the principal variables in the counseling process. Prerequisites: E.Psy. 439, 631, 636 or equivalent.

681. Seminar. (1-0). Credit 1. I, II, S Recent developments, research and problems in counseling and/or educational psychology. Prerequisite: Approval of Department Head.

684. Professional Internship. Credit 1 to 4 each semester. I, II, S Application of academic preparation in a university-directed experience in a professional employment setting. Involves full participation and responsibility in experiences related to career specializations in educational psychology including counseling, guidance, college student personnel work, teaching or research. Offered on an individual basis. Repeatable to 9 hours total. Prerequisite: Approval of student's Advisory Committee Chairman and the Department Head.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problems in field of educational psychology. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

DEPARTMENT OF ELECTRICAL ENGINEERING

C. W. Alworth*, A. K. Ayoub*, S. L. Canterbury, Jr., R. K. Cavin, III*, J. S. Denison*, A. J. Druce*, L. E. Fite*, J. P. German*, A. J. Giarola*, D. R. Gimlin*, G. D. Hallmark*, J. M. Herman, III, H. J. Holley, J. W. Howze, W. B. Jones, Jr. (Head)*, J. S. Linder*, W. T. Mayo*, P. S. Noe*, A. D. Patton*, W. A. Porter*, V. T. Rhyne*, S. Riter*, J. W. Rouse*, J. L. Stone*

The Department of Electrical Engineering offers opportunities for graduate study and research leading to Master's and Ph.D. degrees. Current areas of specialization include solid state electronics, digital systems, communications, control, electromagnetics, power systems and electronic computers. In addition, interdisciplinary programs are available in computer science, biomedical engineering, systems engineering and other areas.

Well-equipped laboratories are available for work in all of these areas. The special facilities and programs of the Institute for Solid State Electronics and the

*Graduate Advisor

Electric Power Institute support research and graduate programs of electrical engineering graduate students in these areas. Electrical engineering faculty and graduate students also participate in programs of the Remote Sensing Center, Data Processing Center, Center for Urban Programs, Space Technology Division and other interdepartmental activities.

There is no foreign language requirement for the Ph.D. in electrical engineering.

(E.E.)

(In the summer session these courses may be divided into two parts, a and b, offered in the first and second session, respectively.)

601. Linear Network Analysis.(3-0). Credit 3. I, S Fourier and Laplace transform methods of analysis applied to linear networks having periodic, transient, or random excitation.

602. Nonlinear Network Analysis. (3-0). Credit 3. II Analysis and application of nonlinear electrical and electronic systems. Introduction to stability and phase plane analysis.

605. Linear Control Systems. (3-3). Credit 4. I, S Continuation of E.E. 420 to include advanced topics which will extend study of analytic methods as applied to linear systems and introduce concepts related to linear systems synthesis. Prerequisite: E.E. 420.

606. Nonlinear Control Systems. (3-0). Credit 3. II Study of techniques avalilable to analyze nonlinear systems and discontinuous systems, and study of associated synthesis procedures. Prerequisite: E.E. 605.

607. Alternating Current Circuits and Machines. (3-4). Credit 4. I Study of transient conditions in electrical machines. Prerequisite: E.E. 401.

615. Methods of Electric Power Systems Analysis. (3-0). Credit 3. II Matrix formulation of power system network problems. Short circuit, load flow, transient stability and economic dispatch studies. Applications of computers in power systems analysis. Prerequisite: E.E. 460 or approval of instructor.

624. Electronic Circuits for Instrumentation and Computation. (3-3). Credit 4. II Analysis and design of electronic circuits used in instrumentation and computation. Amplifiers, "and" circuits, "or" circuits, and "gate" circuits. Problems of drift compensation in DC amplifiers and closed-loop stability in multi-stage amplifiers treated in detail. Prerequisites: E.E. 326, 448, 457.

628. Linear System Theory. (3-0). Credit 3. II Analysis of general dynamic systems using vector space concepts.

630. Electronic Instruments and Measurements. (2-3). Credit 3. I, II For students other than electrical engineering majors. Study of electronic instrumentation and measurement techniques for graduate students in the fields of science and engineering. Concerned with the use and basic operation of oscilloscopes, AC and DC meters, power supplies, signal generators, amplifiers, digital circuits, and transducers as related to the field of measurements.

633. Optimum Control Systems. (3-0). Credit 3. I Study of analytic techniques used to design optimum control systems and of methods of mechanizing systems which adapt to their environment. Prerequisite: E.E. 605.

636. Network Synthesis. (3-0). Credit 3. I Synthesis of electrical networks having arbitrarily specified terminal characteristics. Realizability conditions, realization of general two-terminal and four-terminal networks, and approximation of network specifications. Prerequisites: E.E. 601; Math. 601.

637. Wave Guides and Cavities. (3-0). Credit 3. I Application of Maxwell's equations to solution of guided electromagnetic fields. Studies in skin effect, rectangular wave guides, circular wave guides, cavities, and microwave networks. Prerequisite: E.E. 451.

638. Antennas and Propagation. (3-0). Credit 3. II Application of Maxwell's equations to determine electromagnetic fields of antennas. Studies in radiation, directional arrays, impedance characteristics, aperture antennas. Prerequisite: E.E. 451.

639. Microwave Circuits. (3-0). Credit 3. I Principles of microwave circuits and systems; basic theorems, matrix formulation of microwave network problems. Boundary value problems, including discontinuities in wave guides. Special topics such as slow-wave structures, striplines, microwave integrated circuits, etc. Prerequisite: E.E. 451.

640. Wave Propagation in General Media. (3-0). Credit 3. II Review of mathematical formulation of electromagnetic wave propagation. Elastic waves, spinwaves. Electromagnetic wave propagation in a random medium. Selected topics of current interest, such as elastic wave propagation in a layered medium, spin-elastic waves in magnetoelastic media, etc. Prerequisite: E.E.451.

642. Transistors. (3-3). Credit 4. I, S Theory of junction triodes; voltage, current, power and frequency limitations. Small signal parameters and equivalent circuits for transitors; analysis of design of circuits at both small and large signal levels. Prerequisite: E.E. 326.

643. Electric Power System Reliability. (3-0). Credit 3. I 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. II Study of techniques for analysis of sampled data and discrete data servo systems and associated synthesis procedures. Prerequisite: E.E. 605.

645. Applications of Linear Graph Theory. (3-0). Credit 3. I Engineering applications of linear graph theory to topics in which network topology is of importance, including network analysis and synthesis, switching circuits, signal flow graphs, and communication nets. Prerequisite: Approval of instructor.

646. Statistical Communication Theory. (3-0). Credit 3. II Generalized harmonic analysis of deterministic and random signals; elements of probability and statistics; detection of signals in noise; sampling theory; optimum linear systems. Prerequisites: E.E. 601; Math. 601.

647. Information Theory and Coding. (3-0). Credit 3. II Theorems of Shannon applied to transmission and coding of information. Markov processes, instantaneous codes; transmission over noiseless channels; error-correcting codes and noisy channels without memory. Prerequisites: E.E. 456, 646 or equivalent background in probability theory.

648. Electromagnetic Wave Propagation. (3-0). Credit 3. II Study of electromagnetic surface waves; direct and ground-reflected space waves; tropospheric refraction, reflection, and scattering; ionospheric refraction, reflection and scattering. Prerequisite: E.E. 451.

649. Plasma Waves. (3-0). Credit 3. I Plasma equations in a cold, collisionless plasma. Wave motion with and without magnetic field. Different waves propagating in a plasma. Wave propagation behavior in different temperature regions. Wave guidance. Prerequisites: E.E. 451 or equivalent; Math 407.

651. Microprogrammed Control of Digital Systems. (3-0). Credit 3. I, S Introduction to and historical background of microprogrammed control; contrast with wired-logic controllers; examples of microprogrammed control of digital computers and other digital systems; use of memory; design and construction of microprogrammed systems. Prerequisite: E.E. 448 or approval of instructor.

652. Digital Systems Design. (3-3). Credit 4. I Advanced topics in digital system design, including state reduction and assignment, sequential machines, digital filtering, and error correcting codes. State-of-the-art in component technology for implementing digital systems: characteristics of digital integrated circuits, analog-to-digital and digital-to-analog conversion, electromechanical digital devices. Case studies in digital system design. Prerequisite: E.E. 448 or equivalent.

653. Electronic Computer Design. (3-3). Credit 4. II Design of digital computers including arithmetic unit design, control, and memory. High-speed addition, subtraction, multiplication and division; micro- and macro-programming; magnetic memory devices. Emphasis upon design with integrated circuit components, including MSI devices. Prerequisite: E.E. 448.

656. Physical Electronics. (3-0). Credit 3. I Review of elementary quantum theory. Statistical mechanics. Gaseous electronics. Semiconductor theory. Dielectrics. Magnetic materials. Quantum electronics. Introduction to quantum devices, including the laser. Prerequisite: Graduate classification in electrical engineering or approval of instructor.

657. Advanced Electronic Devices. (3-0). Credit 3. I Advanced electronic devices important to electrical engineers in graduate or industrial research. A range of devices is covered, including advanced semi-conductor devices, magnetic devices, microwave devices, and superconductive devices. Prerequisite: E.E. 656.

658. Lasers. (3-0). Credit 3. I Lasers from physical phenomena to applications. Similarities to feedback amplifiers emphasized. Solid, liquid, and gas lasers considered. Applications include holography, ranging, biomedical, etc. Prerequisite: E.E. 656.

659. Electro-Optical Systems Engineering. (3-0). Credit 3. I Introduces electro-optical devices and systems theory with applications to engineering problems. Topics include laser beam propagation, two dimensional Fourier analysis of optical systems, modulation and detection devices, and limitations of modulation and detection systems. Engineering applications include optical communications, optical data processing, pollution monitoring, holography, and remote sensing instrumentation. Prerequisite: Registration in E.E. 601.

661. Modulation Theory. (3-0). Credit 3. II Study of 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. I Application of classical estimation and detection theory to problems of detecting signals in noise, estimating signal parameters in noise, and continuous modulation theory. Prerequisite: E.E. 646.

665. Electric Power Systems Engineering. (3-0). Credit 3. II Topics in electric power system engineering selected from: transient voltages in power systems, electric utility economics, evaluation of power generation sources, d-c power transmission, load forecasting, and current problems of interest. Will involve group study, reports, design problems. Prerequisites: Graduate classification and approval of instructor.

666. Power System Faults and Protective Relaying. (3-0). Credit 3. I 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.

671. Solid State Devices. (3-0). Credit 3. I Development of mathematical analysis and design of solid state devices. Studies in relationships of measurable electrical characteristics to morphology and material properties of solid state devices.

672. Solid State Device Modeling. (3-0). Credit 3. II Systematic modeling of active and passive solid state devices. Ebers-Moll models, charge control models, and Linvill lumped models with emphasis on the latter and a theory for the systematic derivation of such models. Other nonlinear models also considered. Selected circuit applications.

673. Fundamentals of Microelectronics. (3-0). Credit 3. I Fundamental study of microelectronic systems or integrated circuits, fabrication technologies, monolithic integrated circuits, hybrid integrated circuits (thin films, thick films, monolithic chips). Prerequisite: E.E. 671 or equivalent.

677. Control of Electric Power Systems. (3-0). Credit 3. II 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. I, II 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.

685. Problems. Credit 1 to 4 each semester. I, II, S Research problems of limited scope designed primarily to develop research technique.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

ENGINEERING
(Engr.)

601. Engineering Concepts for Secondary School Teachers I. (1-3). Credit 2. S Materials and solid mechanics; physical structure of solid materials; introduction to solid mechanics; dynamic effects on materials; creep; fatigue.

602. Engineering Concepts for Secondary School Teachers II. (1-3). Credit 2. S System dynamics: an introduction to the concepts and methods of analyzing linear, continuous lumped parameter control and communication systems. Mathematical methods, modeling, stability, performance measures, graphical representations, and laboratory experiments.

603. Engineering Concepts for Secondary School Teachers III. (1-3). Credit 2. S Energy: storage, conversion, and distribution. Conversion methods of natural energy resources into useful forms. Basic laws governing efficiency of conversion, characteristics of machinery used, measurement of performance. Development and use of laboratory equipment to demonstrate principles. Prerequisites: Algebra, trigonometry, chemistry, physics. Enrollment in Engr. 601, 602.

DEPARTMENT OF ENGINEERING DESIGN GRAPHICS

S. M. Cleland, J. H. Earle (Head)*, J. G. McGuire

The graduate program in engineering design graphics provides 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, and special equipment for each course.

(E.D.G.)

601. Advanced Industrial Drawing. (2-3). Credit 3. I, S Pictorial systems — axonometrics, obliques, and perspectives. Shade and shadow theory. Study of industrial pictorial applications. Research and development of visual aids. Introduction to technical illustration. Prerequisites: E.D.G. 106, 127 or equivalent.

603. Advanced Machine Drawing. (1-6). Credit 3. II, S Study of current industrial practices. Graphical applications to design, analysis, and communication. Working drawing practices. Machine components, jigs, fixtures, cams, linkages.

605*. Spherical Projections. (2-0). Credit 2. II, S Graphical cartography and topographical representations. Application of spherical drawings to global projections and spherical structures. Graphical applications to mapping problems.

*Graduate Advisor

606*. Stereographic and Clinographic Projections. (2-0). Credit 2. I, S Research and experimentation with stereographic (3-dimensional) photography and drawing as applied to industry and teaching. Development of audio-visual presentations and teaching aids. Graphical investigation of perspectives and related systems. Prerequisite: E.D.G. 105 or equivalent.

607*. Descriptive Geometry for Teachers. (4-0). Credit 4. I, S Research of early and current applications of descriptive geometry to technical problems. Research and study of new principles for advancement and improvement of teachers of current graphics curricula. Prerequisites: E.D.G. 106; I.Ed. 323 or equivalent.

611. Technical Illustration. (3-3). Credit 4. II, S Introduction to commercial methods and materials of technical illustration. Preparation of illustrations for reproduction. Report illustration, illustrations for publication. Time-saving techniques and methods. Various media including airbrush renderings.

685*. Problems. Credit 1 to 4 each semester. I, II, S Special research problems to fit needs of individual student. Prerequisites: E.D.G. 106; I.Ed. 323; graduate classification; approval of instructor.

*Primarily for graduate students interested in education. Not available for major or minor work toward an engineering degree, except by permission of the Dean of the Graduate College.

DEPARTMENT OF ENGINEERING TECHNOLOGY

C. A. Bertrand, E. R. Glazener (Head)*, D. W. Morgan, D. A. Rice

The graduate program in Engineering Technology offers courses leading to the Master of Science degree in Industrial Technology. This interfaces with engineering, psychology, the physical and biological sciences, business administration, and a number of their 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 to better prepare himself for technical-managerial, production-supervisory, 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.

Other technical courses for the Department of Engineering Technology are in preparation.

(E.T.)

631. Electricity. (1-4). Credit 2. I, II, S Development and preparation of instructional materials for use by electricity and electronics teachers in industrial arts, vocational and technical education programs.

*Graduate Advisor

635. Industrial Automation and Cybernetics. (3-0). Credit 3. I, S Principles and technology of automation and cybernetics as a major movement and influence in modern industry. Prerequisite: I.En. 203 or equivalent.

636. Materials Technology. (2-2). Credit 3. II, S Advanced study of characteristics and application of the newer materials of industry. Study of materials research techniques and materials-oriented product development. Prerequisite: E.T. 207 or approval of Department Head.

638. Industrial Electronics. (2-2). Credit 3. I, II, S Applications of solid state devices to industrial manufacturing processes for the technologist. Prerequisite: E.T. 447 or equivalent.

681. Seminar. (1-0). Credit 1 each semester. I, II, S 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. I, II, S 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.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis in technology option. Prerequisite: Graduate classification.

DEPARTMENT OF ENGLISH

S. L. Archer*, R. H. Ballinger, R. W. Barzak, F. D. Burt, G. H. Cannon, K. E. Elmquist, J. P. Guinn, Jr., L. F. Hauer, H. E. Hierth (Head)*, P. C. Hunter, Jr., R. H. Costa, H. P. Kroitor, C. D. Laverty, E. E. Stokes, Jr., J. E. Van Domelen

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.

The M.A. degree requires a minimum of thirty credit hours. The required thesis may be written on a subject in English literature, American literature, or linguistics. Candidates may present a minor of not more than nine hours, to be selected from related fields.

A minimum of sixty-four credit hours beyond the M.A., or ninety-four hours beyond the B.A., is required for the Ph.D. degree in English. The student's program must include a minor of twelve hours. The dissertation may be written on a subject in English literature, American literature, or linguistics.

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.

*Graduate Advisor

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 Credit 3. II, S Introduction of basic techniques of research and scholarly procedure in English. Research reports.

605. Old English. (3-0). Credit 3. I, S Identical 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. I Identical with Ling. 606. Literary and linguistic study of Beowulf. Prerequisites: Engl. 605, 610; or approval of instructor. Credit cannot be given for both Engl. 606 and Ling. 606.

609. Middle English. (3-0). Credit 3. II, S Identical with Ling. 609. Introduction to Middle 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. 609 and Ling. 609.

612. Chaucer. (3-0). Credit 3. II, S Identical 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. I Drama of the English Renaissance, exclusive of Shakespeare. Research papers. Prerequisite: Graduate classification or approval of Department Head.

614. Studies in the Renaissance: Nondramatic Literature. (3-0). Credit 3. I, S Major writers of nondramatic prose and poetry of English Renaissance: Wyatt, Surrey, Sidney, Spenser, Marlowe, Raleigh, Shakespeare, Drayton, Jonson, and Donne. Research papers. Prerequisite: Graduate classification or approval of Department Head.

615. Seventeenth Century English Literature. (3-0). Credit 3. I, S Poetry and prose of chief writers of seventeenth century: Bacon, Donne, Jonson, Herrick, Milton, and Dryden. Research papers. Prerequisite: Graduate classification or approval of Department Head.

616. Studies in the Eighteenth Century: The Age of Pope. (3-0). Credit 3. I Poetry and prose to 1750, concentrating on Defoe, Addison, Swift, Pope, Thomson, and Young, with emphasis on aesthetic, scientific, and religious ideas. Research papers. Prerequisite: Graduate classification or approval of Department Head.

617. Studies in the Eighteenth Century: The Age of Johnson. (3-0). Credit 3. II, S Prose, including the novel, in latter half of century, concentrating on Fielding, Johnson, Boswell, Goldsmith, Sheridan, Hume, and Gibbon, with emphasis on aesthetic, scientific, and philosophic ideas. Research papers. Prerequisite: Graduate classification or approval of Department Head.

619. Studies in Shakespeare. (3-0). Credit 3. I, S 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 eighteenth century to present. Research papers. Prerequisite: A course in Shakespeare.

621. Milton and His Contemporaries. (3-0). Credit 3. II, S Poetry and prose of John Milton, with emphasis on **Paradise Lost.** Consideration of 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. I, S Studies in 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. I Studies in 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. II, S Prose and poetry from Carlyle to Shaw. Research papers. Prerequisite: Graduate classification or approval of Department Head.

635. Studies in Victorian Poetry and Prose. (3-0). Credit 3. II, S Studies in major Victorian writers of poetry and nonfiction prose, with concentration on two or three authors each time 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. II, S Study of major English novelists from 1740 to twenteith 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. II, S Studies in 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 Twenteith Century: British Literature. (3-0). Credit 3. I Selected authors since 1900: Yeats, Joyce, Huxley, and others. Emphasis upon development of particular literary movement or literary form. Research papers. Prerequisite: Graduate classification or approval of Department Head.

650. Studies in the Twentieth Century: American Literature. (3-0). Credit 3. II Selected authors since 1900: Robinson, Frost, Eliot, Lewis, Faulkner, Hemingway and others. Emphasis on particular literary movement or literary form. Research papers. Prerequisite: Graduate classification or approval of Department Head.

661. Analysis of Composition. (3-0). Credit 3. I, S Principles of 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. II Identical with Ling. 662. Investigation of the phonological, morphological, syntactic, and lexical components of the English language; emphasis on 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. I, S 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.

673. Studies in American Literature: The Beginnings to 1820. (3-0). Credit 3. I, S Colonial, Revolutionary, and Post-Revolutionary literature and the backgrounds; emphasis on various forms of early literature and individual writers. Research papers.

674. Studies in American Literature: The Age of Transcendentalism. (3-0). Credit 3. I, S Backgrounds of transcendentalism in Europe; the movement in the U.S.; works of Emerson, Hawthorne, Poe, Whitman, Melville, Thoreau, and others. Research papers. Prerequisite: Graduate classification or approval of Department Head.

675. Studies in American Literature: The Gilded Age. (3-0). Credit 3. II 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. Prerequisite: Graduate classification or approval of Department Head.

677. Studies in American Poetry. (3-0). Credit 3. I, S Study of major American poets — for example, Edward Taylor, Poe, Whitman, Emily Dickinson, Robert Frost — and a study of the reciprocal influence of American poetry and American culture on each other. Research papers.

683. Theory and Practice of Literary Criticism. (3-0). Credit 3. II, S Analysis of more important theories of literary criticism for students of English and American literature with attention to functional emphasis in critical practice. Research papers.

685. Problems. Credit 1 to 4 each semester. I, II, S 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.

691. Research. Credit 1 or more each semester, I, II, S Research for thesis. Prerequisites: Graduate classification; approval of Department Head.

LINGUISTICS
(Ling.)

602. Sociolinguistics. (3-0). Credit 3. I Study of 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: Engl. 609 or approval of instructor.

605. Old English. (3-0). Credit 3. I, S Identical with Engl. 605. Credit cannot be given for both Engl. 605 and Ling. 605.

606. Beowulf. (3-0). Credit 3. I Identical with Engl. 606. Credit cannot be given for both Engl. 606 and Ling.606.

608. General Linguistics. (3-0). Credit 3. I Study of nature and structure of language; work in phonetics and phonemics, morphology, syntax, lexicography, and generative-transformational models. Prerequisites: Engl. 409 or approval of instructor.

609. Middle English. (3-0). Credit 3. II, S Identical with Engl. 609. Credit cannot be given for both Engl. 609 and Ling. 609.

610. History of the English Language. (3-0). Credit 3. II 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. Prerequisite: Engl. 662 or approval of instructor.

612. Chaucer. (3-0). Credit 3. II, S Identical with Engl. 612. Credit cannot be given for both Engl. 612 and Ling. 612.

662. Analysis of the English Language. (3-0). Credit 3. I, II, S Identical with Engl. 662. Credit cannot be given for both Engl. 662 and Ling. 662.

666. Dialectology. (3-0). Credit 3. I Study of the methods an principles of linguistic dialectology, including 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: Engl. 466, 609 and 662; or approval of instructor.

667. Linguistics and Literature. (3-0). Credit 3. II Study of 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 and 666; or approval of instructor.

669. Theory of Grammar. (3-0). Credit 3. I Advanced linguistic theory, with extensive reading in technical literature; individual research culminating in solution of an original linguistic problem; stress on transformational theory. Prerequisite: Engl. 662.

DEPARTMENT OF ENTOMOLOGY

P. L. Adkisson (Head)*, D. G. Bottrell, D. L. Bull, H. R. Burke, R. N. Coulson, L. E. Ehler, G. W. Frankie, O. H. Graham, R. L. Hanna*, J. A. Harding, M. K. Harris, L. L. Keeley, J. K. Olson, T. L. Payne, F. W. Plapp, M. A. Price, N. M. Randolph, R. L. Ridgway, J. C. Schaffner, J. W. Smith, Jr., W. L. Sterling, H. W. Van Cleave, S. B. Vinson, J. K. Walker, Jr.

Work is offered for advanced degrees in the various phases of entomological science including taxonomy, morphology, parasitology, physiology, toxicology, ecology, economic, forest and urban entomology. Adequate facilities are available for research in these fields including a well- equipped laboratory. 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 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. Specific requirements, in addition to the elementary undergraduate courses pertaining to various lines of major work, are dependent upon previous training and professional experience.

The Ph.D. requires either a comprehensive knowledge of one language, a reading knowledge of two, or a reading knowledge of one language plus approved broadening courses. These options may be met in a number of ways.

(Ento.)

601. Systematic Entomology. (3-3). Credit 4. I Taxonomic study of orders and families, including genera and species of class Hexapoda; study of International Rules of Nomenclature. Special study of some particular group of insects required in practice. Prerequisite: Ento. 302.

602. Systematic Entomology. (3-3). Credit 4. II Continuation of Ento. 601. (Offered in 1972-73 and alternate years thereafter.)

605. Aquatic Entomology. (3-3). Credit 4. II, S Principles and practices concerning aquatic entomology. Emphasis placed on 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. S Biologies, economic importance, and control of insects and other arthropods from a pest management viewpoint are stressed. Taught by instructors specialized in various aspects of entomology. For non-entomology majors only. Prerequisite: Approval of Department Head.

608. Economic Entomology. (3-3). Credit 4. II Detailed study of insect pests, including identification, distribution, principles, and methods of natural, cultural, and chemical controls. Literature and research methods stressed. Prerequisite: Ento. 401 or 402.

613. Morphology. (3-3). Credit 4 each semester. I Detailed study of anatomical structures of insects. Prerequisite: Ento. 305.

*Graduate Advisor

615. Insect Physiology. (3-3). Credit 4. I Physiological processes of insects with emphasis on metabolism nutrition, neuro-endocrinology, nerve action, cell structure, respiration, circulation, excretion and flight. Functional integration and regulatory processes of total organism are stressed. Prerequisite: Ento. 306 or equivalent.

617, 618. Medical and Veterinary Entomology. (3-3). Credit 4 each semester. I, II Taxonomy and biology of parasitic insects, ticks, mites and their role in causation and transmission of diseases affecting man and domestic animals. Prerequisite: Ento. 208 or equivalent.

619. Insect Toxicology. (3-3). Credit 4. II Classification and properties of major types of insecticides including chemistry, metabolism and mode of action. Selectivity, use hazards, residues and resistance are considered. Environmental problems such as biological magnification, persistence, and effects on non-target organisms are stressed. Prerequisite: Ento. 615 or approval of instructor.

620. Insect Biochemistry and Endocrinology. (3-0). Credit 3. II Emphasis on recent information and concepts in the area of insect biochemistry. Special emphasis on 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. I, II 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. I, II, S 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 entomology.

685. Problems. Credit 1 to 4 each semester. I, II, S Entomological problems not pertaining to thesis or dissertation. Prerequisites: Graduate classification with major or minor in entomology; approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Research problems on taxonomy, life histories, biological control, ecology, and physiology of insects, and toxicology of insecticides. Prerequisite: Graduate classification.

FEEDLOT MANAGEMENT

A new Master of Agriculture degree program has been tailored specifically to prepare students for a professional career in the livestock feeding industry. The new program, the first of its kind in the nation, is devoted to training and developing students for feedlot management and other opportunities in related industries.

The curriculum is sufficiently flexible to fit individual needs. Candidates for the degree may acquire advanced training in animal sciences, biochemistry, soil and crop sciences, agricultural economics, entomology, agricultural engineering, accounting, finance, business and management, statistics and veterinary science. The student is required to spend a minimum of one semester in a professional internship program, working with a feedlot operation, in addition to a minimum of 36 hours of graduate credit beyond the Bachelor of Science degree. Students will register for four hours of An.Sc. 684 each semester and two hours each summer session while actively working on the professional internship program under the supervision of his Advisory Committee chairman. Students prepare a professional paper instead of a thesis.

DEPARTMENT OF FINANCE

R. A. Cossaboom, W. E. Etter, D. R. Fraser, C. A. Phillips (Head)*, M. L. Piotrowski, P. S. Rose

Graduate specialization in finance is offered leading to the degrees of Master of Business Administration and Doctor of Philosophy in Business. The M.B.A. specialization is designed to prepare students for professional careers in finance. The Ph.D. specialization is structured to prepare persons for teaching or research careers. Students not in M.B.A. or Business Ph.D. programs may take courses in finance if they meet the prerequisites.

The doctoral program in Businesss Administration requires a basic knowledge of one computer language (COBOL or FORTRAN) which may be demonstrated by passing a proficiency examination or appropriate coursework. In addition, each student is expected to be familiar with the international literature related to his field and research interests.

(Fin.)

630. Problems of Corporation Finance. (3-0). Credit 3. I, II, S Financial problems of corporation analyzed, including current financing, refunding operations, dividend policies, and corporate reorganization. Prerequisite: Graduate classification; approval of graduate advisor.

632. Investment Management. (3-0). Credit 3. I, II, S Provides an improved basis for decision making in administration of investment securities emphasizing recent theoretical and analytical developments in security selection and portfolio management. Prerequisite: Fin. 652 or approval of instructor.

634. Theory of Finance. (3-0). Credit 3. I Development and integration of theoretical structure of finance emphasizing capital allocation, financial analysis, portfolio selection, optimum capital structure and the dividend decision. Prerequisite: Fin. 652 or approval of instructor.

638. Management of Financial Intermediaries. (3-0). Credit 3. II Analysis of problems in financial intermediary management emphasizing influence of changing economic conditions on managerial policy. Prerequisite: Fin. 652 or approval of instructor.

642. Analysis of Money and Capital Markets. (3-0). Credit 3. I Examination of how changes in the supply of and demand for money and capital influence the policies of financial intermediaries, fiscal and monetary authorities, and non-financial firms. Prerequisite: Fin. 652 or approval of instructor.

645. International Finance. (3-0). Credit 3. I, II Analysis of problems faced by financial managers of firms with international business operations. These include differences in taxation, monetary systems, stage of economic development and cultural distinctions. Prerequisite: Fin. 652 or approval of instructor.

652. Financial Management. (3-0). Credit 3. I, II, S Financial policies and practices in business firms; finance function, financial control and organization; financial analysis and planning. Prerequisite: Graduate classification; approval of graduate advisor.

660. State and Local Financial Administration. (3-0). Credit 3. II, S Principal problems of public financial management including planning, programming and budgeting, tax assessment and tax administration, debt management and financial reporting. Prerequisites: Graduate classification, approval of instructor.

670. Planning, Programming, Budgeting Systems. (3-0). Credit 3. I, S 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. Prerequisites: Graduate classification and approval of instructor.

*Graduate Advisor

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

685. Problems. Credit 1 to 3 each semester. I, II, S 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. I 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.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

FOOD TECHNOLOGY

The Department of Animal Science is charged with the administrative responsibility for the curriculum in food technology. Graduate training in food 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 degree of Master of Science or the Doctor of Philosophy.

Prior to enrolling in an advanced degree program in food technology the student is expected to have satisfactorily completed a B.S. program, preferably in food technology or in a specific food commodity, from a college or university of recognized standing.

Departments participating in granting degrees in food technology include Animal Science (meat, fish, and dairy products), Poultry Science, Soil and Crop Sciences (cereals, oil seeds and horticultural products), and Agricultural Engineering. 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. Minors, joint majors, or both in such areas as microbiology (biology), chemistry, biochemistry, engineering, statistics and many others may be readily arranged.

A minimum of 32 semester hours and a thesis are required for the Master of Science degree. 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.

DEPARTMENT OF FOREST SCIENCE

R. L. Bury, D. F. Durso, C. A. Hickman, P. A. Kramer, A. E. Lund, R. G. Merrifield (Head)*, D. M. Moehring, T. L. Payne, R. R. Rhodes, E. P. Van Arsdel, J. P. van Buijtenen, R. A. Woessner

Graduate study in forestry leading to the M.S. and Ph.D. degrees is offered in forest ecology, forest economics, forest engineering (in cooperation with the

*Graduate Advisor

Departments of Agricultural Engineering and Civil Engineering), forest soils, forest genetics, silviculture, wood chemistry and wood technology. Each of these programs may include supporting courses offered by several related disciplines. Related forestry programs in entomology, genetics and pathology are offered in other departments. Training in these fields is oriented toward preparing a student for teaching, research or management positions.

Students are given the opportunity to actively participate in research covering any one of several fields of specialization, utilizing facilities located on the campus as well as at field centers in the forested region of East Texas.

Forestry students may elect to undertake graduate study in the interdisciplinary program of Natural Resource Development, which culminates with a Master of Agriculture degree. This is a professional, non-thesis graduate program which is relatively broad in scope and offers opportunities for student involvement in management and operational activities in the natural resource field.

Graduate programs are developed by the student under the guidance of a graduate committee. The nature of these programs is largely governed by the interests and needs of the individual student.

There is no uniform foreign language requirement for the Doctor of Philosophy degree. Individual students may, however, find it desirable to develop a proficiency in one or more foreign languages.

(F.S.)

601. Forest Ecology. (3-0). Credit 3. I Detailed study of forest communities and successions, interrelationships of various life forms of forest stands. Occasional field trip. Prerequisite: Approval of instructor.

602. Advanced Silviculture. (3-0). Credit 3. II Study of advanced silvicultural methods, techniques and problems including current and recent research and technical literature. Occasional field trip. Prerequisites: F.S. 302, 305.

605. Forest Practices. (3-0). Credit 3. I, II Principles of forest development as related to silvicultural practices and systems. Techniques of measurement and management for regulation and administration of forest properties. Review of current systems of forest product marketing. Prerequisite: Graduate classification in agriculture or allied subjects.

606. The Research Process. (3-0). Credit 3. I Discussion of the nature and objectives of graduate work, the scientific method and basic and applied research. Introduction to design of experiments and analysis of data with emphasis on forest science research. Principles of organization of project proposals, theses and scientific reports.

681. Seminar. (1-0). Credit 1. I, II 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. I, II, S The 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. I, II, S Designed for investigations not included in student's research for thesis or dissertation. Problems to be selected in some aspect of forestry.

691. Research. Credit 1 or more each semester. I, II, S Research in an approved aspect of forestry for thesis or dissertation credit.

GENETICS

E. C. Bashaw, C. R. Benedict, L. Bird, H. T. Blackhurst, A. J. Bockholt, H. H. Bowen, R. D. Brigham, M. S. Brown, T. C. Cartwright, J. W. Collier, G. A. Donovan, R. C.

Fanguy, H. A. Fitzhugh, Jr., R. A. Frederiksen, P. A. Fryxell, C. E. Gates, E. C. Gilmore, F. W. Gould, G. E. Hart, E. C. Holt, N. M. Kieffer, M. L. Kinman, R. J. Kohel, W. F. Krueger, H. O. Kunkel, M. E. McDaniel, N. A. McNeil, O. G. Merkle, G. A. Niles, B. A. Perry, L. M. Pike, K. B. Porter, T. R. Richmond, I. V. Sarkissian, K. F. Schertz, G. L. Schroeter, J. M. Shelton, J. D. Smith, J. W. Stansel, N. A. Tuleen, J. P. van Buijtenen, B. F. Watson, D. F. Weseli

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 specialized fields as biochemistry, biophysics, computer sicence, cytology, pathology, physiology and statistics.

Research areas which may be pursued include cytogenetics, immunogenetics, molecular genetics, population genetics and physiological genetics as well as forest genetics, animal breeding and plant breeding.

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, 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 his 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. II
628. Animal Breeding. (2-2). Credit 3. II

PLANT SCIENCES
(Genetics, Gen.)

603. Genetics (4-0). Credit 4. I
604. Genetics Laboratory. (0-3). Credit 1. I
608. Genetics of Microorganisms. (3-0). Credit 3. I
612. Population Genetics. (3-0). Credit 3. II
613. Quantitative Genetics I. (3-0). Credit 3. I
620. Cytogenetics. (3-0). Credit 3. II
623. Special Topics in Genetics. Credit 1 to 3.
624. Statistical Genetics. (2-0). Credit 2. I
625. Speciation. (3-0). Credit 3. II (Alternate years)
630. Cytogenetics Laboratory. (0-3). Credit 1. II (Alternate years)
631. Biochemical Genetics. (3-0). Credit 3. I
633. Forest Genetics. (2-0). Credit 2. I (Alternate years)
634. Forest Genetics Laboratory. (0-3). Credit 1. II (Alternate years)
681. Seminar. (1-0). Credit 1. I, II

685. Problems. Credit 1 to 4 each semester. I, II, S
691. Research. Credit 1 or more each semester. I, II, S

POULTRY SCIENCE
(P.S.)

613. Breeding and Genetics of Poultry. (3-3). Credit 4. II

RANGE SCIENCE
(R.S.)

610. Range Grasses and Grasslands. (2-3). Credit 3. II

SOIL AND CROP SCIENCES
(Agronomy, Agro.)

603. Cytological and Histological Principles in Plant Breeding. (2-3). Credit 3. II
641. Plant Breeding I. (3-0). Credit 3. II
642. Plant Breeding II. (3-0). Credit 3. II

DEPARTMENT OF GEOGRAPHY

G. F. Carter*, E. F. Cook, E. Doran (Head), C. Kimber, J. Sonnenfeld

Graduate work in geography is offered at both the Master's and Doctoral levels. The Department of Geography has wide interests in the area of interaction between man and the land, and students are encouraged to work in physical, biological, and social sciences. Staff interests include cultural, historical, behavioral, resource, plant geographical and geomorphic studies. Graduate students are expected to be heavily involved in research work throughout their programs. For information concerning the Ph.D. language requirement, the departmental office may be contacted.

(Geog.)

601. Economic Geography. (3-0). Credit 3. I Decision-making in the allocation and management of natural resources among developed and undeveloped populations of the world. Prerequisite: Approval of Department Head.

605. Processes in Cultural Geography. (3-0). Credit 3. I Examination of role of the process of invention and diffusion in the development of civilization emphasizing the American Indian civilizations. Examination of the evidence will be by case studies from a wide variety of fields such as anthropology, architecture, art, botany, mathematics, and zoology. Prerequisite: Approval of Department Head.

606. Agricultural Origins and Dispersals. (3-0). Credit 3. II Origin and spread of agriculture over the world. Single versus multiple origins. The several complexes: Near East, Far East, Africa, America. Prerequisite: Approval of Department Head.

607. Physical Geography of Early Man in America. (3-0). Credit 3. I Applications of physical earth science to the problem of the antiquity of man in America: paleoclimates and paleosols, eustatic sealevel changes and coastal terraces, plus local field problems. Prerequisite: Approval of Department Head.

*Graduate Advisor

610. Geography of Water Transport. (3-0). Credit 3. I Significance of boat types to cultural geography. Distribution and characteristics of great traditions: Western, Chinese, and Oceanic. Ambiguous traditions and their possible meanings. Prerequisite: Approval of Department Head.

619. Man's Impact on His Environment. (3-0).Credit 3. I Alterations by man of the landscapes, the atmosphere, and the waters of the earth; his interference with natural chemical cycles; his disturbances of ecological equilibria; his depletion of natural resources. Roles of technology and population growth. Ecoethics, environmental behavior and decision-making. Prerequisite: Approval of Department Head.

620. Man and Nature. (3-0). Credit 3. I Evolving views of man and nature; constraints on man's use of nature; natural hazards and environmental degradation; alternative consequences approach to resource decisions. Prerequisite: Approval of Department Head.

624. Plant Geography. (3-0). Credit 3. II Plant cover of the world — its composition, local productivity, and distribution. Differences and similarities between various floras and vegetations of the world. Prerequisite: Approval of Department Head.

626. River Basin Development. (3-0). Credit 3. I, II Technological and social problems associated with the development of river basins for navigation, flood control, irrigation and recreation, using as examples various of the world's large rivers. The geography of interbasin water transfer will be considered also. Prerequisite: Approval of Department Head.

627. Coastal Geomorphology. (3-0). Credit 3. I Description, geographical distribution, and evolution of coastal landforms. Emphasis on glacio-eustatic imprint and on landforms of Louisiana and Texas coasts. Floodplain development, terrace chronology, and evolution of estuaries, marshlands, and beaches. Man and coastal environments. Prerequisite: Three hours of advanced geology or physical geography or approval of instructor.

630. Behavioral Geography. (2-2). Credit 3. II Synthesis of concepts derived from behavioral sciences which relate to man-environment interaction. Emphasis on determinants of variability in individual or group relationship with non-human environment, including class research in environmental perception, behavior, and personality, Prerequisite: Approval of Deaprtment Head.

635. Man in Extreme Environments. (2-2). Credit 3. II Human adjustment to novelty, risk, and stress in environment: the arctic, desert and tropics; high altitude and submarine environments; the city and the spacecraft as artificial environments; the "battlefield" and other high risk regions of earthquake, tornado, hurricane and flood. The strategies of adjustment, control, and adaptation. Prerequisite: Approval of Department Head.

641. Exploration and Discovery I. (3-0). Credit 3. I Expansion of geographic knowledge of lands, oceans, and peoples of world from prehistoric times to the fall of the Roman Empire. Prerequisite: Approval of Department Head.

642. Exploration and Discovery II. (3-0). Credit 3. II Expansion of geographic knowledge of lands, oceans, and peoples of world, from the Dark Ages to present. Prerequisite: Approval of Department Head.

650. Cultural Geography of the Caribbean. (3-0). Credit 3. II Investigation of the patterns of distribution of the peoples of Caribbean by cultural origin, technological levels, and changing political affiliations. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1. I, II Reports and discussions of current research and selected topics. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 6 each semester. I, II, S Special topics to meet small group requirements. Problems in various aspects of geography. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Original research in various areas of geography. Research for thesis or dissertation.

DEPARTMENT OF GEOLOGY

W. M. Ahr, R. R. Berg, E. R. Cook, M. Friedman*, J. W. Handin, K. J. Koenig, J. M. Logan, C. C. Mathewson, T. J. Parker, M. C. Schroeder, R. B. Scott, C. L. Seward, R. J. Stanton, Jr., D. W. Stearns (Head)*, T. T. Tieh

Graduate work in geology is offered at both the Master's and Doctorate 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, and engineering geology.

Professional jobs available at the B.S. level in geology are becoming fewer and fewer every year. Therefore, 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.

In addition to Graduate College requirements for the Ph.D., the student's committee chairman, with advice from the other committee members, shall determine on an individual basis the student's non-technical needs in either foreign language or other broadening areas.

(Geol.)

600. Earth Science for Secondary School Teachers. (2-3). Credit 3. II, S Survey of fundamental principles of physical geology, geologic processes, and earth history including 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. S Study of 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. I, II, S Systematic geologic surveying of selected areas. Prerequisite: Geol. 300.

612. Structural Geology. (3-0). Credit 3. I Comparative structural geology including the description and classification of local and regional structures and the application of selected mechanical principles to the development of structural features.

616. Micropaleontology. (1-6). Credit 3. I Study of microscopic fossils and their uses in correlation. Laboratory work in examination of well samples. Prerequisite: Geol. 423.

618. Sedimentology. (3-0). Credit 3. II Mechanisms of transportation and deposition of ancient eolian, fluvial, and marine sediments. Dispersal and depositional patterns. The physical bases for sequences of textures, structures, and grain fabrics in sedimentary rocks. Prerequisites: Geol. 306; Math 307 or approval of instructor.

619. Petroleum Geology. (3-0). Credit 3. II Subsurface fluids and pressures; porosity, permeability, hydrostatic and hydrodynamic pressures, and their effects on subsurface fluid occurrence. Prerequisite: Geol. 404.

620. Geology of Ground Water. (3-0). Credit 3. I 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.

622. Stratigraphy. (3-0). Credit 3. I Sources and depositional environment of sediments, character and relation of sedimentary strata, and principles involved in delimiting, correlating and naming stratigraphic units.

*Graduate Advisor

629. Regional Geology of North America. (3-0). Credit 3. II Study of the regional geology of North America by examining the accumulation and deformation of the rock units involved. Structural form and style are emphasized, but the entire geologic history is investigated.

630. Urban Geology. (2-2). Credit 3. I (1972 and alternate years thereafter) Fundamentals of engineering geology as applied to the planning, development and design of urban areas: including properties of earth materials, land form analyses, and geologic processes. Designed as service course for graduate students interested in urban affairs.

631. Geology in Engineering Construction. (3-0). Credit 3. II Geologic principles applied to construction of highways, foundations, bridge abutments, piers, tunnels, dams, reservoirs, etc. Construction materials. Test borings and their interpretation. Prerequisites: Graduate classification; approval of instructor.

632. Geology in Engineering Construction II. (3-0). Credit 3. II (1973 and alternate years thereafter) Engineering geology of urban areas, including land use and planning, building foundations, water supply, waste water and refuse disposal, and construction materials. Prerequisites: Geol. 440 or 441 or equivalent.

633. Photogeology. (2-3). Credit 3. I (1973 and alternate years thereafter) Application of black and white and color aerial photography to geology, with emphasis on landforms and geologic mapping and application of multi-spectral imagery, including infrared, multi-spectral photography, radar, and other techniques to the geologic environment. Prerequisite: Approval of instructor.

637. Fundamental Geology I. (3-0). Credit 3. I, II, S 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 are emphasized. Prerequisite: Approval of Department Head.

638. Fundamental Geology II. (3-0). Credit 3. I, II, S 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 are emphasized. Prerequisite: Approval of Department Head.

650. Paleoecology. (3-0). Credit 3. II Study of interrelationships of organisms and environment in the fossil record. Analysis of methods and criteria available for interpreting ancient environments. Critical review of classic studies and current research in paleoecology.

652 Biogeology. (3-0). Credit 3. I Analysis of major trends and processes in the evolution of life through geologic time. Interrelationships of biological and physical processes in earth history. The 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. I Geology of volcanic rocks, with emphasis on petrology of layered volcanic rocks and their stratigraphic and structural utility. Relations of volcanism to tectonism and to ore deposition. Prerequisites: Geol. 303, 312.

660. Theoretical Petrology. (2-3). Credit 3. II Origin and evolution of igneous and metamorphic rocks; characteristics and variations of common rock types. Prerequisite: Geol. 304.

661. Igneous and Metamorphic Rock Systems. (2-3). Credit 3. I (Alternate years) Origin and evolution of igneous and metamorphic rocks. Laboratory research problems concentrate upon the petrogenesis of genetically related suits of igneous and metamorphic rocks. Prerequisite: Geol. 660.

662. Sedimentary Petrology. (2-6). Credit 4. II The provenance, mode of transportation, and environment of deposition of sediments as indicated by petrographic studies; introduction to collection and statistical evaluation of petrological data. Prerequisite: Geol. 303 or approval of Department Head.

663. Mineralogy. (2-6). Credit 4. I Laboratory methods for mineral separation and identification by optical and X-ray techniques; detailed study of more important rock-forming and ore minerals. Prerequisite: Geol. 303.

665. Structural Petrology. (2-3). Credit 3. I, II Fabrics of deformed rocks studied on all scales of observation — from single crystal to mountain range. Their tectonic significance evaluated by means of dynamic and kinematic interpretations. Laboratory assignments

on descriptive techniques include petrographic microscope universal-stage methods, field procedures, and data analysis. Prerequisites: Geol. 303; approval of instructor.

667. Structural Geology II. (3-0). Credit 3. I, II Application of theoretical and experimental results to problems in natural rock deformation. Study of structural mechanisms on the phenomenological, laboratory and natural scales with emphasis on the genesis of structural features in layered rocks. Prerequisite: Approval of instructor.

681. Seminar. (1-0). Credit 1. I, II Reports and discussions of current research and selected topics from geologic literature. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 6 each semester. I, II, S 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.

690. Theory of Geological Research. (2-0). Credit 2. I, II, S Theory and design of research problems and experiments in various sub-fields of geology. 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. I, II, S Original research on problems in various phases of geology. Research for thesis or dissertation.

DEPARTMENT OF GEOPHYSICS

D. A. Fahlquist, A. F. Gangi*, J. W. Handin, J. M. Logan, J. N. Shapiro, T. W. Spencer (Head), R. R. Unterberger

The degrees of Master of Science and Doctor of Philosophy are offered in geophysics. Information concerning the Ph.D. foreign language requirement may be obtained from the departmental office. Geophysics includes all areas of scientific inquiry which deal with the physical state of the planets, with the dynamic physical processes which act on and within the planets, and with their evolution. Geophysics is not restricted to the study of a particular environment. The deep interior, crust, atmosphere, oceans, and space all lie within the province ofof 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 mechanism, and seismic exploration; marine studies of the structure of the oceanic crust and the continental margins in the Gulf of Mexico and Caribbean; global tectonics; and studies of the properties of rocks and minerals in the radio frequency band which are relevant to the electromagnetic exploration of the Moon and certain types of terrestrial features.

The Center for Tectonophysics provides unique opportunities for research in the following areas: design and analysis of scaled photomechanical models of structural processes; deformation of rock specimens under conditions which simulate the physical and chemical environment at depth in the earth's crust; use of specialized X-ray diffraction and microscopic techniques to study experimentally and naturally deformed rocks; interpretation of geologic structures in terms of the results of laboratory studies.

An IBM 360/65 computer system is operated by the Data Processing Center for faculty and student research. The research ship ALAMINOS is available for

*Graduate Advisor

research in the marine environment. Special department facilities include: a Standard World-Wide Seismic Station equipped with a laser interferometer for recording very low frequency variations in strain; 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; exploration-type, 24-trace seismic recording and processing systems; two 15-kilowatt peak power, low-frequency radars for long range underground propagation; a LaCoste-Romberg gravity meter; and high-sensitivity, optically pumped nuclear precession magnetometers with automatic recording.

(Geop.)

604. Marine Geophysics. (3-3). Credit 4. I (Alternate years) Analysis of marine seismic, gravity, magnetic and heat-flow data. Interpretation of seismic reflection and refraction profiles and gravity, magnetic and heat-flow anomalies. Geophysical characteristics of sediment and crustal structure underlying tectonic regions in the ocean. Plate tectonics. Laboratory exercises emphasize analysis and interpretation of geophysical data collected at sea. Prerequisites: Math. 122; Phys. 218, 219.

611. Geomechanics. (3-0). Credit 3. I Development and application of physical mechanics to rock deformation. Review of rigid body dynamics emphasizing equilibrium and energy concepts. Strain and stress analysis of deformable bodies. Solution of problems in elasticity and viscoelasticity. Brief consideration of elastic stability, plasticity, and rupture concentrating on topics pertinent to structural geology. Prerequisites: Math. 307; Phys. 218.

615. Experimental Rock Deformation. (2-3). Credit 3. II Laboratory testing of mechanical properties of rocks at high pressure and temperature; photomechanical modeling; strain gage techniques. Theory of testing, apparatus design, data interpretation and extrapolation with emphasis on interaction of theoretical, experimental, petrofabric, and field studies of rock deformations as applied to problems in structural geology, seismology, and engineering. Prerequisite: Geop. 611.

627. Electromagnetic Wave Propagation in Earth Materials. (3-0). Credit 3. I Electromagnetic wave propagation in vacuum, lossless dielectrics and earth materials with loss. Radiation polarization, attenuation, reflection and refraction. Theory of dielectrics applied to earth materials, resonance phenomena, mixing theories, loss mechanisms. Practical application to present-day geophysical problems. Laser radar and future possible applications. Prerequisites: Phys. 413, 416; or E.E. 451; or Math. 405; or approval of instructor.

630. Geophysical Applications of Solid State Theory. (3-0). Credit 3. II Basic physics, chemistry, and mathematics of lasers, radar, optical pumping, nuclear magnetic resonance, and holography discussed with reference to present and future applications in earth sciences. Prerequisite: Approval of instructor.

633. High Pressure/Temperature Geophysics. (3-0). Credit 3. II Theories of the equations of state and their application to geophysics. Isothermal and vibrational formalisms, fourth order theories, and shock waves. The theory of melting. Prerequisite: Phys. 302 or approval of instructor.

651. Theoretical Seismology. (3-0). Credit 3. II Wave propagation in unbounded and bounded media. Body waves and surface waves. Characteristic equation for surface waves on a layered half space. Dispersion. Phase and group velocity. Methods of stationary phase and steepest descent. Geometrical ray theory derived from wave theory in the high frequency limit. Reciprocity. Normal modes of vibration of the earth. Effect of curvature, gravity, and attenuation on waves in the earth. Prerequisites: Geop. 436, 611; or Ocn. 618.

653. Analysis of Gravity and Magnetic Fields. (3-0). Credit 3. I 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.

655. Electrical and Radioactivity Methods. (2-0). Credit 2. II Design of field procedures, instruments, and data interpretation techniques utilized in electric and electromagnetic methods of exploration. Prerequisite: Phys. 416.

657. Planetary Interiors. (3-0). Credit 3. II Study of the 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. Critical analysis of equations of state of earth's interior inferred from seismic data.

681. Seminar. (1-0). Credit 1. I, II Discussion of subjects of current importance. Prerequisite: Graduate classification.

685. Problems. Credit 1 to 6 each semester. I, II, S Designed to enable graduate students with 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.

690. Theory of Geophysical Research. (2-0). Credit 2. I, II, S 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. I, II, S Research toward thesis or dissertation.

DEPARTMENT OF HEALTH AND PHYSICAL EDUCATION

J. M. Chevrette, L. J. Dowell*, C. W. Landiss (Head)*, E. Mamaliga, H. Tolson

Graduate study in health and physical education is offered leading to the Master of Education, Master of Science, and Doctor of Philosophy degrees. A foreign language is not required for the Doctor of Philosophy degree.

Graduate courses in health and physical education have been designed to assist in the advanced preparation of master teachers in health and physical education at the secondary and college level; to prepare health and physical education supervisors and administrators; and to prepare teachers in the allied health professions. A Professional Teaching Certificate for the State of Texas may be earned in this department.

Library, laboratory, research, and physical plant facilities are available to graduate students for specialization in area of concentration.

HEALTH EDUCATION (H.E.)

620. Sex Education in Schools. (3-0). Credit 3. II, S 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. Emphasis given to understanding man's sexuality as a health entity and as a source of creative energy and his total life development.

621. Principles of Health Education. (3-0). Credit 3. I Background and development of health education as an applied science; its role and contribution to the educational process; its content, goals and limitations; and its relationship to other disciplines.

*Graduate Advisor

624. Drugs and Human Health. (3-0). Credit 3. II, S 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. Consideration given to legislative and educational efforts in this area. Prerequisite: Graduate classification.

626. Health Careers. (2-2). Credit 3. II, S Study of the 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. I, S Community health problems; public health laws; national, state and local health agencies. Prerequisite: H.E. 415 or 421.

681. Seminar. (1-0). Credit 1. I, II, S Reports and discussions of topics of current interest in health education.

683. Practicum in Health Education. (1-6). Credit 3. I, II, S Observations and study of health practices and methods utilized in school, public and institutional health settings. Prerequisite: Approval of Department Head.

684. Professional Internship. Credit 1 to 6 each semester. I, II, S Designed to permit students the opportunity for on-the-job training with professionals in schools, public and institutional health agencies. Prerequisites: Twelve semester hours of selected graduate work and approval of Department Head.

685. Problems. Credit 1 to 4. I, II, S Directed study of selected problems in health education.

691. Research. Credit 1 or more. I, II, S Research for thesis or dissertation.

PHYSICAL EDUCATION (P.E.)

601. Readings in Health and Physical Education. (3-0). Credit 3. I, S Study of published reports and research in field of health and physical education. Prerequisite: E.Psy. 426 or P.E. 425.

603. Coaching and Officiating. (3-0). Credit 3. S Advanced coaching and officiating techniques in football, basketball, track, and baseball. Prerequisites: Teaching and coaching experience.

606. Psychological Aspects of Sport and Physical Activity. (3-0). Credit 3. II A study of human behavior in sport and physical activity. Areas of study include: exceptional performances; sport and personality; movement perception; motivation in sports; and maturation and physical activity.

610. Administration of Interschool Athletics. (3-0). Credit 3. II, S Designed for school superintendents, principals, and athletic directors. Study of various problems in administration of interschool athletic program.

614. Philosophy and Principles. (3-0). Credit 3. I, S 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. S Principles and processes of supervision; in-service training of personnel. Prerequisite: P.E. 423.

627. Kinesiology. (3-0). Credit 3. I Investigation and analysis of science of human motion. Relationship between structure and function in accordance with general mechanical laws and interrelated factors. Prerequisite: P.E. 427.

628. Therapeutics. (3-0). Credit 3. II 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. Prerequisite: P.E. 427.

630. Mechanical Analysis of Motor Activity. (3-0). Credit 3. II, S Analysis of human movement with emphasis on sports skills by application of principles of mechanics, kinesiology, and cinematographical analysis. Prerequisite: P.E. 627; approval of instructor.

633. Principles of Exercise and Physical Fitness. (2-2). Credit 3. I, S Analysis of 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. S Critical study of tests and measurements; methods of constructing and evaluating tests. Prerequisite: P.E. 425.

637. Exercise Physiology. (2-2). Credit 3. I Examination and critical analysis of current research in human performance and sport physiology. Analysis of the nature of cardiorespiratory fitness, muscular efficiency, and related topics. Prerequisite: Biol. 653, or approval of Department Head.

638. Ergonomics. (2-2). Credit 3. II, S Examination of current methods of imposing work in the exercise physiology laboratory and current techniques for evaluating man's physiological responses to work. Critical analysis of current research in the area of work physiology with special emphasis on physical work capacity in different environments. Prerequisite: P.E. 637; approval of Department Head.

641. Motor Development. (3-0). Credit 3. II Motor, physical, and neuromuscular development from prenatal periods to old age. Specific areas of study include stages of development, motor system, and development of specific movement patterns. Prerequisite: P.E. 406.

681. Seminar. (1-0). Credit 1. I, II, S Discussions of laws, certification, professional ethics, and other current problems relating to health, physical education, and recreation.

683. Practicum in Physical Education. (1-6). Credit 3. I, II, S 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. I, II, S 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. I, II, S Directed study of selected problems of health, physical education, and recreation not related to thesis.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

DEPARTMENT OF HISTORY

A. C. Ashcraft, G. E. Bayliss, T. R. Christofferson, H. C. Dethloff, C. H. Hall*, L. D. Hill, A. Kosztolnyik, H. H. Lang, I. M. May, T. L. Miller, H. M. Monroe, Jr., D. T. Morgan, J. M. Nance (Head)*, D. E. Schob, B. S. Stadelman, L. S. Taylor, Jr., B. M. Unterberger

Graduate study in history is offered leading to the degrees of Master of Arts 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 Texas history, United States history (colonial, early national, Old South, the West, Civil War period,

*Graduate Advisor

recent, social and intellectual, agricultural history, American diplomatic), European history and Latin American history.

Students will find acceptable minors in economics, education, English, 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 major field; and for a minor at least 12 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. See page 63 of this catalogue.

Normally for the Ph.D. in American History the student shall demonstrate a reading knowledge of two (2) 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 (6) semester hours of graduate work outside the major and minor fields of study, completed after the filing of his degree program, may be substituted for one language.

(Hist.)

601. American Colonial Life and Institutions. (3-0). Credit 3. II, S Study of the seventeenth and eighteenth century English American colonies. Prerequisite: Approval of Department Head.

603. The United States: Revolutionary Era, 1750-1789. (3-0). Credit 3. I, S 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. II, S 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. II, S Study of the West in American history. Emphasizes political, economic, social and cultural influences of frontier. Prerequisite: Approval of Department Head.

611. American Leaders. (3-0). Credit 3. II, S Personalities and contributions of 36 American leaders from Samuel Adams to Dwight Eisenhower. Prerequisite: Approval of Department Head.

612. The French Revolution and Napoleon. (3-0). Credit 3. II Detailed consideration of decline of ancient regime, influence of Encyclopedists, causes and course of events during revolution and after; evaluation of source material. Prerequisite: Approval of Department Head.

613. Twentieth Century United States Diplomacy. (3-0). Credit 3. II, S United States foreign policies from end of Spanish-American War to present, including scope, principles, practices, objectives, dangers, and lessons learned. Prerequisite: Approval of Department Head.

615. Growth of Spanish Institutions in America, 1492-1857. (3-0). Credit 3. I Study of 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. II, S Formation and development of United States policy towards Latin America with principal emphasis upon major countries in North, South, and Central America; Pan-Americanism, Good Neighbor Policy, and recent trends. Prerequisite: Approval of Department Head.

621. The United States, 1877-1914. (3-0). Credit 3. I, S Economic, social, political history of the U.S., 1877-1914, emphasizing 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 the Present. (3-0). Credit 3. II, S The United States during World War I, the "Roaring Twenties," the Depression, the New Deal, World War II, and the Cold War. Prerequisite: Approval of Department Head.

623. United States in World Perspective Since 1933. (3-0). Credit 3. S Examination of changes in United States by its transition towards internationalism since 1933. Particular emphasis upon agriculture, labor, industrialization and urbanization, science and technology, and foreign policy. Prerequisite: Approval of Department Head.

626. Recent American Cultural and Intellectual History. (3-0). Credit 3. I, S Contribution of social and political thought, religion, science, scholarship, and education to the history of American civilization. Prerequisite: Approval of Department Head.

629. United States Historical Bibliography. (3-0). Credit 3. I Acquaints the advanced student with the bibliographical sources and the nature and extent of materials for the study, interpretation, and writing of the United States history. Prerequisite: Twelve advanced hours in United States history; or approval of Department Head.

630. European Historical Bibliography. (3-0). Credit 3. II Acquaints the advanced student with bibliographical sources and nature and extent of materials for the study, interpretation, and writing of European history. Prerequisites: Twelve advanced hours in European history; or approval of Department Head.

631. Reading Seminar in United States History to 1877. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

632. Reading Seminar in United States History after 1876. (3-0). Credit 3. II, S Prerequisite: Approval of Department Head.

633. Reading Seminar in the American West. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

634. Reading Seminar in American Agricultural History. (3-0). Credit 3. II Prerequisite: Approval of Department Head.

635. Reading Seminar in American Diplomatic History. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

636. Reading Seminar in the History of the South. (3-0). Credit 3. II, S Prerequisite: Approval of Department Head.

637. Reading Seminar in the Spanish Borderlands. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

639. Reading Seminar in Modern European History. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

642. Reading Seminar in Recent Asian History. (3-0). Credit 3. II, S Prerequisite: Approval of Department Head.

651. Research Seminar in United States History. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

653. Research Seminar in Modern European History. (3-0). Credit 3. I, S Prerequisite: Approval of Department Head.

670. Russian-American Relations in Asia Since 1894. (3-0). Credit 3. I, S 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. I, S Europe from 1648 to 1789, with particular emphasis upon France. The political history of the age will be supplemented by examination of economic and social institutions and of the Enlightenment. Reading knowledge of French and/or German is required. Prerequisite: Approval of Department Head.

675. Central and Eastern Europe Since 1930. (3-0). Credit 3. S Comprehensive analysis of conditions in central and eastern Europe in the 1930's, in World War II, the Communist takeover, status today; analyses of ideologies of Communism and of western democracies; possible solutions to problems of central and eastern Europe. Prerequisite: Approval of Department Head.

677. Twentieth Century Britain. (3-0). Credit 3. I, S A study of the political, constitutional, social, economic, and diplomatic development of the United Kingdom, including Ireland. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 3 each semester. I, II, S 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.

691. Research. Credit 1 or more each semester. I, II, S Thesis research. Credit given only upon acceptance of completed thesis. Prerequisites: Twelve hours of advanced history and approval of Department Head.

DEPARTMENT OF INDUSTRIAL EDUCATION

H. D. Bearden, J. L. Boone, Jr. (Head)*, D. L. Clark*, G. D. Gutcher*, L. V. Hawkins*, W. A. Mayfield*, R. P. Perkins*, J. K. Weaver*

It is the responsibility of the Industrial Education Department to develop master teachers, researchers, and effective leaders in such human relationship vocations as teaching of industrial arts and vocational industrial education, technical education, vocational guidance, industrial school administration and supervision. It is a major function of the department to promote the interest of industrial education programs and to afford opportunities for professional education, both theoretical and practical. Graduate degree programs in this department are: Master of Education, Master of Science, and Doctor of Education. To become a master teacher in industrial arts, a student may earn a professional Teaching Certificate for the State of Texas through this department.

The classrooms, laboratories, and libraries of Texas A&M University are made available to students studying industrial education. The high schools in the vicinity of the University afford ample opportunity for students to observe the most modern techniques of teaching industrial subjects.

Specialists in other departments and divisions of the University give instruction in subject material which is closely related to industrial education. The laboratories embody the newest types of equipment, machine arrangements, and instructional aids.

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 utilized 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. I, II, S Planning, coordination and evaluation of local book and non-book media services. Acquisition of materials and equipment.

*Graduate Advisor

615. Selection and Evaluation of Learning Resources. (3-0). Credit 3. I, II, S Selection of book and non-book learning resource materials for specific needs or for general collections. Utilization 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. I, II, S Application of research findings and design criteria to graphic communication design techniques. Emphasis given to techniques of preparation and utilization of programmed slide sets, filmstrips, and motion pictures and their application in instructional systems.

631. Instructional Television. (3-0). Credit 3. I, II, S Utilization of television in instructional systems. Program design and content specification.

641. Message Design. (3-0). Credit 3. I, II, S Systematic application of task and learner analysis research findings and design criteria to the design of instructional materials.

684. Professional Internship. Credit 1 to 6. I, II, S 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. I, II, S Directed individual study of selected problems in instructional technology not within thesis research and not covered by any other course. Prerequisite: Approval of instructor.

INDUSTRIAL EDUCATION (I.Ed.)

601. History of Industrial Education. (3-0). Credit 3. I, II, S Study of leaders, movements, and agencies with special emphasis on economic, social, and philosophical factors which have contributed to development of industrial education in the United States.

602. Industrial Arts Administration and Supervision. (3-0). Credit 3. I, II, S Problems of local director or supervisor of industrial arts.

603. Administration and Supervision of Vocational Industrial Education. (3-0). Credit 3. I, II, S Problems of local director or supervisor of vocational industrial education.

604. Industrial Programs for Community Colleges and Technical Schools. (3-0). Credit 3. I, II, S Study of kinds, purpose, size, accreditation, growth, and teaching problems in community colleges, technical institutes, and adult schools, with particular emphasis on organization and presentation of industrial subject material in these schools.

606. Organization of Industrial Education Departments. (3-0). Credit 3. I, II, S Problems in determining type and size of industrial education program for various types and sizes of schools with plans for organization of each.

609. Innovative Programs in Industrial Arts. (2-3). Credit 3. I, II, S Survey of development programs in industrial arts. Designing and organizing problems for teaching these programs.

613. Audio-Visual Communication. (2-2). Credit 3. I, II, S Study of communications with special emphasis upon senses of hearing and seeing in teaching-learning processes. Emphasis given to preparation and utilization of audio-visual tools available for helping to develop abstract concepts. Prerequisite: Graduate classification.

614. Guidance Seminar. (3-0). Credit 3. I, II, S Organization of occupational information, educational and vocational guidance, counseling case problems. Prerequisite: I.Ed. 406 or equivalent.

616. Methods of Teaching Industrial Education. (3-0). Credit 3. I, II, S Selecting and organizing instructional material for problems in a particular industrial activity.

618. Tests and Measurements in Industrial Education. (3-0). Credit 3. I, II, S Study of testing and measuring devices and their application to industrial education subjects.

619. Related Subjects in Part-Time Cooperative Programs. (2-0). Credit 2. I, II, S Organization and presentation of content material necessary in part-time cooperative programs, and direction of the study of students engaged in such programs.

621. Philosophy of Vocational Education. (2-0). Credit 2. I, II, S Basic principles involved in development and operation of industrial education programs under state and federal vocational laws.

622. Philosophy of Industrial Arts Education. (3-0). Credit 3. I, II, S Principles involved in development and operation of industrial arts courses and their purpose and function in the field of general education.

623. Vocational Guidance Procedures. (3-0). Credit 3. I, II, S Workshop approach to study of vocational guidance, programs, relationships, group techniques, and methodology of clinical approach.

626. Classroom Management and Shop Organization. (3-0). Credit 3. I, II, S Organization of procedures to facilitate teaching; setting up roll-checking devices, 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. I, II, S Discussion of problems related to administration of industrial education programs, in-service training, and upgrading of programs on local level. Methods of organizing and conducting teacher improvement programs including methods of conducting organized research.

628. Organization of Vocational Industrial Programs. (3-0). Credit 3. I, II, S 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. I, II, S 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. Prerequisite: I.Ed. 336 or equivalent.

681. Seminar. (1-0). Credit I. I, II, S General discussions of laws, legislation, certification, professional ethics, and other current problems relating to industrial education teaching profession.

684. Professional Internship. Credit 1 to 6 each semester. I, II, S 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 utilized. Prerequisite: Approval of chairman of Advisory Committee and of Department Head.

685. Problems. Credit 1 to 4 each semester. I, II, S Designed to enable Master's candidate majors to undertake and complete with credit limited investigations not within thesis research and not covered by any other course.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

SAFETY EDUCATION

The graduate program in safety education offers an area of concentration for students seeking the Master of Education, Master of Science, 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 programs in safety education are designed to assist in the advanced preparation of master teachers in driver and traffic safety education; to prepare safety education supervisors and administrators; and to prepare safety education research and development specialists.

Library, laboratory, internship, and research facilities are available to graduate students.

(Sa.Ed.)

601. Behavioral Factors in Traffic Safety. (3-0). Credit 3. I, S A study of personality factors related to unsafe driving behavior. Special emphasis will be given to the effect of attitudes, motivations, and adjustment on behavior. The course will also include an investigation of principles and methods appropriate in identifying, understanding, and modifying unsatisfactory attitudes and behavior. Prerequisites: I.Ed. 427 and 428 or equivalent.

604. Alcohol and Traffic Safety. (3-0). Credit 3. I, II, S An in-depth study of the relationship between the consumption of alcohol and its effect upon traffic safety and driving of motor vehicles. Special emphasis given to the role that traffic safety education can play in educating drivers to the risks and problems involved in drinking and driving.

610. Administration of Safety Education Programs. (3-0). Credit 3. II, S A study of safety education programs at national, state and local levels including the administrative, instructional and supervisory aspects of the programs. Basic emphasis on implementation.

620. Traffic Safety Communications. (3-0). Credit 3. II, S 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. Emphasis on planning and managing public information and community support program.

624. School and College Accident Prevention. (3-0). Credit 3. II, S An in-depth study of accident prevention and control programs for educational institutions, with special emphasis given the human, environmental and legal factors effecting program development, implementation and management.

628. Professional Development in Safety Education. (3-0). Credit 3. S An in-depth exploration of the problems of safety education at the university level. Review of related research. Emphasis on the development of representative model curricula for the preparation of safety education personnel. Prerequisites: Approval of instructor.

630. Traffic Safety Education Innovations. (3-2). Credit 4. I, S An exploration of the broad spectrum of recent traffic safety education innovations. Particular emphasis will be placed upon their applications for improving the quality of classroom and laboratory instruction. Prerequisite: I.Ed. 427 and 428 or equivalent.

684. Professional Internship. Credit 1 to 6. I, II, S Supervised graduate practicums, observations and internships in the various fields of safety education. Prerequisites: Approval of instructor.

685. Problems. Credit 1 to 6. I, II, S Supervised experiences in performing research appropriate to career goals. Prerequisite: Approval of instructor.

DEPARTMENT OF INDUSTRIAL ENGINEERING

R. J. Anderson, R. P. Beals, H. J. Benet, A. R. Burgess, B. K. Chakraborty, D. Colunga*, J. R. CoVan, G. L. Curry, D. W. DeMichele, D. D. Drew, R. W. Elliott, N. C. Ellis*, J. W. Foster, M. J. Fox, R. D. Huchingson, W. A. Hyman, R. J. Jendrucko, W. L. Johnston, R. B. Konzen, T. A. Krouskop, W. M. Lively, A. M. Mayyasi, R. J. McNichols, W. L. Meier*, P. H. Newell (Head)*, U. W. Pooch, P. J. Sharpe, A. M. Sherwood*, C. S. Shih, P. R. Shreve, D. B. Simmons, R. L. Street*, R. J. Vernon*, R. B. Wadsworth, A. W. Wortham

The Graduate Program in Industrial Engineering is quite broad and is 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 his natural and social environment. Courses are available and academic programs are being developed in the areas of Behavioral Engineering, Bioengineering, Hygiene and Safety Engineering, Cybernetic Engineering, and Industrial Engineering. The masters' degrees available at present in the Industrial Engineering

*Graduate Advisor

Department are the Master of Industrial Engineering and Master of Computing Science (non-thesis) and Master of Science degrees in Industrial Engineering, Computing Science, Industrial Safety, and Industrial Hygiene. The degree of Doctor of Philosophy is available in Industrial Engineering and Computing Science. Masters' and Doctoral degrees in the other areas of interest in the Industrial Engineering Department such as Bioengineering are available through the Interdisciplinary Engineering program described elsewhere in this catalogue. The graduate courses listed below indicate the depth of work available in each of these areas.

The graduate research program within the industrial Engineering 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, service systems engineering, operations research and optimization, computer graphics, social and political systems engineering, medical engineering, computing science, information storage and retrieval, systems safety engineering, hygiene engineering, production design engineering, industrial operations, biomechanics, maintainability engineering, bionics, and ecological systems engineering.

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, 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 no longer a part of the minimum requirements for a Doctor of Philosophy degree in the Department of Industrial Engineering.

BIOENGINEERING (B.E.)

612. Experimentation. (2-3). Credit 3. II Study of selection and use of experimental animals and use of human subjects; biomedical engineering research teams. Experimental verification of engineering models selected from bionics, properties of biomaterials, biological controls, biomechanics and bioelectric phenomena. Prerequisite: Approval of instructor.

622. Cybernetic Engineering. (3-0). Credit 3. II Comparative study of the automatic control and communication systems associated with living organisms and artificial intelligence system designs. Prerequisite: B.E. 401 or approval of instructor.

633. Biochemical Thermodynamics. (3-0). Credit 3. I Biochemical thermodynamics, kinetics and transport mechanisms. Integration of the classical statistical and informational aspects of thermodynamics as they relate to living systems. Prerequisites: B.E. 412, 452 or approval of instructor.

635. Biomaterials Compatibility. (3-0). Credit 3. I Rheology of biological tissue systems with particular emphasis on engineering testing and subsequent modeling of the constitutive relations is presented. Effect of the body environment on synthetic implanted materials will be examined. Rejection mechanisms used by the body to maintain homeostasis will be discussed. Prerequisite: B.E. 422 or approval of instructor.

638. Control Mechanisms in Living Systems. (3-0). Credit 3. II 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: Bi.Ch. 410; B.E. 401; Math. 602; V.P.P. 323; or approval of instructor.

681. Seminar. (1-0). Credit 1. I, II, S Designed to permit student to broaden his capability, performance, and perspective in biomedical engineering via a formal presentation of his own and by presentations from engineering, medical and veterinary professionals.

685. Problems. Credit 1 to 4 each semester. I, II, S 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.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

COMPUTING SCIENCE (C.S.)

641. Computer Languages. (4-0). Credit 4. I, II, S Logical operations of a large-scale digital computer through its basic machine language and associated assembly languages. Includes theory of design and implementation of assembly language. Prerequisite: C.S. 458.

642. Computer Methods in Applied Sciences. (4-0). Credit 4. I Thorough treatment of numerical solution of initial value problems in ordinary differential equations, solution of linear systems by direct and iterative methods, matrix inversion, the evaluation of determinants, and the calculation of eigenvalues and eigenvectors of matrices. Application to boundary value problems in ordinary differential equations. Introduction to numerical solution of partial differential equations. Selected algorithms will be programmed for solution on computers. Prerequisites: C.S. 458, Math. 417.

643. Logic of Information Processing. (4-0). Credit 4. I, II, S Study of application of digital computers to problems other than those defined by a series of explicit mathematical equations. Emphasis on programming of data processing problems. Prerequisite: C.S. 458.

644. Information Processing Systems. (3-0). Credit 3. I Study of data processing systems including 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. 643.

645. Data Processing Management. (3-0). Credit 3. II, S Presents comprehensive study of problems associated with management of data processing facility. Particular emphasis placed on problems of machine configuration, personnel, systems planning, and personnel training requirements. Prerequisites: C.S. 642.

646. Computer Methods in Applied Sciences. (4-0). Credit 4. II Extension of C.S. 642 to encompass more complex systems. Includes recently developed calculation techniques; applications to transient and steady-state analysis. Emphasis on coordinate systems, matrix operator and tracer methods, imposition of boundary conditions, special boundary configuration and stability considerations. Prerequisite: C.S. 642.

647. Compiler Theory. (4-0). Credit 4. II 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. Prerequisite: C.S. 641.

648. Computer Software Systems. (3-0). Credit 3. I, II Review of batch process systems programs, their components, operating characteristics, user services and their limitations. Implementation techniques for parallel processing of input/output and interrupt handling. Prerequisite: C.S. 641.

649. Time-Sharing Computer Systems. (3-0). Credit 3. I Comprehensive survey of time-sharing computational techniques with emphasis on software for time-shared computer operations. Time-sharing hardware, processors, and monitors; multiprocessing concepts; data flow; central processors; multiplexing devices; general software concepts; data management; performance analysis. Rerequisites: C.S. 641.

650. Real-Time Simulation and Function Generation. (4-0). Credit 4. I Analog, hybrid and related digital techniques for solution of differential equations. Analog simulation languages, scaling methods, operational characteristics of analog components, digital differential analyzers, analog-to-digital and digital-to-analog conversion, modeling methods, digital simulation of continuous systems. Prerequisites: C.S. 641.

652. Computer Languages for Simulation. (3-0). Credit 3. I Introduction to simulation and comparison with other 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. 641.

653. Information Storage and Retrieval. (3-0). Credit 3. II Structure of semiformal languages and models for the representation of structured information. Analysis of information content by statistical, syntactic, and logical methods. Search and matching techniques. Automatic retrieval systems, matching techniques. Automatic retrieval systems, question-answering systems. Evaluation of retrieval effectiveness. Prerequisites: C.S. 641, 643.

654. Assembly Language Techniques. (2-2). Credit 3. II Study of assemblers, assembly language optimization techniques, macro facilities, and software program check-out aids. Prerequisite: C.S. 641.

655. Artificial Intelligence. (3-0). Credit 3. I, II, S A critical discussion of concepts and methods of artificial intelligence. Properties of single-goal decision making systems. Decision making under certainty, uncertainty, and under risk. Prediction, learning, and adaptation. Self-organizing systems. Single-level, multi-goal systems. Formal theory of game playing and teams. Multi-level, multi-goal (hierarchical) systems and organization. Prerequisite: C.S. 641.

656. Computer Language Design. (3-0) Credit 3. I, S An advanced treatment of computer language design based on the theory of formal languages and emphasizing the construction of compilers. Prerequisites: C.S. 641, 647.

657. Computer Structures. (3-0). Credit 3. I, S Components of computer hardware: control units, arithmetic units, input/output channels, memory systems. Mathematical methods of digital arithmetic; difference and implementations of memory. Choice of an instruction set; analysis of instruction execution. Actions of input/output channels; specific examinations of selected peripheral equipment and usage of controllers. Examination of types of systems. Prerequisites: C.S. 641, 648.

658. High Level Computer Languages. (3-0). Credit 3. I, S Treatment of mechanical languages including syntax, semantics, pragmatica, and semiotic relationships. Specification languages such as natural languages, regular expressions, phrase structure grammars, propositional languages, Turing machines. Treatment of specialized languages. Prerequisite: C.S. 641.

659. Formal Languages and Automata Theory. (3-0) Credit 3. II Presents theoretical foundation necessary for design of computer languages and systems. Areas covered will be switching theory, formal languages, automata theory, Turing machines, computability and unsolvability.

681. Seminar. (1-0). Credit 1. I, II, S 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. I, II, S Research problems of limited scope designed primarily to develop research technique.

691. Research. Credit 1 or more. I, II, S Research for thesis or dissertation.

INDUSTRIAL ENGINEERING
(I.En.)

601. Location Logistics of Industrial Facilities. (3-0). Credit 3. II 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.

603. Human Relations in Industry. (4-0). Credit 4. I Discussion of background literature in human relations as it applies to industry. Control conditions which influence productivity and motivate the worker. Principles of leadership and causes of misunderstandings between management and labor; incentives, i.e. direct systems, seasonal bonus, quality incentives, and profit/sharing systems. Prerequisites: I.En. 412, or approval of instructor.

604. Advanced Time and Motion Studies. (1-6). Credit 3. II Advanced methods in time and motion study, balancing operations, learning curves, work sampling memomotion and chronocyclegraph studies, fatigue effects, determination and application of elemental times, Master Standard Data system, and statistical methods in time study. Prerequisite: I.En. 404.

605. Materials Handling. (3-0). Credit 3. I Design of integrated materials handling systems, emphasizing automatic storage and retrieval of unit loads. Remote switching and traveling memory systems; computer simulation of material flow. Prerequisites: C.S. 201; I.En. 414, 416.

606. Collective Bargaining in the Public Sector (3-0). Credit 3. S Special characteristics of collective bargaining in the public sector. Union organizational trends of government employees at the federal, state, and local levels. Case studies in union organizational drives, collective bargaining, and grievance handling, Prerequisites: I.En. 412, 603 or approval of instructor.

608. Industrial Case Analysis. (3-0). Credit 3. II Practice in applications of principles to solution of actual case problems involving broad management decisions. Special attention given to problems indigenous to Texas industry. Prerequisite: I.En. 403.

609. Plant Engineering and Maintenance. (3-0). Credit 3. II Major considerations in factory building design and construction; plant utility systems; preventive, predictive, and emergency maintenance; monitoring construction contracts. Prerequisites: I.En. 416; approval of instructor.

610. Production System Design. (2-3). Credit 3. I Analysis of the factors governing the degree of specialization of labor in production systems. Learning behavior in complex industrial tasks; station interference in progressive manufacture; assembly line simulation. Prerequisites: I.En. 404, 414, 415, and approval of instructor.

611. Arbitration Procedures in Work Practices. (3-0). Credit 3. II Legal 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. Prerequisites: I.En. 412, 603 or approval of instructor.

612. Design by Reliability. (3-3). Credit 4. II Combines principles of design specification and reliability. Emphasis upon reliability aspects of design as related to mechanical systems which will include analysis of design specifications, safety factors, probability of failure, wear, fatigue, and computation of reliability. Prerequisites: I.En. 614, 617, 619.

613. Process Control and Optimization. (3-0). Credit 3. I Covers advanced topics used in industrial quality control and experimentation. Theory developed for special control charts, sequential sampling plans, optimization techniques, and experimental designs. Prerequisite: I.En. 414, 614.

614. Advanced Quality Control. (3-0). Credit 3. I, S Advanced methods applied to quality control and industrial experimentation. Covers aspects of physical application of significance tests; process control theory, techniques, and applications; analysis of process variables; and industrial experimentation. Prerequisite: I.En. 414 or approval of instructor.

615. Production and Inventory Control (3-0). Credit 3. II, S Recent developments in techniques used to control inventories and production by means of statistical analysis of problems, simulation techniques, and mechanized execution of inventory and production control functions. Prerequisite: I.En. 415 or equivalent.

616. Advanced Industrial Analysis. (3-0). Credit 3. II Designed for combining engineering principles with applied statistics in order to provide student with mechanics for analysis of industrial experimentation. Emphasis placed upon applications of principles of I.En. 414, 613, 614 and the planning required for proper use of those techniques. Prerequisites: I.En. 414, 613, 614.

617. Maintainability Engineering I. (3-0). Credit 3. I, II Designed to make engineering applications of techniques developed in I.En. 414, 415, 420, and 614 to problems in analysis of systems maintainability. Will involve model development and analysis in addition to industrial problems in maintainability areas. Prerequisites: I.En. 414, 415, 420, and 614 or equivalent.

618. Maintainability Engineering II. (3-0). Credit 3. II Designed to extend basic principles developed in I.En. 617 and to provide more of basic theory necessary for design and analysis of engineering systems relative to maintainability problems. Prerequisite: I.En. 617 or equivalent.

619. Analysis and Prediction. (3-0). Credit 3. I, S Designed to provide student with model building technology in area of maintainability. Includes data collection and analysis, development of parameters empirically, time dependent models and generalized simulation. Prerequisites: I.En. 614, 620.

620. Principles of Operation Analysis. (4-0). Credit 4. I, II, S 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. 420 or equivalent.

622. Applied Linear Programming . (3-0). Credit 3.I Designed to provide students with 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. Prerequisites: I.En. 420, 620.

623. Nonlinear and Dynamic Programming. (3-0). Credit 3. II Designed to provide student with an 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. Emphasis on application of methods to problems in operations research and industrial engineering. Prerequisite: I.En. 622.

624. Applied Distribution and Queuing Theory. (3-0). Credit 3. I Detailed study of queuing theory applications and its associated emphasis on industrial, traffic, and service problems. Consideration given to methods of using statistical distributions most often required in solution of queuing problems in industrial engineering and operations research. Prerequisites: I.En. 420, 620; Stat. 601 or equivalent.

625. Applications of Simulation Technology. (3-0). Credit 3. II Designed to provide student with appropriate methods and illustrative applications necessary for the highest level of sophistication in models using simulation techniques. Prerequisite: I.En. 624 or 626 or equivalent.

626. Model Building and Applications of Operations Research. (3-0). Credit 3. I, S Application of techniques developed in I.En. 420 and 620 in a systems analysis context. Provides student with proper perspective of operations research within total system framework and its use in formulation, support and construction of mathematical models. Prerequisites: I.En. 420, 620.

627. Engineering Analysis for Decision Making. (3-0). Credit 3. II Designed to provide student with principles and application of techniques in analysis of decision processes involving engineering systems under uncertainty. Introduces student to areas of utility and information theory as related to quantification of information for decision making. Prerequisites: I.En. 414, 420, 620, 622, 628.

628. Applied Game Theory. (3-0). Credit 3. I Provides student with understanding of mathematics associated with game theory and proficiency in recognition, definition, and solution of all types of applied game theory problems. Covers application of this methodology in operations research, military operations research, and industrial engineering problems. Prerequisites: I.En. 420, 620.

629. Engineering Optimization. (3-0). Credit 3. I Designed to provide a suitable interface between mathematics of a group of related optimization techniques and engineering applications that use them. Orientation toward specialized techniques and those presently limited in application in order to complement the student's existing background in optimization. Prerequisite: I.En. 420 or 620 or Math. 308.

630. Human Operator in Complex Systems. (3-0). Credit 3. I, II Provides student basic understanding of how human body and environmental factors affect human performance. Includes broad coverage of work organization and integration of human element in work design. Prerequisites: I.En. 430, graduate classification in Industrial Engineering or approval of Department Head.

631. Engineering Man-Machine Interface II. (3-0). Credit 3. II Second course in a sequence designed to enlarge the student's understanding of the man-machine interface and develop in him the capability of applying human performance data in the design of man-machine systems. Prerequisite: I.En. 630.

632. Human Factors Engineering in System Design. (3-0). Credit 3. II This course is intended to develop within the student the capability of functioning as a human factors engineer in the system design and development environment. Included are applications of human factors to design and evaluation of man-machine systems. Prerequisite: Math. 308, I.En. 432.

633. Human Factors Laboratory. (1-3). Credit 2. II This course is designed to familiarize the student, through laboratory exercises, with the various techniques of measuring and/or monitoring human performance variables both physiological and psychological. Also to develop in the student the ability to control environmental variables in order to simulate real life problems and conditions. Prerequisite: I.En. 631.

634. Man-Machine Systems Engineering. (3-0). Credit 3. II Provides the student with an 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. I This course is designed to provide a background of understanding and relevant data to students concerned with the design of man-machine systems. The value of including a man in the system rests upon his unique ability to translate sensed data into meaningful command signals. The minimization of control errors and decision making techniques are developed. Prerequisites: I.En. 630, 631.

636. Biological Control System Analysis. (3-0). Credit 3. II Builds upon the principles developed in I.En. 632. Primary concern will be development of mathematical and electromechanical models of biological systems, and derivation of human transfer functions. Prerequisites: I.En. 630, 631.

637. Human Factors Engineering. (3-0). Credit 3. I, II Continuation of I.En. 430. Provides the student with an in-depth understanding of human factors engineering data and methods in operational settings and of the interface between human factors and other systems engineering functions. Prerequisite: I.En. 430 or approval of instructor.

638. Human Operator as a Systems Controller. (3-0). Credit 3. S Provides the student with an understanding of the theory and application of the human control process in both manual and automatic control systems, giving him a capability to develop human factors engineering requirements for the design of control systems. Prerequisite: Approval of instructor.

639. Engineering Biotechnology. (3-0). Credit 3. I, II Designed to investigate the current methods and techniques of simulation and measurement of human engineering variables and further explore new ideas for possible contribution to the advancement of the art. The theory of manual control and its application to manual and automatic systems will be covered. Research ability and originality will be emphasized. Prerequisites: Enrollment in Ph.D. program

651. Tool Design. (3-3). Credit 4. II Design of automatic machine tools; tracer and director control of tool paths; numerical control, automatic feeding, holding, indexing and ejection of work pieces; tool replacement analysis. Automatic inspection and sorting, assembly, and packaging. Prerequisite: I.En. 453.

660. Design and Control of Engineering Management Systems. (3-0). Credit 3. I Survey of analytical methods for optimal design, operation, and control of engineering management systems. Techniques in analysis of complex engineering systems. Methodology for determining optimal operating criteria. Prerequisites: I.En. 414, 415, 420.

661. Network-Based Planning and Scheduling Systems. (3-0). Credit 3. I, S Advances and theoretical developments in network-based scheduling systems. Specific topics include analytical study of network statistics, development of mathematical basis for time compression, consideration of decision point theory, generalized activity networks, probabilistic networks, and analysis of engineering cost control systems. Prerequisites: I.En. 614, 620.

662. Planning Technology. (3-0). Credit 3. I Recent advances in analytical planning theory. Techniques for determining man-power requirements, allocation of resources, and project selection while satisfying overall planning objectives in an optimal manner. Methods for formulating planning objectives in quantitative terms; solution procedures. Prerequisite: I.En. 660.

663. Engineering Management Control Systems. (3-0). Credit 3. II Methods for controlling engineering management systems. Topics from areas of control system theory, production and inventory control, and quality control are combined to develop systematic approach to optimal control of engineering management systems. Prerequisite: I.En. 660.

664. Principles of Scheduling. (3-0). Credit 3. II Advanced prediction techniques useful in forecasting and scheduling problems associated with industrial engineering analyses. Topics discussed include time series analysis, probabilistic models, smoothing techniques, and error analysis. Prerequisite: I.En. 660.

665. Advanced Production Control. (3-0). Credit 3. I Study of production operations as integrated systems. Analytical techniques employed for the purpose of making decisions about aggregate production rates, work force sizes, and shipments over time. Prerequisites: I.En. 414, 415, 615, and approval of instructor.

666. Cost Estimating, Engineering Economy and Planning. (3-0). Credit 3. II, S Expands on prerequisite courses in the specific areas of cost estimating and production planning. Special consideration to analytical methods which aid in management decision making. Various case studies are utilized in order to illustrate specific applications in real world situations. Prerequisites: I.En. 414, 415, 420 or approval of instructor.

670. Industrial Safety Engineering. (3-0). Credit 3. I Provides a solid foundation in the general concepts and techniques of safety engineering upon which more detailed and advanced applications may be based, in particular, applications of safety principles to industrial and commercial systems are discussed and the concept of engineering new systems from the safety standpoint is introduced. Prerequisite: Graduate classification in Industrial Engineering or approval of Department Head.

671. Safety Engineering in Equipment Design. (3-0). Credit 3. II Provides specialized emphasis required to develop within a student the ability to function in the equipment design process as a specialist in safety engineering. Generalized safety and human factors principles are brought to focus upon specific problems of accident elimination as related to the man-machine system design. Emphasis placed upon operator/maintenance technician factors such as sensory perceptions, physical characteristics, physiological and mental stress, etc., as design considerations. Prerequisite: I.En. 632 or registration therein.

672. Safety Engineering in Facilities Design. (3-0). Credit 3. I, S Provides specialized training for students interested in design of buildings and similar facilities from the standpoint of accident elimination. Generalized safety and human factors principles are brought to focus upon specific problems of safety as related to facilities designed for use by human beings. Emphasis placed upon such factors as environmental effects and control, flow of traffic (human and materials), access to facilities, etc. Prerequisite: I.En. 632 or registration therein.

673. Safety Engineering in Design of Transportation Systems. (3-0). Credit 3. II, S Provides the student with specific background material which will allow him to serve as a safety specialist on the design team working on transportation systems. Discussion includes all modes of transportation and the integration of human factors principles into their design for purposes of accident prevention. Emphasis placed on vehicle and total system control, operator/maintenance technician check-out procedures, use of specific safety devices, etc. Prerequisite: I.En. 632 or registration therein.

674. System Safety Engineering. (3-0). Credit 3. II Provides requisite background which will allow the student to serve as a system safety specialist on a design team. Emphasis placed on application, selection, and utilization of various system safety analytic approaches. Prerequisites: Graduate classification in Industrial Engineering or approval of Department Head.

675. Integrated Logistics Support. (3-0). Credit 3. I, II To provide student with specific background material which will allow him to serve as logistics specialist on a design team. The course concentrates on the development of management and engineering concepts relating to I.L.S. of systems. These concepts emphasize the design for performance and support in contrast with design for performance only. The concepts highlight a balanced consideration between operation, economic, and logistics factors. Prerequisite: Approval of Department Head.

676. Safety in Materials Handling. (2-0). Credit 2. I, II, S Manual and mechanical materials handling systems, selection, placement and training of personnel; selection of equipment, interaction of manual and mechanical systems. Prerequisites: I.En. 438, 448.

677. Fire Protection and Prevention. (2-0). Credit 2. I, II, S Fire resistance, flame spread, fire protection principles; flammable liquids, gases, solids, dusts, chemicals and explosives; public and private extinguishing equipment and methods, including automatic extinguishing systems. Prerequisites: I.En. 438, 448.

678. Problems in Industrial Safety. (2-0). Credit 2. I, II, S Basic reasons for accidents, prevention of industrial accidents, qualifications and duties of safety consultants, methods of making investigations, safety surveys and the preparation of safety reports for management.

679. Machine Safeguarding. (2-0). Credit 2. I, II, S Design of machine safeguarding methods incorporating existing codes, regulations, and operating practices for point-of-operation exposures and power transmission. Prerequisite: I.En. 423 or equivalent.

680. Industrial Hygiene. (2-0). Credit 2. I, II, S Occupational environment and its effect on the health, safety, and performance of employees. Prerequisite: I.En. 423 or equivalent.

681. Seminar. (1-0). Credit 1. I, II Group study and discussion of current developments in industrial engineering practices as reported in literature and as presented by representatives from industry. Prerequisite: Graduate classification in Industrial Engineering.

682. Instrumentation for Industrial Hygiene. (2-0). Credit 2. I, II, S Introduction to specific quantitative and qualitative instrumentation available and in use in industrial hygiene and the continuing need for development of precise methods and equipment. Prerequisites: Chem. 227, V.P.P. 633.

683. Evaluation and Control of the Occupational Environment. (3-3). Credit 4. I, II, S Detection, evaluation and control of chemical, physical and biological occupational hazards affecting health and safety. Prerequisites: Chem. 227; I.En. 680, 682; V.P.P. 633.

684. Acoustics and Noise Control. (2-3). Credit 3. I, II, S Physical and psychological aspects of noise and evaluation and control of the noise problem in the environment. Prerequisite: I.En. 680 or equivalent.

685. Problems. Credit 1 to 4 each semester. I, II, S Investigation of special topics not within scope of thesis research and not covered by other formal courses. Prerequisite: Graduate classification in industrial engineering.

691. Research. Credit 1 or more each semester. I, II, S Research in industrial engineering field; content and credit dependent upon needs of individual student.

INTERDISCIPLINARY EDUCATION

The Interdisciplinary Education division in the College of Education provides the setting for a series of unique graduate programs which draw upon the resources

of several academic departments within the University. Graduate programs currently based upon an interdisciplinary arrangement include (1) a comprehensive program in Vocational Education for administrators, supervisory personnel, guidance counselors, curriculum specialists, and research personnel; (2) a program for the preparation of specialists in Adult and Continuing Education; and (3) a program in Cooperative Extension Education for specialists in this important field of study.

In addition to utilizing appropriate courses from other departments of the University, these comprehensive graduate curricula also include selections from a series of specially designed courses in Interdisciplinary Education described in this section.

(Id.Ed.)

601. Principles of Vocational Education. (3-0). Credit 3. I, S Principles of vocational education stressing the 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. II, S The administration of comprehensive vocational education programs emphasizing the 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. II, S Study of 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. II, S 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. II, S Principles and applied practices in developing curricula for different areas of vocational education. Emphasis on the process of curricular development and improvement using a systems approach.

620. Evaluation and Analysis in Vocational Education. (2-2). Credit 3. I Principles and procedures of evaluation used in developing and conducting programs of vocational education. Field practice in evaluation procedures will be required.

630. Adult Learning. (3-0). Credit 3. I An in-depth study of the research and experimentation in adult learning. Emphasis will be placed on changes occurring in adult life as they affect the teaching-learning process.

632. Methods of Adult Basic Education. (3-0). Credit 3. I The theory and practice of methods in adult education. Particular emphasis given to individualized teaching, including programmed instruction, and evaluation in basic and G.E.D. preparation. Prerequisites: Ag.Ed. 610; Id.Ed. 630.

633. Adult Literacy Education. (3-0). Credit 3. II A review of the pertinent literacy programs in the U.S. and abroad. The relevancy to social and vocational skills will be determined and related to the sociopsychological factors in education. Prerequisite: Id.Ed. 630.

640. Principles and Practices of Bilingual Education. (3-0). Credit 3. S A review of the bilingual programs in the U.S. and other countries. Analysis of the teaching methods employed, especially the visual-oral-aural approaches. Prerequisites: E.Psy. 602 or 673 or Id.Ed. 630; Spanish proficiency certified by Department of Modern Languages.

650. History and Philosophy of Cooperative Extension. (3-0). Credit 3. II, S A study of the philosophical bases for and historical development of cooperative extension education in agriculture, home economics and 4-H. Prerequisite: Ag.Ed. 610.

657. Administration and Supervision in Cooperative Extension. (3-0). Credit 3. I Administration and supervision of cooperative extension at the state and federal levels; relations with other divisions of the Land-Grant College system; role of the state director and other staff in planning and coordinating resources; delegation of authority. Prerequisite: Ed.Ad. 653.

660. Community Development Education. (3-0). Credit 3. S Preparation in the area of community development with special reference to the role of education. Particular attention will be given to social and economic aspects. Case studies of national and international studies will be analyzed. Prerequisite: Ag.Ed. 640 or Soc. 609.

681. Seminar. (1-0). Credit 1. I, II, S Problems pertinent to vocational, adult, and cooperative extension education. Recent developments and research in appropriate areas.

684. Professional Internship. Credit 1 to 6. II Supervised experiences in performing professional functions appropriate to career goals. Prerequisite: Approval of program coordinator.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problems in the fields of adult, vocational or cooperative extension education.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation. Prerequisite: Approval of student's Advisory Committee Chairman.

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. Students with undergraduate degrees in other fields such as mathematics or science with an acceptable understanding of engineering fundamentals are invited to participate in the program. The principal programs under Interdisciplinary Engineering are Activation Analysis, Bioengineering, Mechanics and Materials, and Systems Engineering. Other degree programs may be tailored to suit a student's desires subject to Graduate College regulations and the approval of the student's committee. The Doctor of Philosophy language requirement will be determined by the student's Advisory Committee. Students interested in this program should contact Dr. James A. Stricklin, Room 113K, Engineering Building.

(ltd.E.)

681. Seminar. (1-0). Credit 1. I, II, S 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. I, II, S Research problems of limited scope designed primarily to develop research technique.

691. Research. Credit 1 or more. I, II, S Research for thesis or dissertation.

BIOENGINEERING

Bioengineering is the application of engineering principles to living systems. Within this broad spectrum exist many challenging problems, each of which requires a specific set of skills, ranging from the traditionally oriented engineer who learns

only enough physiology to facilitate his work with pacemakers, to the physician who obtains an operational understanding of complex instrumentation used in intensive care units. The Texas A&M Bioengineering program is designed to give students the broad base of knowledge necessary for work in the interdisciplinary area midway between engineering and medicine. Persons interested in this program should contact Dr. Paul H. Newell, Jr., 337 Zachry Engineering Center.

Courses offered in Bioengineering can be found in the course listings for the Department of Industrial Engineering.

MECHANICS AND MATERIALS

The Mechanics and Materials program performs three major functions. First, and most importantly, it is the interdisciplinary vehicle for staff and students to study and conduct research in those increasingly important problems requiring a blending of mechanics and materials. Second, it is a formal program wherein graduate students can pursue studies in the traditional areas of either applied mechanics or materials science. Third, it provides a coordinated set of service courses for the engineering departments. Students interested in this program should contact Dr. Thomas J. Kozik, Mechanical Engineering Department, Zachry Engineering Center.

(M.M.)

601. Theory of Elasticity (3-0). Credit 3. I Study of 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.

602. Vectors and Tensors in Mechanics. (3-0). Credit 3. I Unified study of continuous media using vectors and tensors.

603. Foundations of Solid Mechanics (3-0). Credit 3. II Fundamental description of displacement, stress and strain mechanisms in deformable solids. Major effort directed toward microscopic theory; comparision of macroscopic analysis. Prerequisite: Math 601.

604. Mechanics of Viscous and Elastic Fluids. (3-0). Credit 3. I Study of basic dynamics and kinematics of viscous and visco-elastic fluids. Newtonian, non-Newtonian, and viscoelastic fluids are considered. Fundamentals of tensor analysis are included and are utilized in generalizing rheological equations of state. Prerequisite: Math 601.

605. Energy Methods. (3-0). Credit 3. I Study of 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.

606. Shock Waves in Continuous Media (3-0). Credit 3. I Theory of one-dimensional shock wave propagation in gases, liquids and solids. Numerical techniques and the method of characteristics are applied to shock tubes, water pipes and the impact of elastic and plastic systems. The mechanism of wave transmission and reflection in layered materials is used to predict shock wave amplification and attenuation. Prerequisites: Math 601 or registration therein.

607. Flow and Fracture of Solids (3-0). Credit 3. II Study of flow theories and fracture mechanisms of crystalline solids. Elasticity, materials science applications to engineering. Dislocation theory, fracture, creep, and fatigue.

608. Experimental Structural Analysis. (1-3). Credit 2. II, S Study of observations and measurements, dimensional analysis, prediction equations, and theory of similitude. Design, construction, and use of structural models. Prerequisites: M.M. 467, 470 or registration therein.

609. Materials Science. (3-0). Credit 3. II Detailed study of structure and properties of solid materials. Prerequisites: Graduate classification; approval of instructor.

610. Thermodynamics of Materials. (3-0). Credit 3. I Application of thermodynamics to materials and materials processes. Solid state reactions emphasized with particular attention to metallurgical processes. Atomistic approach to properties of materials included where beneficial. Prerequisite: Approval of instructor.

611. Physical Metallurgy (3-0). Credit 3. II Properties of metals and alloys described by application of simple physical laws. Dislocation theory, thermodynamics, statistical mechanics, vacancies and deformation twinning used to explain mechanical and physical behavior of metals. Prerequisite: Approval of instructor.

612. Materials in Design. (3-0). Credit 3. I Utilization of fundamental knowledge of solid state and available materials data in selection of materials for engineering applications. Advanced techniques described and applied to numerous examples. Prerequisite: M.M. 609.

613. Principles of Composite Materials. (3-0). Credit 3. II Atomic, molecular, micro/macrostructure studied with respect to physical and mechanical properties of composite materials. Includes 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.

615. Introduction to X-Ray Metallography. (3-3). Credit 4. I, II Course designed for students with only a cursory knowledge of crystal structure. Will attempt to instruct them on the nature and production of x-rays; some experimental methods using x-rays and the use of x-rays in solving some selected problems in materials. Prerequisite: Approval of instructor.

632. Structural Stability. (3-0). Credit 3. II 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. I 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. II Basic study of 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. II 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. II 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.

645. Application of the Theory of Shells. (2-0). Credit 2. I Specialization of general shell equations to certain classical geometries and methods of solution. Problems of shell dynamics and anisotropic shells. Prerequisite: Math 601.

647. Theory of Finite Element Analysis. (3-0). Credit 3. I Finite elements of a continuum; plane stress and plane strain; area coordinates; bending of plates; axi-symmetric stress analysis; three-dimensional stress analysis; recent developments.

650. Dynamic Fluid-Solid Interactions. (3-0). Credit 3. II Advanced topics of the dynamic interaction between fluid and solid systems with applications to space vehicles, nuclear reactors, heat exchangers and structures in general. Topics include 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. I 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. II 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.

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. Degree programs 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 Dr. William B. Jones, Jr., Electrical Engineering Department, Zachry Engineering Center.

(Sy.En.)

601. Systems Engineering. (3-0). Credit 3. I Study of processes and patterns of systems engineering, a discipline concerned with planning, organization, and management of programs for developing large, highly complex systems.

610. System Characterization. (3-0). Credit 3. I Study of concepts and techniques of characterizing systems and subsystems to facilitate their analysis and design. Prerequisite: ltd.E. 601.

611. System Reticulation. (3-0). Credit 3. II Study of techniques used in decomposing system concepts into identifiable structural components and of task allocation between man and system. Prerequisite: ltd.E. 610.

612. Multilevel System Theory. (3-0). Credit 3. II Study of multilevel concept and how it is applied in design of complex technological systems. Prerequisite: ltd.E. 601.

620. Preliminary System Design. (3-3). Credit 4. II Study of procedures, methods, and factors influencing preliminary design of complex technological systems. Prerequisite: ltd.E. 601.

621. Detailed System Design. (3-3). Credit 4. S Study of methods for abstractly analyzing, synthesizing, and evaluating complex systems. Prerequisite: ltd.E. 620.

622. Computer-Aided Design. (3-0). Credit 3. S Study of theoretical and practical aspects of specialized computing systems used to assist engineers in design of complex technological systems.

DEPARTMENT OF LANDSCAPE ARCHITECTURE

W. W. Harper*, J. H. Marsh*, E. J. Romieniec, W. C. Steward, R. F. White (Head)*

The Department of Landscape Architecture offers a graduate program leading to the degree of Master of Landscape Architecture. The program is intended to develop capabilities beyond those acquired at the undergraduate level. It offers 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 all aspects of land development. Emphasis is placed on the necessity of collaborative professional efforts in the solution of all environmental design problems.

*Graduate Advisor

(Land.)

620. Open Space Development I. (2-9). Credit 5. I, S 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. II, S Continuation of Land. 620 with special emphasis of production of plans and reports. Prerequisite: Graduate classification in Landscape Architecture.

630. Land Development Principles. (1-6). Credit 3. I, S 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. Prerequisite: Graduate classification in Landscape Architecture, Architecture, Urban and Regional Planning, Civil Engineering, Recreation and Parks, Sociology, or Economics.

631. Land Development Techniques. (1-6). Credit 3. II, S Continuation of Land. 630 with special emphasis on interprofessional collaborative efforts. Prerequisite: Land. 630.

681. Seminar. (1-0). Credit 1 each semester. I, II Analysis and criticism of selected landscape architectural projects. Includes lectures, reports and discussions. Prerequisite: Graduate classification in Landscape Architecture.

684. Professional Internship. Credit 1 to 8. I, II, S Professional practice internship or research in professional practice activities in lieu of the thesis or dissertation. Prerequisite: Twenty hours of work toward MLA degree or approval of Department Head.

685. Problems. Credit 1 to 6. I, II, S Special problems in landscape architectural design with emphasis on analytical. Research approach toward design expression. Prerequisite: Graduate classification in Landscape Architecture.

LIVESTOCK PRODUCTION

A dynamic livestock industry in Texas is creating a tremendous opportunity for well-trained, management-oriented people. The new Master of Agriculture degree program in the College of Agriculture provides this type of training in Beef Cattle, Sheep, Swine and Horse production. The Professional Internship program is in cooperation with some major livestock enterprises. Other requirements for the degree are the same as those for the other Master of Agriculture degrees in Animal Science.

DEPARTMENT OF MANAGEMENT

R. Albanese, L. R. Burgess, P. B. Goode, J. E. Pearson, C. A. Phillips, G. H. Rice, J. L. Sandstedt, A. W. Smith, B. D. Stone, Jr. (Head)*, A. V. Wolfe

Graduate study in management is offered leading to the Master of Business Administration in Organization and Administration, the Master of Science in Management and to satisfy the requirements for a field in management for the degree

*Graduate Advisor

of Doctor of Philosophy in Business Administration. Students may concentrate their research and study in one of the following areas: behavior in organizations, legal and social role of business, personnel management, theory of organization, and the use of quantitative techniques in management decision making.

Graduate students in other programs who satisfy the prerequisites may take courses offered by the department.

Information on the graduate programs is available from the Director of Graduate Programs of the College of Business Administration.

(Mgmt.)

609. Management Seminar. (3-0). Credit 3. I, S Study of organization theory and its application to business systems. Prerequisites: Mgmt. 655 or equivalent.

610. Business and Society. (3-0). Credit 3. II Covers the roles of the businessman and his major instrument of organization, the corporation, particularly as they relate to social and political environment. Prerequisite: Mgmt. 655 or equivalent.

620. Personnel. (3-0). Credit 3. I, S Analysis and evaluation of practices and problems in the acquisition, maintenance, development and utilization of personnel. Prerequisite: Mgmt. 655 or equivalent.

623. Wage and Salary Administration. (3-0). Credit 3. II Trends in wages, salaries and fringe benefits. Prerequisites: Mgmt. 422 or equivalent; Mgmt. 655 or equivalent.

624. Seminar in Human Resources. (3-0). Credit 3. I Seminar in human resources, emphasis on individual student research projects.

625. Management Training in Industry. (3-0). Credit 3. I Examination of theoretical foundations for and implementation of manager development efforts in American industrial organizations. Prerequisites: Mgmt. 422 or equivalent; Mgmt. 655 or equivalent.

630. Behavior in Organizations. (3-0). Credit 3. II, S Systematic review, critique, and application of the findings of the research in the behavioral sciences to the understanding, prediction and management of individual and group behavior in formal organizations. Prerequisites: Approval of instructor; graduate classification.

635. Research Topics in Labor Relations. (3-0). Credit 3. I An analysis of selected labor and manpower problems and issues relevant to the current business environment. A major emphasis will be placed on individual student research projects. Prerequisite: Approval of instructor.

643. Legal Relationships. (3-0). Credit 3. II, S Various relationships based on law encountered by business executive, agreements, circumstantial relationship, and governmental responsibilities. Prerequisites: Graduate classification; approval of graduate advisor.

655. Survey of Management. (3-0). Credit 3. I, II, S Personnel and production management practices and theories, organization, plant efficiency studies, control administration, personnel methods and techniques, and human relations. Prerequisites: Graduate classification, approval of graduate advisor.

661. Marine Resource Management. (3-0). Credit 3. II Analysis of problems in management of marine resources. Develops decision-making skills for optimal use of these resources. Prerequisites: Graduate classification and approval of instructor.

662. Marine and Coastal Zone Law. (3-0). Credit 3. I Draws from Maritime, Constitutional, and International Law principles relevant to major legal problems involved in developing marine and coastal zone resources. Prerequisites: Graduate classification and approval of instructor.

663. Legal Environment of Business. (3-0). Credit 3. I, S Constitutional and legislative enactments, stare decisis and judicial process, regulation of commerce. Taxation and regulations of competition, business and labor. Prerequisites: Mgmt. 643 or equivalent, approval of graduate advisor.

672. Management Information Systems. (3-0). Credit 3. I, S Integrative approach to data processing and management information systems with emphasis on data flow, systems analysis and design, and information economics. Prerequisite: Mgmt. 655 or equivalent.

680. Business Policy. (3-0). Credit 3. I, II, S Case study of decision-making within the business firm, with emphasis on corporate strategy, policy formulation and implementation; supplemented by a comprehensive business game and research projects. Prerequisite: Graduate classification in business administration; approval of graduate advisor.

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

685. Problems. Credit 1 to 3 each semester. I, II, S Directed study on selected problems using recent developments in business research methods. Prerequisites: Graduate classification; approval of instructor.

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

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

DEPARTMENT OF MARKETING

J. U. McNeal (Head)*, S. M. Gillespie, M. J. Houston, H. G. Thompson

Graduate work in marketing offers an MBA and an MS in Marketing as well as a field for a Ph.D. in Business Administration. The MBA or the MS requires approximately 36 hours presuming an undergraduate degree in Business Administration. Undergraduates from other fields will be required to take some preparatory courses.

The MS degree concentrates almost entirely on marketing courses, while the MBA emphasizes other functional areas of Business Administration in addition to marketing.

Marketing courses are open as electives to students in other disciplines where prerequisites are met.

The Ph.D. language requirement is determined by the student's Advisory Committee, but usually does not entail a foreign language.

(Mktg.)

622. Marketing Regulations. (3-0). Credit 3. II Study of the governmental and quasi-governmental regulation of marketing. Considers state and national regulatory agencies and acts. Prerequisites: Mktg. 649 or equivalent; graduate classification.

649. Survey of Marketing. (3-0). Credit 3. I, S Analysis of marketing functions and institutions. Marketing mix related to consumer, trade, and industrial products. Emphasis on terminology and essential concepts. Prerequisites: Graduate classification; approval of graduate advisor.

650. Analyzing Consumer Behavior. (3-0). Credit 3. I, S Examines theoretical and empirical materials on consumer behavior in terms of marketing communications. Considers such topics as personality, social class, and perception of consumer. Prerequisites: Graduate classification; Mktg. 649 or equivalent.

655. Marketing Communications: Personal. (3-0). Credit 3. I, S Considers such functions as personal selling, public relations and customer service. Prerequisites: Graduate classification; Mktg. 649 or equivalent.

656. Marketing Communications: Non-Personal. (3-0). Credit 3. II, S Considers such activities as advertising, product and package design, sales promotion, and pricing. Prerequisites: Graduate classification; Mktg. 649 or equivalent.

*Graduate Advisor

665. Research for Marketing Decisions. (3-0). Credit 3. II, S Research design and execution related to problems in marketing communications. Covers effectiveness of advertising, packaging design, product design and selling. Prerequisites: Graduate classification; Mktg. 649 or equivalent.

671. Product Innovation. (3-0). Credit 3. II, S Understanding of consumer needs and translating them into new products and services whose design and presentation convey satisfaction of these needs. Prerequisites: Graduate classification; Mktg. 649 or equivalent.

675. Marketing Management. (3-0). Credit 3. II, S Analysis of marketing as it relates to over-all business objectives. Marketing activities integrated with other business functions, analysis strategy, and tactics. Prerequisites: Graduate classification in business administration; approval of graduate advisor.

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

685. Problems. Credit 1 to 3 each semester. I, II, S 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. II 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.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

DEPARTMENT OF MATHEMATICS

O. G. Aberth, G. D. Allen, G. R. Blakley (Head), J. R. Boone, J. D. Bryant, C. H. Ching, C. K. Chui, L. F. Guseman, D. J. Hartfiel, A. M. Hobbs, J. T. Hurt, J. T. Kent, D. G. Kostka, H. A. Luther, W. R. Madych, C. J. Maxson, W. S. McCulley, T. A. Metzger, B. C. Moore, F. J. Narcowich, N. W. Naugle, W. L. Perry, H. W. Pu, P. W. Smith, A. H. Stroud, J. L. Tollefson, L. B. Treybig

The Mathematics Department has two main objectives in its graduate offerings. First, it offers courses from which a graduate student may choose an appropriate sequence for an advanced degree in mathematics; second, it attempts to furnish proper mathematical preparation for graduate students majoring in other departments.

The department 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 advisor.

(Math.)

600. Fundamental Mathematics in Secondary Schools. (3-0). Credit 3. S Basic concepts of arithmetic, algebra, geometry, and trigonometry as viewed from standpoint of higher analysis. Famous problems, construction of tables and slide rules, other topics designed to help vitalize teaching of high school mathematics. Prerequisite: Math. 122 or 210.

601. Higher Mathematics for Engineers and Physicists. (4-0). Credit 4. I, II, S Geometry, topology and algebra of vectors, matrix methods, vector calculus, complex analysis, infinite series, conformal mapping. Prerequisite: Math. 308.

602. Higher Mathematics for Engineers and Physicists. (4-0). Credit 4. I, II, S Fourier Series, Fourier integrals and transforms, orthogonal functions, applications to partial differential equations. Special functions: gamma function, orthogonal polynomials. Bessel functions, Strum-Liouville theory, application to differential equations. Prerequisite: Math. 601 or 405 and 407.

*Graduate Advisor

603. Operator Theory and Partial Differential Equations. (4-0). Credit 4. II Theory of operators in partial differential equations and boundary value problems: Laplace and other integral transforms, adjoint operator, self-adjoint and differential operators, classification of linear partial differential equations of the second order. Prerequisite: Math. 602, or 311, 312 and 407.

606. Theory of Probability. (4-0). Credit 4. II Markov processes, matrix theory applications, special limit theorems, transforms. Prerequisite: Math. 411 or approval of instructor.

607. Real Variables I. (4-0). Credit 4. I Lebesgue measure and integration theory, differentiation, L spaces, abstract integration, signed measures. Radon-Nikodyn theorem, Riesz representation theorem, integration on product spaces. Prerequisite: Math. 410.

608. Real Variables II. (4-0). Credit 4. II Banach spaces, theorems of Hahn-Banach and Banach-Steinhaus, the closed graph and open mapping theorems, Hilbert space techniques, topological vector spaces, weak and weak* topologies. Prerequisite: Math. 607.

609. Numerical Analysis. (3-3). Credit 4. I, II Linear and nonlinear programming, simulation, Monte Carlo techniques, game theory. Laboratory will consist of programming appropriate problems. Prerequisite: Math. 417.

610. Numerical Methods in Differential Equations. (3-3). Credit 4. II, S Elementary numerical solutions, analytical foundations, systems of equations, higher order equations, two-point boundary problems, numerical methods for partial differential equations. Laboratory will consist of programming a high speed digital computer. Prerequisite: Math. 417 or 418.

611. Ordinary Differential Equations. (4-0). Credit 4. I 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. II General solution of first order equations, second order equations from physics and mechanics. Prerequisite: Math. 611 or equivalent.

615. Vector Spaces and Matrices I. (3-0). Credit 3. I Vector spaces, linear transformation, fundamental properties of matrices including canonical forms. Prerequisite: Math. 409 or 415 or equivalent.

616. Vector Spaces and Matrices II. (3-0). Credit 3. II Metrization and consequent matrix properties. Prerequisite: Math. 615.

617. Theory of Functions of a Complex Variable I. (3-0). Credit 3. I, S Homomorphic 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. II Infinite product, Weierstrass factorizations theorem, Mittag-Leffler's theorem, normal family, Riemann mapping theorem, analytic continuation, Picard's theorems and selected topics. Prerequisite: Math. 617.

620. Fourier Series and Allied Topics. (4-0). Credit 4. II, S 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.

622. Laplace Transforms. (4-0). Credit 4. II, S Fundamental theorems concerning Laplace transforms. Applications to ordinary and partial differential equations, difference equations, and integral equations. Prerequisite: Math. 601.

625. Matrix Algebra and Tensor Calculus. (4-0). Credit 4. I, II Elementary matrix operations, canonical forms, special matrices, characteristic roots, tensor concept, covariance and contravariance, metric tensors, Christoffel's symbols, covariant differentiation. Prerequisite: Math. 405 or 601.

627. Theory of Numbers. (3-0). Credit 3. I Quadratic residues; the Legendre, Jacobi, and Kronecker symbols; quadratic reciprocity; residue characters; character sums; sums of squares; diophantine equations. Prerequisite: Approval of instructor.

628. Theory of Numbers. (3-0). Credit 3. II Commutative rings, ideals and residue class rings, principal ideal rings, unique factorization rings, quadratic fields, fields of higher degree. Prerequisite: Math. 627.

631. Ring Theory I. (3-0). Credit 3. I Rings and ideals, chain conditions, radicals, simplicity and semisimplicity, modules, homology. Prerequisite: Math. 653 or approval of instructor.

632. Ring Theory II. (3-0). Credit 3. II Recent developments in rings and their generalizations. Prerequisite: Math. 653 or approval of instructor.

633. Group Theory I. (3-0). Credit 3. I Abelian groups, homomorphisms, Sylow theorems, permutation groups. Prerequisites: Math. 653 or approval of instructor.

634. Group Theory II. (3-0). Credit 3. II Solvable and nilpotent groups, free groups, extensions, representations. Prerequisite: Math. 633.

636. Topology. (3-0). Credit 3. II Axiomatic treatment of topological spaces. The metrization problem. Applications to arcs and curves. Prerequisite: Math. 607.

637. Advanced Topics in Topology. (3-0). Credit 3. II Topics in topology not provided for in other courses. Prerequisite: Math. 636 or approval of instructor.

638. Calculus of Variations. (3-0). Credit 3. II Theory and applications of methods of calculus of variations as applied to optimal problems. Prerequisite: Math. 601.

639. Iterative Techniques. (3-3). Credit 4. I Iterative techniques for solving single equations, systems of equations, and eigenvalue problems. Prerequisite: Math. 423 or 601 or 615.

641, 642. Modern Analysis. (4-0). Credit 4 each semester. I, II, Recent developments in the theory of functions. Prerequisite: Math. 608.

643. Algebraic Topology I. (3-0). Credit 3. I Fundamental ideas of algebraic topology, homotopy and fundamental group, covering spaces, polyhedia. Prerequisite: Math. 436 or approval of instructor.

644. Algebraic Topology II. (3-0). Credit 3. II Homology and cohomology theory. Prerequisite: Math. 643.

645. Geometry I. (3-0). Credit 3. I Linear algebra and geometry; affine and projective geometry. Prerequisite: Math. 416.

646. Geometry II. (3-0). Credit 3. II Sympletic and orthogonal geometry, general linear group. Prerequisite: Math. 645.

651. Optimization I. (3-0). Credit 3. I Study of 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. Prerequisites: Math. 410, 416, or approval of Department Head.

652. Optimization II. (3-0). Credit 3. II Study of 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. I, II, S Survey of groups, rings, ideals. Prerequisite: Math. 415 or approval of instructor.

654. Algebra II. (3-0). Credit 3. I, II, S Survey of modules, field extensions, Galois theory. Prerequisite: Math. 653 or approval of instructor.

655. Functional Analysis I. (3-0). Credit 3. I 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. II Topological linear spaces, locally convex spaces, duality in locally convex spaces, ordered topological vector spaces, distribution theory, applications to analysis. Prerequisite: Math. 655.

660. Advanced Topics in Algebra. (3-0). Credit 3. I, II, S Topics in algebra not provided for in other courses. Prerequisite: Math. 653, or approval of instructor.

661. Calculus of Finite Differences. (3-0). Credit 3. I, II Difference calculus, interpolation with remainder theory, Tschbychef, Bernoulli and Euler polynomials, introduction to difference equations. Prerequisite: Math. 308.

685. Problems Credit 1 to 4 each semester. I, II, S A course 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.

690. Theory of Mathematical Research. (2-0). Credit 2. I, II, S Discussion and evaluation of current research in mathematics. May be repeated for credit.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

MEAT INDUSTRIES

A dynamic livestock and meat industry is creating exceptional opportunities for well-trained management and technically oriented graduates.

The multi-million dollar meat industry is one of the leading agri-business operations. Many facets of the meat industry such as wholesaling, prefabrication, retailing, specialty products, hotels, restaurants, institutions, vendors, custom processing, meat industry suppliers and regulatory agencies require leadership of the highest quality. Management training is essential to provide such leadership.

A new Master of Agriculture degree program at Texas A&M University has been tailored specifically to prepare students for a professional career in every phase of the meat industry. The program, one of the first of its kind, trains and develops students for meat industry management and other opportunities in the meat industries.

Entrance requirements and academic standards are the same as required for other graduate programs. The curriculum is flexible to fit individual needs. Students prepare a professional paper instead of a thesis on a research project. A required "professional internship" program (minimum 6 months) in some phase of the meat industry gives the student actual contact with meat industry operations. Students will register for four (4) hours of An.Sc. 684 each semester and two (2) hours each summer session while actively engaged in the program under the supervision of committee chairman. The student's course of study (36 hours of graduate credit) is developed from the following departments: Animal Science, Agricultural Economics, Agricultural Engineering, Biochemistry and Biophysics, Finance, Accounting, Management, Marketing, Business Analysis, Soil and Crop Sciences, Statistics, and Veterinary Public Health.

Other Master of Agriculture program options available in Animal Science are: Dairy Production, Dairy Manufacturing, Food Industries, Livestock Production, and Physiology of Reproduction.

MEAT SCIENCE

Graduate study in the area of meat science is designed to furnish advanced information in the technological, biochemical, microbiological, physical, economic and business aspects of meat and meat products. (Students entering this program should have adequate preparation in animal science, general biology or zoology, chemistry, mathematics, economics, business and physics. Deficiencies in the above areas may be corrected during the first year of graduate study.)

Minors, joint majors or both, in such areas as Biochemistry and Biophysics, Microbiology, Animal Breeding, Nutrition and Statistics, according to the field of interest of the student may be readily arranged. At least one of the above areas should be selected as a minor subject and be emphasized in the degree program.

DEPARTMENT OF MECHANICAL ENGINEERING

M. P. Boyce, J. H. Caddess, L. A. Hale, E. S. Holdredge*, F. W. Holm, C. F. Kettleborough, T. J. Kozik*, R. E. Martin, P. H. Newell, Jr., T. A. Noyes, J. V. Perry, Jr., C. M. Simmang (Head)*, J. G. H. Thompson, H. R. Thornton, P. D. Weiner

The graduate program in mechanical engineering is designed to prepare a student to work in the more technical phases of this field. The courses are planned not only to give certain factual information but to emphasize fundamentals and methods, to clarify principles, to indicate their applicability in a growing field, to develop a rational analysis from basic fundamentals, and to develop skill in the formulation of solutions to engineering problems. Instrumentation and research techniques are emphasized.

The student is allowed to choose his courses so as to specialize in the fields of heat power, mechanical design, applied mechanics, structural mechanical design, applied mechanics, structural mechanics, metallurgy and materials. Laboratory facilities are available for graduate study and research in materials and metallurgy, stress analysis including photoelasticity, vibrations, internal combustion engines, refrigeration, heat transfer, fluid flow, and computer theory.

In lieu of a foreign language requirement for the doctoral program in Mechanical Engineering, the student is required to absolve a broadening program of 6 to 12 hours of non-technical courses. The courses will be agreed upon by the student and his Advisory Committee early in his program.

(M.E.)

601. Advanced Machine Design. (4-0). Credit 4. II Advanced problems in design, forces and stresses in piping systems subjected to thermal expansion, combined stresses and theories of failure, bearing design, curved beams and flat plates.

*Graduate Advisor

603. Power Plants. (3-0). Credit 3. II Design of central and isolated power plants with special attention to over-all economic operation. Fossil fuel and nuclear plants analyzed. Prerequisite: M.E. 417.

605. Engineering Analysis. (4-0). Credit 4. I, S Study of analytical, graphical, and approximate methods of solving problems common to engineering. Dimensional analysis and model study, design of experiments. Statistical analysis and interpretation of test data including derivation of empirical equations. Prerequisite: Math. 308.

613. Engineering Dynamics. (4-0). Credit 4. II Study of dynamics of particles and of rigid bodies; virtual work principle, Lagrange's and Euler's equations of motion, and Hamilton's principle applied to engineering problems. Prerequisite: Math. 601.

615. Advanced Engineering Thermodynamics. (4-0). Credit 4. I Theories of thermodynamics and their application to the more involved problems in engineering practice. Topics involving equilibrium, Gibbs' function, nonideal gases, and various equations of state are covered. Second law analysis and statistical theory emphasized. Prerequisite: M.E. 328.

616. Heat Transmission. (4-0). Credit 4. II Fundamental laws relating to heat flow, application of these laws to engineering materials used in various industrial processes, study of recent developments by reference to current literature. Prerequisite: Math. 601.

617. Mechanical Vibrations. (4-0). Credit 4. I, S Theory of vibrations of machines and structures. Vibration of elastic bodies and of nonlinear systems. Prerequisite: Undergraduate course in dynamics.

618. Advanced Air Conditioning. (3-0). Credit 3. II Thermodynamics of air-vapor mixtures as applied to air conditioning. Design and selection of equipment with emphasis on system planning, air distribution, controls, noise and vibration elimination, costs and economics. Prerequisite: M.E. 436.

620. Experimental Stress Analysis. (3-3). Credit 4. I Review of stress and strain at a point. Relations and procedures of specific significance in photoelasticity are emphasized. Review of optics and double refraction and an explanation of the optical phenomena in the polariscope. Meaning of fringe patterns, isoclinics and stress trajectories and methods of obtaining them. Methods of calculating principal stresses from photoelastic data. Use of electric strain gages and stresscoat.

621. Fluid Mechanics. (3-0). Credit 3. I Study of 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 are stressed.

623. Two-Phase Flow. (3-0). Credit 3. I Current status of two-phase flow technology. Covers basic one-dimensional treatment of two-phase flow; detailed analysis of flow of suspended particles, bubbles, and mists; analysis of slug and annular flows; measurement techniques; system stability. Prerequisite: Undergraduate course in fluid mechanics.

626. Lubrication Theory. (3-0). Credit 3. II 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. Study of 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. I Mathematical theory of steady-state and transient heat conduction. Solution of the governing differential equations by analytical, graphical and analogical methods; applications to various geometric configurations. Prerequisites: Math. 601 or registration therein; M.E. 461.

628. Heat Transfer-Convection. (3-0). Credit 3. II Mathematical theory of convection energy transport, combined mass and heat transfer. Solution of the governing equation by analytical, numerical, and analogical methods. Applications to the design of heat-transfer apparatus are included. Prerequisite: M.E. 627.

629. Heat Transfer-Radiation. (2-0). Credit 2. I Mathematical theory of thermal radiation with applications. Ideal and nonideal radiating surfaces, heat transfer in enclosures, solar radiation. Analytical, numerical and analogical methods stressed in problem solving. Prerequisite: M.E. 627 or registration therein.

631. Jet Propulsion. (3-0). Credit 3. II Study of fluid mechanics and thermodynamics of turboprop engines, ramjets, turbojets, rocket motors, and electric propulsion systems. Where applicable, analysis of performance of these systems will be made. Prerequisite: Graduate classification in engineering; approval of Department Head.

632. Field Computations in Engineering. (3-0). Credit 3. I Application of matrix methods to problems associated with flow of fluids, heat and stress. Emphasis on application to physical problems. Prerequisites: Math. 601; graduate classification.

634. Two-Phase Heat Transfer. (3-0). Credit 3. II Presents current state of the art. Summary of current research efforts in heat transfer situations involving liquid-to-vapor or vapor-to-liquid phase changes. Prerequisite: M.E. 461 or equivalent.

640. Ferrous Metallurgical Design. (3-3). Credit 4. II A detailed study of the ferrous alloys relative to factors in specification and testing of materials for their influence upon the design of machine elements. Areas covered include mechanical, electrical and severe service functions with some attention given to material failures, trouble shooting and prediction criteria for use in design. Prerequisite: M.E. 409 or its equivalent.

645. Advanced Gas Dynamics. (3-0). Credit 3. I Analysis of 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. Prerequisites: Math. 601 or approval of instructor; M.E. 472.

646. Aerothermodynamics of Turbomachines. (3-0). Credit 3. II Fluid mechanics and thermodynamics as applied to rotating systems. Development of turbomachinery equations. Detailed aerodynamic design of compressors and turbines. Prerequisites: Math. 601 or approval of instructor; M.E. 472.

648. Turbulence. (3-0). Credit 3. II Familiarizes the student with current literature and theories about turbulent fluid flow. Emphasis placed on developing a strong theoretical background in this area. Special attention to discussing the mechanism of turbulence in relation to flow resistance and to mass and heat transfer. Prerequisite: M.E. 621 or approval of instructor.

650. Random Vibration. (3-0). Credit 3. I Characterization of random vibration; stochastic processes; stationary and ergodic assumptions; special density. Transmission of random vibration; linear single and multidegree of freedom structures; nonlinear structures; Markov vector approach. Failure due to random vibration; fatigue; first passage. Prerequisites: M.E. 459; approval of instructor.

685. Problems. Credit 1 to 4 each semester. I, II, S Content will be adapted to interest and needs of group enrolled.

691. Research. Credit 1 or more each semester. I, II, S Methods and practice in mechanical engineering research for thesis or dissertation.

(The Mechanical Engineering courses in applied mechanics such as elasticity, plasticity, continuum mechanics, etc., are listed under the section entitled Mechanics and Materials under Interdisciplinary Engineering.)

DEPARTMENT OF METEOROLOGY

K. C. Brundidge*, H. R. Byers, R. A. Clark*, P. Das, D. Djuric, D. M. Driscoll, G. A. Franceschini, J. F. Griffiths, W. K. Henry, G. L. Huebner, Jr., V. E. Moyer (Head), R. C. Runnels, J. R. Scoggins, A. H. Thompson

DEGREES

Degrees of Master of Science and Doctor of Philosophy are offered in meteorology in addition to the Bachelor of Science degree. In addition to the

*Graduate Advisor

Graduate College requirements, doctoral candidates must pass (B average) at least 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 modern, foreign languages shall be included in this work.

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, such as in weather forecasting. The greatest uses of weather information and forecasts have been in aviation, space exploration and travel, 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, and related sciences.

Persons with B.S. degrees in meteorology typically obtain employment with the U.S. National Weather Service or enter military service in the meteorology branches of the U.S. Air Force, U.S. Army, or U.S. Navy. Their responsibilities most likely would be in the accumulation and analysis of weather data and in weather prediction. Positions in teaching and research almost exclusively require a graduate-level degree.

Prerequisites for graduate work in meteorology are satisfied by the undergraduate program offered in the department. Also, most graduates in science or engineering may qualify for a graduate degree in meteorology by scheduling approximately two extra semesters of work. Programs may be organized to provide specialization in certain applications such as marine, agricultural, radar, dynamical and numerical, chemical, physical, and synoptic meteorology and in climatology.

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, others are available in the College of Geosciences for working at sea and several coastal and offshore locations.

(Met.)

600. Survey of Meteorology. (3-0). Credit 3. II, S 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. I Study of 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. II Study of advanced methods of measurement in geoscience with emphasis on meteorological parameters. Prerequisite: Met. 615 or equivalent.

625. Applied Climatology. (3-0). Credit 3. I Practical applications of climate to other disciplines and study of methods used for this coordination. Prerequisite: Met. 425 or approval of instructor.

635. Reading Seminar in Dynamic Meteorology. (3-0). Credit 3. II, S 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. II Prerequisites: Met. 435. (Offered in 1971-72 and in alternate years thereafter.)

637. Numerical Weather Prediction. (3-0). Credit 3. I Numerical solution of hydrodynamical relationships; modeling, smoothing, and filtering; stability; accuracy of solutions. Prerequisites: Math. 417; Met. 435.

638. Dynamics of Convective Clouds. (3-0). Credit 3. I Bénard convection, Rayleigh theory; parcel slice and entrainment concepts; bubble and plume theories, the starting plume; one-dimensional models; select topics of current interest. Prerequisite: Approval of instructor.

640. Atmospheric Radiation. (3-0). Credit 3. I, S Consideration of radiative transfer in a stratified atmosphere, with emphasis on gaseous absorption and emission; use of charts and tables for computing fluxes; applications to remote sensing by aircraft, balloon, and satellite. Prerequisite: Met. 445.

645. Cloud and Precipitation Physics. (3-0). Credit 3. I Physics of clouds and precipitation, convection theories, homogeneous and heterogeneous nucleation, precipitation processes, atmospheric electricity, artificial modification. Prerequisite: Met. 446.

647. Meteorology of the Upper Atmosphere. (3-0). Credit 3. I Effects of solar system astrophysical processes and properties on extratropospheric terrestrial atmosphere. Composition, structures, and characteristic phenomena. Prerequisite: Bachelor of Science degree in science or engineering.

648. Cosmic Meteorology. (3-0). Credit 3. II Continuation of Met. 647. Properties and processes of interplanetary medium, atmospheres of other planets, cosmological implications in planetary environments. Prerequisite: Met. 647.

651. Meteorological Analysis. (0-6). Credit 2. I Analysis of mesoscale and tropical systems; Fjörtoft graphical integration method; single station analysis; Sutcliffe and other development theories. Prerequisite: Met. 452.

656. Tropical Meteorology. (3-0). Credit 3. II Theory and structure of the meteorological phenomena of tropical latitudes, easterly waves and tropical cyclones, the tropics and the general circulation, trade wind regime, convective phenomena. Persons desiring practice in analysis techniques should enroll for one or more hours of Met. 685. Prerequisite: Met. 453 or approval of instructor.

657. Mesometeorology. (3-0). Credit 3. II Theory and structure of mesoscale weather systems and their relation to larger and smaller 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.

658. Synoptic Meteorology. (3-0). Credit 3. I Examination of structure of macroscale atmospheric disturbances. Procedures for forecasting their development. 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. I Theory of atmospheric turbulence; production and dissipation of eddy energy; eddy energy equation; similarity theory; structure of turbulence. Prerequisites: Math. 308; Met. 445.

662. Atmospheric Diffusion and Air Pollution. (3-0). Credit 3. II Theories of atmospheric diffusion and transport from continuous point, volume, line, and other sources; survey of air pollution in cities; meteorological and climatological conditions associated with air pollution. Prerequisite: Met. 661 or approval of instructor.

665. Micrometeorology. (3-0). Credit 3. II Earth-atmosphere interface processes with special emphasis on exchange concepts and resulting modifications to wind, temperature, and moisture. Prerequisites: Math. 308; Met. 445.

666. Agricultural Meteorology. (3-0) Credit 3. II Application of physical concepts of meteorology to problems arising in agriculture, with detailed study of meso-micro-climates. Prerequisite: Met. 465 or approval of instructor.

674. Radar Meteorology. (3-0). Credit 3. II Theoretical considerations of principles of electromagnetic propagation; radar applications in cloud physics research. Prerequisites: Math. 601; Met. 475.

676. Hydrometeorology. (3-0). Credit 3. II Role of weather and weather processes in land-water problems. Prerequisite: Approval of instructor.

681. Seminar. (2-0). Credit 2. I, II, S Presented by students and based upon their research work and upon surveys of the literature.

685. Problems. Credit 1 or more each semester. I, II, S 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.

691. Research. Credit 1 or more each semester. I, II, S For thesis or dissertation. Topic subject to approval of Department Head.

DEPARTMENT OF MODERN LANGUAGES

E. C. Breitenkamp, J. A. Dabbs (Head)*, A. M. Elmquist, W. Koepke.

CZECH
(Czch.)

627. Introduction to Scientific Czech. (3-0). Credit 3. S Intensive course to prepare graduate students to read scientific material; language structure; technical vocabulary and translation. Prerequisite: Graduate classification.

628. Readings in Scientific Czech. (3-0). Credit 3. S Continuation of Czech. 627. Reading and translation of selected texts relating to various sciences. Designed to develop technical vocabulary and facility in reading scientific Czech. Prerequisites: Czech. 627 with grade of B, or equivalent; approval of Department Head.

FRENCH
(Fren.)

601. Introduction to Scientific French. (3-0). Credit 3. I, S 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. II, S Continuation of Fren. 601. Reading and translation of material relating to various sciences. Designed to develop technical vocabulary and facility in reading scientific French. Prerequisite: Fren. 601 or approval of Department Head.

GERMAN
(Germ.)

603. Introduction to Scientific German. (3-0). Credit 3. I, S 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. II, S Continuation of Germ. 603. Translation of material relating to various sciences. Designed to develop technical vocabulary and facility in reading scientific German. Prerequisite: Germ. 603 or approval of Department Head.

*Graduate Advisor

RUSSIAN
(Russ.)

609. Introduction to Scientific Russian. (3-0).Credit 3. I, S Intensive course to prepare graduate students to read scientific material. Technical vocabulary and translation. Prerequisite: Graduate classification.

610. Readings in Scientific Russian. (3-0). Credit 3. II, S Continuation of Russ. 609. Selected material relating to various sciences. Designed to develop technical vocabulary and facility in reading scientific Russian. Prerequisite: Russ. 609 or approval of Department Head. Intended for Ph.D. candidates.

SPANISH
(Span.)

605. Spanish and the Bilingual Movement. (3-0). Credit 3. I, S Intensive course in basic oral and written Spanish; the bilingual movement in Texas; problems of the Spanish-speaking child. Prerequisite: Graduate classification.

606. Spanish Language in Texas. (3-0). Credit 3. II, S Continuation of Spanish 605; practice in reading for content; special problems of Spanish as spoken by Spanish-speaking population of Texas. Prerequisite: Span. 605.

616. The Indian in Spanish American Literature. (3-0). Credit 3. II, S Literary treatment of the Indian in works of representative authors of Spanish America is studied. Comparison with legal and sociological works and factual treatment. Prerequisite: Twelve hours of advanced Spanish courses.

625. Spanish Literary Movements in the Caribbean Area. (3-0). Credit 3. I, S Study of writers in Cuba, the Dominican Republic, Puerto Rico, and smaller islands; foreign influences in literary tastes; political developments reflected in the humanities. Conducted in Spanish. Prerequisite: Twelve hours of advanced Spanish courses.

626. Twentieth-Century Spanish Literature. (3-0). Credit 3. II, S Recent literary movements; study of leading writers and their works; conflict between the stage and cinema. Conducted in Spanish. Prerequisite: Twelve hours of advanced courses in Spanish.

635. Contemporary Spanish and Spanish American Novelists I. (3-0). Credit 3. I, S Intensive study of life and works of a selected Spanish novelist. Conducted in Spanish. Prerequisite: Twelve hours of advanced Spanish courses.

636. Contemporary Spanish and Spanish American Novelists II. (3-0). Credit 3. I, S Intensive study of life and works of a selected Spanish novelist. Conducted in Spanish. Prerequisite: Twelve hours of advanced Spanish courses.

645. Interpreter's and Translator's Course in Spanish. (3-0). Credit 3. II, S Intensive review of Spanish grammar and vocabulary; principles of interpretation and translation; simultaneous and consecutive translation; practice with translator's electronic equipment; written translations. Prerequisite: Six hours of 400-level Spanish courses.

656. Spanish Lexicography. (3-0). Credit 3. I, S Acts of Spanish Academy; spelling changes; development of Spanish vocabulary; regional variations; meaning as shown in historical study of dictionary developments. Prerequisite: Twelve hours of advanced Spanish courses.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problems in the field of Spanish language or literature. Prerequisite: Twelve hours of advanced Spanish courses.

691. Research. Credit 1 or more each semester. I, II, S 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 (Head)*, J. N. Davidson, E. J. Dowdy*, H. R. Leribaux*, R. D. Neff*, J. D. Randall*, J. B. Smathers*, R. S. Wick*

The rapid growth in the relatively new field of nuclear engineering has created a great demand for trained nuclear engineers. The nuclear engineer is concerned with the release, control and utilization 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 for the benefit of mankind. Consequently, the nuclear engineer will be involved in many of the most challenging technological problems of tomorrow, such as providing adequate low cost energy for our vast urban and industrial complexes, desalting the water of the oceans, designing the propulsion and power systems for man's exploration and utilization of space and sea.

The Nuclear Engineering Department offers the Master of Engineering, Master of Science, and Doctor of Philosophy degrees. Admission to the program 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 are encouraged which include a minor field of study. This minor field would normally include graduate study in the area of the student's baccalaureate degree.

The Nuclear Engineering Department does not have a foreign language requirement for the Ph.D. degree. However, an individual student's Advisory Committee Chairman may require knowledge in a foreign language if it contributes to the educational goals of the student.

The facilities available for instructional and research purposes include a radiation measurements laboratory, a sub-critical reactor laboratory, IBM 360-65 and an analog computer, a reactor simulator, a radiochemistry laboratory, a low power nuclear reactor, a 14 Mev Cockcroft-Walton pulsed accelerator, and a large research reactor located at the Texas A&M Nuclear Science Center. An 88-inch cyclotron is available for research in nuclear physics and engineering.

PROFESSIONAL EDUCATIONAL PROGRAM IN HEALTH PHYSICS

This program is offered as a specialized area of study by the Nuclear Engineering Department and is strongly based on the fundamental aspects of radiation. The curriculum content is such that students are trained at a professional level in radiological safety activities.

The program requires that a student spend his initial academic year taking formal coursework in the Department of Nuclear Engineering and other cooperating departments of the University. His summer is then spent in a government laboratory or at Texas A&M University for three months of on-the-job training. If he wishes a degree in Nuclear Engineering with Health Physics as his specialty, he is then required to return to the University for at least one additional semester to complete the Master of Engineering (Health Physics) degree.

Graduate studies in health physics may also be undertaken in the Department of Biochemistry and Biophysics (See page 91).

*Graduate Advisor

(N.E.)

601. Nuclear Reactor Analysis. (3-0). Credit 3. I Neutron balance and cycle. Neutron slowing-down and diffusion in finite systems. Fermi Age and multigroup criticality for bare, homogeneous cores. Reflected homogeneous and heterogeneous reactor. Reactor kinetics. Prerequisites: Math. 308, 601 or registration therein.

602. Nuclear Reactor Analysis. (4-0). Credit 4. II Introductory transport theory, multigroup slowing-down diffusion theory for bare and reflected cores, thermal utilization, resonance escape, fast fission, heterogeneous lattices, temperature coefficients, control rods, reactor kinetics and perturbation theory. Prerequisites: Math. 601; N.E. 601.

603. Fast Reactor Analysis. (3-0). Credit 3. I 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. Discussion of existing fast reactor experiments. Prerequisite: Approval of instructor.

605. Nuclear Measurements Laboratory. (2-3). Credit 3. I Basic techniques of nuclear measurements discussed and practiced. Behavior of neutrons in multiplying and nonmultiplying media observed. Extensive use made of nuclear reactor. Prerequisite: N.E. 601 or registration therein.

606. Reactor Experimentation. (2-3). Credit 3. II 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. Prerequisites: N.E. 602 or registration therein, 605.

607. Thermonuclear Engineering. (3-0). Credit 3. I, II, S Fusion reactions, orbit theory in magnetic and electric fields, Coulomb interactions, formulation of Boltzmann equation, magnetohydrodynamics, plasma waves. Prerequisite: Math. 601.

608. Thermonuclear Engineering. (3-0). Credit 3. I, II, S 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. S Applies fundamentals of nuclear physics and reactor theory with engineering fundamental to design of nuclear reactors. Prerequisite: N.E. 602 or registration therein.

612. Radiological Safety and Hazards Evaluation. (3-0). Credit 3. II State and Federal regulations concerning radioactive materials. Radiation safety as applied to accelerators, nuclear reactors and radioactive byproducts. Rigorous methods of analysis applied to computation of biological radiation dose and dose rates from various sources and geometries. Radiation effects on physical systems. Prerequisites: Math. 601; N.E. 409; or approval of instructor.

613. Principles of Radiological Safety. (3-0). Credit 3. I 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. Prerequisite: Math. 308.

615. Nuclear Radiation Detection. (3-0). Credit 3. I Interaction of radiation with matter and behavior of ion pairs in presence of electric fields. Theory of operation for radiation detection devices. Prerequisite: Math. 307.

618. Nuclear Control Systems. (3-0). Credit 3. II Fundamentals of servocontrol developed and applied to nuclear reactor. Safety aspects of reactor control and operational problems. Prerequisite: N.E. 602 or registration therein.

621. Nuclear Materials and Metallurgy. (3-0). Credit 3. II Physical and metallurgical properties of metals used in nuclear reactors and reasons for their use. Prerequisite: M.E. 409.

622. Nuclear Power Plant Design and Analysis. (3-0). Credit 3. I Designed to present application of nuclear reactor systems to field of power production, utilizing general fields of thermodynamics and heat transfer, along with special problems arising from nuclear system. Prerequisites: M.E. 323 or 328; N.E. 601.

623. Analytical Nuclear Engineering I. (3-0). Credit 3. I 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. Prerequisite: Math. 601 or registration therein.

624. Analytical Nuclear Engineering II. (3-0). Credit 3. II 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. 610.

625. Nuclear Reactor Theory. (4-0). Credit 4. I, II 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 or 617; N.E. 602.

626. Nuclear Reactor Theory. (4-0). Credit 4. I, II Continuation of N.E. 625. Variational principles for discrete and continuous eigenvalues. Milne problem and Wiener-Hopf techniques. Serber-Wilson and Feynman methods. Spatially independent and dependent slowing-down theory. Prerequisite: N.E. 625.

629. Numerical Methods in Reactor Analysis. (3-0). Credit 3. I, II, S Solution of variable dimensions multigroup P_n calculations. In addition, Monte Carlo techniques, reactor kinetics, fuel cycle and reactor life study approximations will be presented. Prerequisite: Approval of instructor.

630. Analysis of Isotopic Enrichment. (3-0). Credit 3. II Development of general cascade equations for isotopic enrichment; analysis of the ideal cascade, squared off cascade, close separation cascade approximations. Discussion of various processes used to achieve enrichment and application. Prerequisite: N.E. 404.

631. Reactor Fuel Reprocessing. (3-0). Credit 3. I 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.

679. Practical Applications of Radiological Safety I. (1-6). Credit 3. S Intensive and comprehensive lecture and practical training in radiological safety operations. Includes radioactive license application,review, and compliance. Major emphasis on 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. S Continuation of N.E. 679 with student reaching point where he can design and conduct radiation surveillance operations on his own with no immediate supervision. Prerequisite: N.E. 679.

681. Seminar. (1-0). Credit 1. I, II 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. I, II 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.

691. Research. Credit 1 or more each semester. I, II, S Research toward thesis or dissertation.

DEPARTMENT OF OCEANOGRAPHY

D. V. Aldrich, L. D. Berner, Jr., A. H. Bouma*, T. J. Bright, W. R. Bryant, L. R. A. Capurro, J. D. Cochrane, R. Darnell*, S. Z. El-Sayed, R. A. Geyer (Head), T. Ichiye, L. M. Jeffrey, W. D. Nowlin, Jr., T. S. Park, W. E. Pequegnat, C. W. Poag, B. J. Presley, S. M. Ray, R. O. Reid, R. Rezak, W. M. Sackett*, D. R. Schink, T. K. Treadwell, Jr., A. C. Vastano*, W. B. Wilson, J. H. Wormuth

*Graduate Advisor

DEGREES

Degrees of Master of Science and Doctor of Philosophy are offered in oceanography.

OCEANOGRAPHY

Oceanography is the study of the oceans and their boundaries. It is based upon the unity of the sciences of the sea. Effective study of the subject requires thorough previous training in one of the basic sciences, such as biology, chemistry, geology, mathematics, meteorology, physics, or in engineering. Therefore, much of the work in oceanography is conducted at the senior and graduate levels.

Oceanography may be utilized in solving certain problems arising in fisheries work, offshore oil and gas operation, navigation, prevention of beach erosion, certain aspects of weather forecasting, extraction of raw materials and fresh water from the sea, marine construction, coastal sanitation, military operations, fresh water supply, and many other activities. It requires broad interest, numerous skills, a real liking for the sea, and an adaptability to shipboard life.

Six options are offered in oceanography. These are the biological, chemical, geological, geophysical, physical, and air-sea interactions. Prerequisites required are the equivalent of a B.S. degree in one of the basic fields and some work in each of the other basic fields.

All students are expected to have had mathematics through integral calculus, at least one year of physics and chemistry, and at least one survey course in biology and geology in addition to the usual amount of coursework in their major field of science.

To qualify for an advanced degree in oceanography, the student must learn how to apply his training in his basic science to the marine environment. This requires a combination of principles and methods and a certain body of knowledge unique to oceanography. He is expected to develop an interest in the other marine sciences.

FACILITIES AND PARTICIPATION IN RESEARCH

Graduate students often take an active part in one or more of the research contracts sponsored in the Department of Oceanography by industry and by state and federal agencies. In addition to departmental campus facilities, others are available in the College of Geosciences, and for working at sea and at several coastal and offshore locations.

REQUIRED COURSES

Ocn. 603 is required of all graduate students taking advanced degrees.

Ocn. 681 is required of all graduate students who are candidates for the degree of Master of Science.

Ocn. 682 is required of all graduate students who are candidates for the degree of Doctor of Philosophy.

A reading knowledge of one modern foreign language is required. Further information is available from the department.

(Ocn.)

603. Sea Laboratory Techniques. (0-3). Credit 1. II Practice in techniques used regularly aboard ship and in collecting field data, cruise planning and execution, processing and analysis of data. Prerequisite: Ocn. 608.

604. Biological Oceangraphy Cruise. Credit 2. I, II, S 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

oceangraphy 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. I, II, S 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. I, II, S 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. I, II, S 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. I Observations, physical properties of sea water. Property distributions, heat budget, oceanic waters, kinematics, gravity, pressure, hydrostatics, stability, Coriolis force. Wave motions, horizontal flow, geostrophy, wind drift, circulation. Prerequisites: Math. 122 or 210; Phys. 219.

609. Physical Oceanography. (3-0). Credit 3. II Advanced treatment of topics introduced in Ocn. 608, including vorticity, turbulent transfer, wind-driven and thermohaline circulation. Prerequisite: Ocn. 608.

611. Theoretical Physical Oceanography. (3-0). Credit 3. I Kinematics and dynamics of fluids, Eulerian and Lagrangian description, thermodynamic considerations of single and multicomponent fluid mixtures, thermal stability, steady circulation. Prerequisites: Math. 601; Met. 435 or Ocn. 609.

612. Elements of Ocean Wave Theory. (3-0). Credit 3. I Theories of simple harmonic surface waves, capillary waves, and internal waves. Wave energy, propagation, modification in shallow water. Superposition, waves of finite height. Prerequisites: Math. 601; Ocn. 609; or approval of instructor.

614. Dynamics of the Ocean and Atmosphere. (3-0). Credit 3. I Unified linear perturbation theory of rotating stratified fluid with application to ocean and atmosphere. Energy considerations, characteristic modes of motion, approximate methods of analysis. Prerequisites: Math. 602; Ocn. 611, 612.

615. Long Waves and Tides. (3-3). Credit 4. II Free and forced surges, seiches, effect of variable depth, WKB and Rayleigh-Ritz methods. Method of characteristics, bores, Kelvin and Stokes waves, oceanic tides, cooscillating tides, storm tides. Prerequisites: Math. 602; Ocn. 612.

616. Theory of Ocean Waves. (3-0). Credit 3. II Wave height statistics, wave spectra and their determination. Pierson-Neumann wave forecasting theory, effects of viscosity on surface, gravity waves, wave generation by wind, nonlinear interaction.

617. Theories of Ocean Circulation. (3-0). Credit 3. I Theories of wind-driven circulation, Sverdrup solution, frictional and inertial boundary domains, energy and vorticity considerations, role of stratification and bathymetry, theories of thermohaline circulation, model experiments. Prerequisite: Ocn. 611 or approval of instructor.

618. Underwater Sound. (3-0). Credit 3. II Introduction to basic concepts, units and calibration. Sonar systems — sources, arrays, processing, and self-noise; medium — thermal structure of sea, velocity of sound profiles, ray analysis, transmission losses, ambient noise and reverberation; and target characteristics — echo structure and characteristic sounds. Prerequisite: Math. 601 or equivalent.

619. Marine Boring and Fouling Problems. (3-0). Credit 3. II (Alternate years) Nature of biofouling communities discussed together with suggested new control methods. Relationships between fouling and chemical pollution abatement are studied. Industrial cognizance of both fouling and borer activities is examined. Prerequisite: Ocn. 620 or approval of instructor.

620. Biological Oceanography. (3-0). Credit 3. I Critical analysis of contribution of biological science to our understanding of sea. Discernible interrelationships between organisms and physicochemical parameters emphasized. Prerequisite: General prerequisites for oceanography.

622. Analysis of Benthic Communities. (2-3). Credit 3. II Comprehensive study of marine benthos with principal emphasis upon Gulf of Mexico and Caribbean Sea. Prerequisite: Ocn. 620 or equivalent.

623. Marine Zooplankton. (2-3). Credit 3. I Detailed examination of selected aspects of biological oceanography with particular reference to the zooplankton of the Gulf of Mexico and Caribbean. Prerequisite: Ocn. 620 or equivalent.

624. Marine Phytoplankton. (2-3). Credit 3. I Detailed studies of phytoplankton with emphasis on physical and chemical factors which affect plankton production. Study of phytoplankton-zooplankton relationship, sampling problems. Prerequisite: Ocn. 620 or equivalent.

625. Deep-Sea Pelagic and Demersal Fishes. (2-3). Credit 3. I Study of the taxonomy, life histories, special adaptations and distribution of the mesopelagic, bathpelagic and abyssal deep-sea fishes. Prerequisites: Ocn. 620; approval of instructor for non-oceanography majors.

626. Organic Cycles of the Sea. (3-0). Credit 3. II Treatment of 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: Ocn. 620.

627. Ecology of the Continental Shelf. (3-0). Credit 3. II An analysis of the environments, populations, and communities of the continental shelf with the estuaries and the deep sea will be discussed, and attention will be given to man's impact on the shelf ecosystem. Prerequisite: Ocn. 620.

628. Biology of Coral Reefs. (2-2). Credit 3. II A consideration of the 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. S 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. I Survey of marine geology, structure and composition of ocean basins and continental margins, properties of marine sediments. Prerequisite: General prerequisites for oceanography.

631. Geological Oceanography. (3-0). Credit 3. II Transport and deposition of marine sediments, marine shorelines, environmental characteristics and processes. Prerequisite: Undergraduate major in geology or approval of instructor.

632. Benthic Marine Microfauna. (2-6). Credit 4. I (Alternate years). Study of the ecology and paleoecology of benthic marine microfauna that contribute significantly to the fossil record. Analysis of composition and distribution of modern communities and their controlling ecological parameters. Application to interpretation of ancient marine environments. Laboratory includes five days of shipboard experience in sampling various marine biotopes. Prerequisite: Invertebrate biology or paleontology.

633. Carbonate Sediments I. (1-3). Credit 2. I (Alternate years) Detailed examination of skeletal microstructures of carbonate producing organisms and recognition of these organisms through particle identification in carbonate sediments. Prerequisite: Approval of instructor.

634. Carbonate Sediments II. (2-3). Credit 3. II (Alternate years) Composition, classification, and distribution of carbonate sediments; processes of carbonate sedimentation and diagenesis. Laboratory work includes study of both recent and ancient carbonates. Prerequisite: Approval of instructor.

635. Techniques in Geological Oceanography. (3-2). Credit 4. I (Alternate years.) Review of 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. Prerequisite: Approval of instructor.

636. Marine Biostratigraphy I. (2-3). Credit 3. I (Alternate years) Biostratigraphy as applied to deep-sea cores emphasizing planktonic foraminifers: their ecology, distribution, morphology, classification, and evolution. Laboratory deals with systematics and evolution of Quaternary planktonic foraminifers. Prerequisite: Invertebrate paleontology, stratigraphy, or approval of instructor.

637. Marine Biostratigraphy II. (2-3). Credit 3. II (Alternate years) Continuation of Ocn. 636. A detailed examination of foraminiferal biostratigraphic zonation, the European stratotypes, correlation with the paleomagnetic record, paleoclimatic interpretation, and Neogene biostratigraphy of the Gulf of Mexico. Laboratory deals with systematics and evolution of Cretaceous and Tertiary planktonic foraminifers. Prerequisite: Ocn. 636.

638. Simulation Techniques. (2-6). Credit 4. I Simulation research applications utilizing large general purpose electronic analog computer. Problem material from many disciplines but primary emphasis on hydro-dynamic model design and solution procedures of ocean-atmosphere interaction. Prerequisites: Math. 308; approval of instructor.

639. Lithophycology. (2-3). Credit 3. II (Alternate years) Morphology, taxonomy, and ecology of calcareous algae and stromatolites with emphasis on their role as builders of limestones. Laboratory work includes identification of both recent and fossil species. Prerequisite: Approval of instructor.

640. Chemical Oceanography. (3-0). Credit 3. I Chemical composition and properties of sea water, 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. II Selected topics in chemical oceanography including: industrial utilization of sea water, chemical products of marine biota, water freshening, corrosion, photosynthesis and fertility of sea. Prerequisite: Undergraduate major in chemistry or approval of instructor.

643. Geochemistry of the Ocean. (3-0). Credit 3. I Study of chemistry of elements in lithosphere, atmosphere and hydrosphere with emphasis on marine environment. Prerequisite: Undergraduate major in geology or approval of instructor.

644. Isotope Geochemistry. (3-0). Credit 3. II Study of isotope geochemistry of different elements in nature. Evaluation of various age dating techniques. Prerequisite: Undergraduate major in geology or approval of instructor.

645. Marine Organic Geochemistry. (3-0). Credit 3. II The origins, fates and distribution of organic compounds in contemporary marine environments and in recent and ancient sediments will be emphasized. Specific analytical techniques will also be outlined. Prerequisite: Approval of instructor.

651. Meteorological Oceanography. (3-0). Credit 3. II Large scale ocean-atmosphere interaction. Ocean emphasis. Interaction in relation to fog-hurricanes, water and air mass modification, and elements of circulations of air and water. Prerequisite: Met. 445 or Ocn. 609.

652. Ocean Boundary Layer Problems. (3-0). Credit 3. II Theory of turbulent transfer of momentum, heat and moisture. Mechanics of turbulence, dispersions, methods of analysis of stochastic time sequences. Prerequisites: Ocn. 611; Stat. 601.

653. Synoptic Physical Oceanography. (2-2). Credit 3. I Methods, climatology of the air-sea boundary, evolution of oceanic waters quasi-permanent and varying upper oceanic currents, vertical motions, spreading of waters, abyssal circulation, planetary heat distribution, observational design. Prerequisite: Ocn. 609.

660. Quatenary History of the Oceans. (2-0). Credit 2. II (Alternate years) Investigation of geologic and paleoceanographic phenomena related to glacial events during the Pleistocene and Holocene epochs. Critical review of glacial theory, modern and ancient continental glaciation, sea level fluctuations, sedimentation, and stratigraphy. Prerequisite: Approval of instructor.

681. Seminar I. (1-0). Credit 1. I Presented by students and based upon their research work and upon surveys of literature.

682. Seminar II. (1-0). Credit 1. II Seminar intended for Ph.D. candidates. Searching discussions of recent topics in the field, participation by students and staff. Prerequisite: Two years of graduate oceanography work.

685. Problems. Credit 1 to 4 each semester. I, II, S Special topics to suit small group requirements. Deals with problems not within thesis research and not covered by any other course in established curriculum. Prerequisite: General prerequisites for oceanography.

691. Research. Credit 1 or more each semester. I, II, S For thesis or dissertation. Topic subject to approval of Department Head.

DEPARTMENT OF PETROLEUM ENGINEERING

J. C. Calhoun, Jr., P. B. Crawford, R. A. Morse, W. J. McGuire, J. S. Osoba*, J. R. Pedigo, W. D. Von Gonten, R. L. Whiting (Head)*

Graduate work in petroleum engineering is offered at both the master's and doctorate levels. On 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, secondary 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.

On the doctorate 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 reservior behavior at high pressures and temperatures.

Specialized research and analytical equipment available include a potentiometric model, reservoir analog computer, mass spectrometer, low-temperature distillation equipment, and vapor phase chromatograph.

A strong program 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.

Students are encouraged to become proficient in the programming and utilization of the IBM 7094 high-speed digital computer in engineering and research.

(Pet. E.)

601,602. Drilling and Completing Wells. (3-3). Credit 4 each semester. S Advanced study of problems encountered in drilling and completing of oil and gas wells. Prerequisite: Approval of Department Head.

603,604. Advanced Reservoir Engineering. (3-3). Credit 4 each semester. I, II Advanced course in petroleum production practices with special reference to fundamental principles of flow of reservoir fluids. Prerequisite: Approval of Department Head.

605. Phase Behavior of Petroleum Reservoir Fluids. Credit 2 to 4 each semester. I Study of pressure, volume, temperature, composition relationships of petroleum reservoir fluids. Prerequisite: Approval of Department Head.

*Graduate Advisor

607. Recovery Methods. Credit 2 to 4 each semester. II Study of methods of increasing recovery of petroleum from petroleum reservoirs. Prerequisite: Approval of Department Head.

608. Well Logging Methods. (2-3). Credit 3. II Advanced study of well logging methods for determining nature and fluid content of formations penetrated by drill. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1 each semester. I, II Study and presentation of papers on recent developments in reservoir mechanics. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 4 each semester. I, II 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.

691. Research. Credit 1 or more each semester. I, II 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, S. R. Carpenter, M. M. Davenport (Head), C. E. Harris, Jr.

(Phil.)

601. Major Philosophical Issues. (3-0). Credit 3. I, II, S Designed to introduce graduate students to major issues of philosophical thought.

618. Contemporary European Philosophy. (3-0). Credit 3. II Current philosophical positions in European thought emphasizing phenomenology, existentialism and humanism. Prerequisite: Phil. 418 or 601.

620. Philosophy of Mind. (3-0). Credit 3. I, II Systematic and critical study of representative positions concerning the nature and function of human mind.

630. Esthetics. (3-0). Credit 3. II, S Theories and problems concerning the nature, meaning and standards of art as a valued object and creative process.

631. The Nature of Religious Knowledge. (3-0). Credit 3. I Investigation of common nature and cognitive significance of religious beliefs and experiences. Prerequisites: Phil. 331, 421 or 601.

632. Metaphysics and Politics. (3-0). Credit 3. II Metaphysical foundations of major social and political philosophies such as Communism, Fascism and Democracy. Prerequisites: Phil. 332, 381 or 601.

641. Mathematical Logic. (3-0). Credit 3. I Formal development of first order logic together with extensive metamathematical investigation of this theory.

DEPARTMENT OF PHYSICS

T. W. Adair, R. E. Allen, W. H. Bassichis, R. A. Bryan, J. B. Coon*, G. D. Doolen, N. M. Duller, Jr., E. S. Fry, P. J. Green, J. S. Ham, J. C. Hiebert, J. C. Hill, G. W. Kattawar, R. A. Kenefick, J. A. McIntyre, K. Nagatani, D. G. Naugle*, L. C. Northcliffe, G. N. Plass (Head), J. F. Reading, W. M. Saslow, H. A. Schuessler, R. A. Shorn, M. Trumper, J. R. Wayland, D. H. Youngblood

*Graduate Advisor

The present rapid advance in the development and application of fundamental physical theory has created many opportunities for research and development. The offerings in physics enable graduates in physics, mathematics, chemistry or engineering to prepare either for a career of research and teaching at a university or research and development at an industrial laboratory.

Physics 601, 603, 606, and 607 together with courses in mathematics and research in the field of his thesis will normally comprise the program of a candidate for the degree of Master of Science. The four courses mentioned, together with Physics 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.

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 six semesters for the Ph.D. degree.

The current research areas of members of the department include theory of elementary particle interactions, quantum field theory, theoretical nuclear physics, nuclear structure, low temperature physics, transport properties of solids, molecular structure, radiative transfer, atmospheric physics, cosmic ray physics, and quantum electronics. Special research facilities include a nuclear reactor presently operating at 100 kilowatts, an 88-inch cyclotron, and an IBM digital computer.

(Phys.)

601. Analytical Mechanics. (4-0). Credit 4. I, S Dynamics of particles and rigid bodies, hydrodynamics, Hamilton's principles, principle of least action, LaGrange's and Hamilton-Jacobi equations. Prerequisites: Math. 311 or 601; Phys. 405.

603. Electromagnetic Theory. (4-0). Credit 4. I Static and time-varying fields, propagation, reflection and refraction of electromagnetic waves. Prerequisites: Math. 601; Phys. 416; or equivalents.

606. Quantum Mechanics. (4-0). Credit 4. II, S Postulational development. Hamiltonian formalism, canonical transformations, representation and expansion theory, perturbation theory. Prerequisites: Math. 601, Phys. 412.

607. Statistical Mechanics. (4-0). Credit 4. II Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distributions. Ensemble theory, statistical thermodynamics, electrons in metals, lattice specific heats. Prerequisites: Math. 601, Phys. 408.

611. Electromagnetic Theory. (4-0). Credit 4. II Continuation of Phys. 603. Boundary value problems of vector wave equation, effect of matter on waves, anisotropic dielectrics, dispersive media. Prerequisite: Phys. 603.

615. Methods of Theoretical Physics I. (3-0). Credit 3. I Application of matrix and group theoretical methods to problems in quantum mechanics, electromagnetism and solid state; perturbation and variational schemes as applied to many body systems with emphasis toward numerical solutions. Prerequisites: Phys. 408, 412, 416 or equivalent.

616. Methods of Theoretical Physics II. (3-0). Credit 3. II Continuation of Phys. 615. Theory of Green's functions as applied to wave and diffusion equations; applied statistics; solution of integral equations encountered in diffusion and wave theory. Prerequisites: Phys. 615.

617. Physics of the Solid State. (3-0). Credit 3. I, S Crystalline structure, lattice vibrations, dielectric phenomena, luminescence, magnetism, free electron and band theories, semiconductors. Prerequisites: Phys. 412, 607.

624. Quantum Mechanics. (4-0). Credit 4. I Continuation of Phys. 606. Scattering theory, angular momentum theory, matrix mechanics, application to atomic and nuclear systems, semi-classical radiation theory. Prerequisite: Phys. 606.

625. Nuclear Physics. (3-0). Credit 3. I The two-nucleon problem, electromagnetic interactions, beta decay, nuclear reactions, subnuclear particle reactions. Prerequisites: Phys. 428, 606 or equivalent.

626. Atomic and Space Physics. (3-0). Credit 3. I Plasmas in space; atomic spectroscopy; solar terrestrial relations, radiative transfer; space spectroscopy. Prerequisite: Phys. 412.

628. Quantum Optics and Radiation Theory. (3-0). Credit 3. II Photon polarization; interaction of radiation with matter; quantum interference effects; quantum theory of the laser; light absorption and scattering spectroscopy; nonlinear optical processes. Prerequisite: Phys. 606 or approval of instructor.

629. Special Relativity. (3-0). Credit 3. I Events, worldlines, basic principles; Minkowski space, Lorentz transformations; invariants, covariant and contravariant vectors, tensors; kinematics of particle and wave motion; dynamics of particles, collision problems; particle systems; continuous matter; rigid bodies; the electro-magnetic field, algebraic properties of the field tensor; Maxwell equations in four-dimensional formulation. Prerequisites: Phys. 601, 603 or approval of instructor.

631. Quantum Theory of Solids. (3-0). Credit 3. I Second quantization, phonons, plasmons and other quasiparticles, transport phenomena, topics of current research interest. Prerequisite: Phys. 617.

632. Molecular Structure. (4-0). Credit 4. II Applications of group theory, electronic structure of molecules, molecular vibrations, the rigid rotator, ultraviolet and infrared spectra. Prerequisite: Approval of instructor.

634. Relativistic Quantum Field Theory. (3-0). Credit 3. I Perturbation theory and renormalization techniques, dispersion relations, Mandelstam representation. Prerequisite: Phys. 606.

635. Scattering Theory. (3-0). Credit 3. I Scattering of particles by noncentral fields, polarized particles, scattering of pions and nucleons by nucleons, the optical model, the deuteron stripping reaction. Prerequisite: Phys. 606.

636. The Many-Body Problem. (3-0). Credit 3. II Nuclear matter, liquid He^3, the Bose gas, the electron gas, superconductivity. Prerequisite: Phys. 606.

637. General Relativity. (3-0). Credit 3. II Spacetime geometry and measurement; Riemannian geometry; Newton's and Einstein's Theory of Gravitation; static and stationary gravitational fields; solutions of Einstein's field equations; motion of particles; elements of relativistic hydronamics; gravitational waves. Prerequisites: Phys. 601, 603.

638. Physics of Plasmas. (3-0). Credit 3. I Many-body kinetic theory of plasmas, plasma fluctuations, propagation of electromagnetic waves through plasmas, magnetohydrodynamics, plasma stability and confinement. Prerequisites: Phys. 603, 607, 624.

640. Theory of Liquids. (2-0). Credit 2. I Discussion of statistical mechanics of simple liquids for equilibrium and nonequilibrium phenomena. Shows how every property may be calculated from first principles. Predictions of theory compared to experimental results. Emphasis on physical content rather than mathematics. Prerequisite: Phys. 607.

642. Atomic and Electron Physics. (3-0). Credit 3. II Theory of hyperfine structure; atomic and nuclear moments; isotope shift; core polarization atomic beam resonance methods; optical pumping and level crossing; quantum electronics; nuclear resonance in liquids and crystals; paramagnetic resonance; topics from current literature involving recent theories and experimental methods on stored ions, dilute plasmas and polarized beams. Prerequisite: Approval of instructor.

643. Topics in Astrophysics. (3-0). Credit 3. II States of matter, interaction of radiation and matter, statistical equilibrium, local thermodynamic equilibrium, spectral line formation, particle and gas dynamics, relativistic astrophysics, nucleosynthesis. Prerequisite: Phys. 420.

644. Low Temperature Physics. (3-0). Credit 3. I Quantum behavior of matter at extremely low temperatures, superfluid liquid helium, superconductivity, thermal properties of solids, electric and magnetic phenomena. Prerequisites: Phys. 606, 607.

645. Nuclear Theory. (3-0). Credit 3. II Topics of current interest, e.g., multiple theory of electromagnetic interaction, shell model, and collective model of nucleus. Prerequisites: Phys. 606, 625.

648. Cosmic Rays. (3-0). Credit 3. II Phenomenology and theory of contemporary cosmic ray physics with emphasis on subjects of current research interest. Prerequisites: Phys. 603, 606; approval of instructor.

650. Radiative Transfer. (3-0). Credit 3. II Derivation of equation of transfer for scalar and vector fields; principles of invariance; Rayleigh scattering; numerical techniques for more general laws of scattering; dependence of scattering on type of cloud, amount of aerosols, and planetary surface. Prerequisite: Phys. 412.

654. Low Temperature Physics. (3-0). Credit 3. II Continuation of Phys. 644. Topics from current literature involving latest theories and experiments on superfluids, thermal properties of solids, and electromagnetic effects on matter at very low temperatures. Prerequisite: Phys. 644.

659. The Evolution of Physics. (3-0). Credit 3. I Traces the development of physics from early Greek times through the present day highlighting the feedback between ideas in physics and ideas in the surrounding culture.

681. Seminar. (1-0). Credit 1. I, II Examination of subjects of current importance. Required of all graduate students in physics.

685. Problems. Credit 1 to 4 each semester. I, II Individual problems not related to thesis.

690. Theory of Physical Research. (2-0). Credit 2. I, II, S 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 equivalent.

691. Research. Credit 1 or more each semester. I, II, S Research toward thesis or dissertation.

PHYSIOLOGY OF REPRODUCTION

A major in physiology of reproduction may be undertaken by selecting appropriate courses in animal science, biology, dairy science, genetics, and poultry science. The Master of Agriculture is offered in Physiology of Reproduction and the requirements, other than curricular, are the same as for other Master of Agriculture degrees in Animal Science.

PLANT BREEDING

A major in plant breeding may be undertaken by selecting appropriate courses in genetics and in agronomy, floriculture, or horticulture.

DEPARTMENT OF PLANT SCIENCES

J. G. Atkins, A. A. Bell, C. R. Benedict, L. S. Bird, T. E. Boswell, G. A. Donovan, R. A. Frederiksen, C. E. Gates, J. R. Gipson, F. J. Gough, R. S. Halliwell, A. L. Harrison, G. E. Hart, C. W. Horne, H. E. Joham, W. R. Jordan, D. L. Ketring, N. M. Kieffer, S. D. Lyda, N. A. McNiel, C. W. Magill, C. S. Miller, P. W. Morgan, R. E. Pettit, R. D. Powell, D. W. Rosberg (Head), H. W. Schroeder, J. D. Smith*, L. R. Smith, R. D. Stipanovic, W. H. Thames, Jr.*, R. W. Toler, E. P. Van Arsdel, J. P. van Buijtenen, G. M. Watkins*, R. A. Woessner

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 utilizing 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 of Plant Sciences offers three options in its Master of Agriculture degree program: Aerobiology, Plant Protection and Plant Sciences. The Master of Agriculture 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 Master of Agriculture 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 student specialization in the fields of bacterial genetics, biochemical genetics, cytogenetics, forest genetics, fungal genetics, physiological genetics and population genetics.

An unusual opportunity exists for graduate students to develop multidisciplinary programs involving genetics, plant pathology and plant physiology within the department.

Programs in the various areas of 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 Catalogue listing under Genetics.

(Gen.)

603. Genetics. (4-0). Credit 4. I 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. I Inheritance studies including laboratory techniques and methods. Arranged to complement Gen. 603 and required for genetics majors.

*Graduate Advisor

608. Genetics of Microorganisms. (3-0). Credit 3. I Contributions to the understanding of genetics which have come from studies of microorganisms, including bacteria, viruses, fungi, protozoa and lower algae. Emphasis will be placed on areas of special interest to the students enrolled. Prerequisite: Gen. 301 or equivalent.

612. Population Genetics. (3-0). Credit 3. II A 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. 406.

613. Quantitative Genetics I. (3-0). Credit 3. I 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 and Stat. 602.

620. Cytogenetics. (3-0). Credit 3. II Examination and analysis of variation in chromosome structure, behavior, and number, and study of developmental and evolutionary effects of this variation. Prerequisite: Gen. 603.

623. Special Topics in Genetics. Credit 1 to 3. Content will depend upon interest of students and specialty of instructor. Lecturers who have attained distinction in genetics or related fields will conduct course offered when such lecturers are in residence.

624. Statistical Genetics. (2-0). Credit 2. I Probability as applied to genetic systems, derivation of genetic expectations, theory of inbreeding, estimation and testing of genetic parameters, statistical aspects of quantitative inheritance. Prerequisites: Gen. 603; Stat. 602.

625. Speciation. (3-0). Credit 3. II Study of the 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. (Offered in 1974-75 and in alternate years thereafter.)

630. Cytogenetics Laboratory. (0-3). Credit 1. II Study of variations in chromosome morphology, behavior and number based on observation and analysis of meiosis and mitosis in appropriate organisms. Prerequisite: Gen. 620 or registration therein. (Offered in 1973-74 and in alternate years thereafter.)

631. Biochemical Genetics. (3-0). Credit 3. I Study of genetic control of cellular metabolism. Mechanism of gene action, genetic capacity for biosynthesis. Gene-enzyme relationships; chemical nature of agents of heredity. Prerequisites: Bi.Ch. 410 or 603; Gen. 301.

633. Forest Genetics. (2-0). Credit 2. I Specialized study of genetics as applied to forest trees; forest tree improvement and forest tree breeding, with emphasis on genetics of conifers, especially pines. Prerequisite: Gen. 603. (Offered in 1973-74 and in alternate years thereafter.)

634. Forest Genetics Laboratory. (0-3). Credit 1. II Methods and techniques in forest genetics, forest tree breeding; crossing, grafting, air layering, field layouts, seed handling, greenhouse techniques. Prerequisite: Gen. 633. (Offered in 1973-74 and in alternate years thereafter.)

681. Seminar. (1-0). Credit 1. I, II 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. I, II, S Individual problems or research not pertaining to thesis or dissertation.

691. Research. Credit 1 or more each semester. I, II, S 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, as well as majors and minors in the plant sciences. 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.)

616. Methods in Plant Pathology. (2-6). Credit 4. I Familiarization with standard principles, techniques, and equipment used in investigation of plant disease and plant pathogens. Prerequisite: Pl.Pa. 301 or equivalent.

617. Parasitism in Plant Disease. (3-3). Credit 4. I Critical review of literature on parasitism, mechanisms of host defense, and host-parasite interactions. Theoretical aspects of parasitism stressed. Prerequisite: Pl.Pa. 301.

618. Bacterial Plant Diseases. (2-3). Credit 3. II Detailed study of bacterial diseases of fruit and vegetable crops, field crops and ornamental plants, with special emphasis upon nature of the disease, dissemination of the pathogen, and methods of control. Prerequisite: Pl.Pa. 301 or equivalent. (Offered in 1971-72 and in alternate years thereafter.)

619. Forest Pathology. (3-3). Credit 4. II Life histories of representative tree diseases. Concept of parasitism, physiological relationships, epidemiology and control of forest tree diseases. Prerequisite: Pl.Pa. 301 or approval of instructor. (Offered in 1970-71 and in alternate years thereafter.)

620. Plant Viruses. (2-3). Credit 3. II Study of nature and properties of plant viruses and plant virus diseases. Prerequisite: Pl.Pa. 301 or equivalent. (Offered in 1971-72 and in alternate years thereafter.)

621. Plant Parasitic Nematodes. (2-3). Credit 3. I Morphology, identification, and biology of plant parasitic and soil-borne nematodes; damage they cause; methods of control. Prerequisite: Approval of instructor.

622. Plant Nematology. (1-6). Credit 3. II Advanced study of principal groups of plant parasitic and soil-borne nematodes with emphasis on biology. Prerequisite: Pl.Pa. 621 or equivalent. (Offered in 1971-72 and in alternate years thereafter.)

623. Diseases of Field Crops. (2-3). Credit 3. II Intensive study of both fundamental and practical aspects of more important and representative diseases of field crops. Plant disease problems peculiar to extensive cultivation methods will be stressed. Prerequisite: Pl.Pa. 301.

624. Diseases of Fruits, Vegetables and Ornamentals. (2-3). Credit 3. I Study of various disease inciting agents responsible for fruit, vegetable, and ornamental diseases. Emphasis upon fungal identification, host-parasite physiology, pathogen dissemination and control of the pathogen. (Offered in 1970-71 and in alternate years thereafter.)

681. Seminar. (1-0). Credit 1 each semester. I, II Reports and discussions of topics of current interest in plant pathology, including reviews of literature on selected subjects.

684. Professional Internship. Credit 1 to 4. I, II, S 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. I, II, S Individual problems or research not pertaining to thesis or dissertation. Prerequisite: Pl.Pa. 301 or equivalent.

691. Research. Credit 1 or more each semester. I, II, S Original investigations in support of thesis or dissertation.

PLANT PHYSIOLOGY SECTION

The primary objective of this section is to train students in basic plant physiology. Facilities for research and coursework include modern, well-equipped laboratories and greenhouses. Because of the availability of specialized equipment and excellent faculty, students are able to conduct research in phytohormones and bioregulating systems, mineral nutrition, physiology of disease resistance, defoliation and desiccation, air pollution, systemic chemicals, plant nucleic acids,

photobiology and environmental physiology. Excellent support in the basic sciences and biochemistry make it possible to give the plant physiology student the breadth of training necessary for his profession.

(P.Phy.)

601. Physiological Plant Chemistry. (3-0). Credit 3. II Advanced course dealing with chemical constitution of plants and inter-relationship of various types of plant constituents. Topics included are photosynthesis, oligosaccharides and the biochemistry of terpenes, flavones, sterols and alkaloids. Prerequisites: Chem. 228; Bi.Ch. 603 or P.Phy. 605; P.Phy. 314.

605. Plant Metabolism. (3-0). Credit 3. I Intermediary metabolism of the major classes of plant compounds, dark and light CO_2 fixation, respiration and bioenergetics. Prerequisites: Chem. 228; P.Phy. 314.

607. Physiology of the Fungi. (3-0). Credit 3. II General course in physiological activities of fungi, including growth and development, nutrition, intermediary metabolism, reproduction and physiology of parasitism. Prerequisite: Biol. 353 or approval of instructor. (Offered 1971-72 and alternate years thereafter.)

609. Quantitative Plant Physiology. (2-6). Credit 4. I Methods employed in various types of physiological investigations and interpretation of results obtained by them. Prerequisite: P.Phy. 314.

610. Environmental Physiology. (2-0). Credit 2. I A quantitative study of the biological and agricultural effects of elements of the environment including pollutants. Prerequisite: Approval of instructor. (Offered 1971-72 and alternate years thereafter.)

611. Plant Nutrition. (3-0). Credit 3. II Inorganic nutrition of plants, including 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.

612. Phytohormones and Plant Growth Regulators. (3-0). Credit 3. I Classification, properties, and action of naturally occurring plant hormones as well as synthetic growth regulators and their practical application. Prerequisite: P.Phy. 314.

613. Plant Growth and Development. (3-0). Credit 3. II Course dealing with growth, differentiation, and development of higher plants. Comprehensive study of vernalization and photoperiodism as well as discussion of hormones and biological rhythms. Prerequisite: P. Phy. 314.

681. Seminar. (1-0). Credit 1 each semester. I, II Reports and discussions of topics of current interest in plant physiology including reviews of literature on selected subjects.

685. Problems. Credit 1 to 4 each semester. I, II, S Individual problems or research not pertaining to thesis or dissertation. Prerequisite: P. Phy. 314.

691. Research. Credit 1 or more each semester. I, II, S Original investigations in support of thesis or dissertation.

DEPARTMENT OF POLITICAL SCIENCE

W. E. Benton, R. A. Bernstein, W. A. Dixon, G. M. Halter, R. S. Hambrick, J. L. Payne, K. H. Ro, B. W. Robeck*, E. Thermos, P. P. Van Riper (Head)*

Graduate study in political science is offered leading to the degree of Master of Arts. The curriculum is appropriate (1) for those interested in teaching and research at the collegiate level, (2) as preparation for a career in the public service, either

*Graduate Advisor

political or administrative, (3) for teaching at the secondary level, (4) and as preparation for still more advanced work in the discipline.

There are opportunities for specialization in the areas 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.

A major in political science requires a thesis and a minimum of 30 semester hours of credit, at least 24 of which must be for other than thesis research. These latter hours must include work in more than one of the above areas of specialization and at least 16 hours at the 600 level. A minor in political science requires at least 9 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 and he and the committee together design a suitable program.

Prerequisites: While there are no precise course prerequisites for entry into a graduate 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 head of the department prior to entering into the admissions process. On language requirements and other relevant matters see especially the general discussions of the Master of Arts degree and of financial assistance elsewhere in this announcement.

(Pol.S.)

601. Components of Political Inquiry. (3-0). Credit 3. I, S Research designs, data collection and analysis, models, theories and conceptual frameworks as used in the social sciences, especially political science. Prerequisite: Six hours of advanced Political Science or approval of instructor.

610. Parties and Group Politics. (3-0). Credit 3. I, S Nature of the American political process: party system, structure and organization; interest groups, influence and regulation; nominations, campaigns, and elections; comparative party systems; the political environment. Prerequisite: Six hours of advanced Political Science or approval of instructor.

614. The American Presidency. (3-0). Credit 3. I The office of President of the United States; its place in the constitutional and political system. Emphasis on modern experience and current problems of the office. Prerequisite: Six hours of advanced Political Science or approval of instructor.

615. Legislative Process and Behavior. (3-0). Credit 3. II Study of Congress and state legislatures with emphasis on recent research findings and relevant theoretical frameworks. Prerequisite: Six hours of advanced Political Science or approval of instructor.

618. Urban Political Systems. (3-0). Credit 3. I, S Studies in urban political problems with emphasis upon suburban-central city conflicts, party structure and activities, power structures and current political developments. Prerequisite: Six hours of advanced Political Science or approval of instructor.

619. Reading Seminar in Urban Government and Administration. (3-0). Credit 3. II Involves directed work in depth on selected problems in urban government and administration through study of the relevant literature; reports and seminar discussions. May be repeated for credit. Prerequisites: Pol.S. 618 or equivalent or approval of instructor.

620. Comparative Political Systems. (3-0). Credit 3. II, S Comparative study of national political systems, with an emphasis on cross-national relationships and techniques of analysis. Prerequisite: Six hours of advanced Political Science or approval of instructor.

621. Comparative Foreign Policies. (3-0). Credit 3. II Comparative analysis of the foreign policies of different varieties of nations. Will examine factors — both internal and external — which determine a state's foreign policy. Discussion of differences in foreign policies of dictatorships and democracies, small states and great powers, industrialized states and new emerging nations. Prerequisite: Six hours of advanced Political Science or approval of instructor.

625. Politics in the Communist Bloc. (3-0). Credit 3. I, S Emphasizes politics, ideology, and political development in and among major communist nations and their relationships with communist satellite countries, major Western democracies, and non-aligned nations. Prerequisites: Six hours of advanced Political Science or approval of instructor.

626. Politics in Modern Japan. (3-0). Credit 3. II Analysis of Japanese politics in terms of its major functions. Incorporated is a detailed interpretation of many behavioral aspects of the Japanese and of their political structures. Special emphasis placed on behavior of those performing political roles and on mixtures of traditional and modern political behavior. Prerequisite: Six hours of advanced Political Science or approval of instructor.

627. China in World Politics. (3-0). Credit 3. I, S Analysis of formulation, substance and conduct of Chinese foreign policy. Special attention given forces shaping Chinese behavior in the area of international politics. Prerequisite: Six hours of advanced Political Science or approval of instructor.

629. Latin American Politics. (3-0). Credit 3. II Intensive survey of current research literature on Latin American politics. Focus is on Latin America as a general entity and on selected countries and institutions. Prerequisite: Six hours of advanced Political Science or approval of instructor.

630. Theories of International Politics. (3-0). Credit 3. II Review of the literature of international politics, including security politics, the development of nations and international integration. Concerned with traditionalist theory as well as the newer systems, decision theory, and related approaches. Prerequisite: Six hours of advanced Political Science or approval of instructor.

632. International Law. (3-0). Credit 3. II, S Nature and sources of international law, recognition, jurisdiction on high seas, rights and immunities of states and persons in foreign courts, law of international claims, law of war and neutrality. Prerequisites: Six hours of advanced Political Science or approval of instructor.

634. Issues in War and Peace. (3-0). Credit 3. I, S Consideration at an advanced level of approaches to and the substantive aspects of the study of national security, defense policies, and related issues involved in war and peace among nations and political systems. Prerequisite: Six hours of advanced Political Science or approval of instructor.

636. Politics and Development of the Non-aligned Nations. (3-0). Credit 3. II Examines the role of the non-aligned nations in world politics and those factors that lead to political development and modernization. Prerequisite: Six hours of advanced Political Science or approval of instructor.

643. Theory and Practice of Public Administration. (3-0). Credit 3. I, S Consideration is given to the theory, structure, and process of public administration. Emphasis is on American public administration, with some attention to the integration of the literature on organization theory and behavior with the practical operation of governmental agencies. Prerequisite: Six hours of advanced Political Science or approval of instructor.

645. Politics, Policy and Administration. (3-0). Credit 3. II, S Studies the 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. Prerequisite: Six hours of advanced Political Science or permission of the instructor.

651. Reading Seminar in Political Theory. (3-0). Credit 3. II Involves directed work in depth on selected problems in political theory through the study of relevant literature; reports and seminar discussions. May be repeated for credit. Prerequisite: Pol. S. 454 or 456 or equivalent or approval of instructor.

655. Law and Society. (3-0). Credit 3. I Considers the broader aspects of law with emphasis upon the meaning of law, its purpose, functions, origin, nature, and history as well as the interactions of law and society. Law is examined as a system and a social device central to the governing of society. Prerequisite: Six hours of advanced Political Science or approval of instructor.

660. Political Behavior. (3-0). Credit 3. II An analysis of the major approaches to the study of political behavior, personality and politics, political socialization, and the social, cultural, and economic characteristics of advanced political activists. Prerequisite: Six hours of advanced Political Science or approval of instructor.

662. Political Leadership and Elites. (3-0). Credit 3. I Examines the political behavior and roles of leaders and elites, primarily in modern mass societies. Prerequisite: Six hours of advanced Political Science or approval of instructor.

681. Seminar. (1-0). Credit 1. I, II, S Discussion of topics of current research interest in Political Science with emphasis on promising areas of research opportunity. Prerequisite: Six hours of advanced Political Science, graduate classification, or approval of Graduate Advisor.

685. Problems. Credit 1 to 4 each semester. I, II, S Individual instruction in selected fields of Political Science. Will stress reports and wide reading in field selected. Prerequisite: Six hours of advanced Political Science or approval of instructor.

691. Research. Credit 1 or more each semester. I, II, S Thesis research. Credit will be given only upon acceptance of completed thesis. Prerequisite: Six hours of advanced Political Science or approval of Graduate Advisor.

DEPARTMENT OF POULTRY SCIENCE

R. L. Atkinson*, J. R. Cain*, J. R. Couch*, C. R. Creger*, R. C. Fanguy*, T. M. Ferguson*, F. A. Gardner*, W. F. Krueger (Head)*, D. B. Mellor, J. H. Quisenberry*, C. B. Ryan*

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 successful poultry production have supplied the motivation for the development of graduate courses in this phase of graduate courses in this phase of agriculture. In no field of agriculture is an understanding of the science and practice of feeding, breeding, physiology, pathology, heating, ventilation, processing, product development, and marketing more necessary or more rewarded 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 poultry and poultry products; and to give men 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 college curriculum.

*Graduate Advisor

Through cooperation with the Departments of Agricultural Economics, Biochemistry and Biophysics, Biology, and the Genetics Section of the Department of Plant Sciences, the department is in a position to offer graduate work leading to the Master of Agriculture, Master of Science and Doctor of Philosophy degrees in the fields of poultry genetics and breeding, poultry nutrition and feeding, avian physiology, environmental physiology, incubation, production and management, poultry processing and marketing, and poultry product development.

(P.S.)

603. Principles and Practices of Incubation. (3-3). Credit 4. II Study of basic principles underlying successful artifical incubation of eggs. Relation of egg characters to hatchability. Development stages of chick during incubation. Prerequisite: P.S. 308 or equivalent.

604. Environmental and Developmental Relationships. (3-2). Credit 4. I Intensive literature review and analysis of environmental and physiological factors influencing growth and development of domestic birds. Density, seasonal rhythms, social behavior, plane of nutrition, etc., are considered. Prerequisites: P.S. 201, 425, or equivalent.

609. Avian Physiology. (3-3). Credit 4. I Study of basic physiological principles pertaining specifically to avian species. Chicken used as laboratory animal. Vascular, digestive, neural, respiratory, and reproductive systems will be stressed. Prerequisites: Biol. 433; approval of instructor.

611. Poultry Processing, Storing, and Distribution. (3-0). Credit 3. II Studies of poultry and egg quality, methods of maintaining quality, effects of storage conditions and of time on egg and meat quality. Production factors affecting quality. Evaluation of commercial methods of product assembly, processing and distribution.

612. Laboratory Problems in Poultry Processing, Storing, and Distribution. (0-3). Credit 1. II Survey of methods of processing poultry and eggs. Selected processing plants visited and study made of operating methods. Poultry and egg products analyzed using standard quality control methods. Effects of processing methods on market quality.

613. Breeding and Genetics of Poultry. (3-3). Credit 4. II Advanced poultry breeding, emphasis on estimation of genetic parameters, measuring genetic improvement, effective population size, general and specific combining ability, fitness, diallel crossing, efficiency of breeding systems in poultry. Prerequisite: Approval of instructor.

615. Avian Nutrition. (3-0). Credit 3. I 1974;1976 To cover metabolism and nutritional requirements of domestic fowl to include proteins, carbohydrates, fats, minerals, vitamins and related feed additives. Prerequisites: Chem. 228 or 232; P.S. 411.

681. Seminar. (1-0). Credit 1 each semester. I, II 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.

685. Problems. Credit 1 to 6 each semester. I, II, S Intensive study of newer principles and methods in various specialized fields of poultry science — breeding, nutrition, market technology. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S 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

B. O. Bergum, A. E. Bourgeois, A. J. Casey, L. B. Christensen, J. M. Elliott, C. J. Martin, (Head), W. R. Smith, W. A. Varvel*

The Department of Psychology offers graduate studies leading to the Master of Science degree. Graduate programs are available in general-experimental, industrial and pre-clinical. 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 his committee and the choice of courses within the department and in his minor area. While the Graduate College requires a minimum of 32 semester hours, the Department of Psychology requires additional hours beyond this minimum depending upon the student's background and professional goals.

(Psy.)

601. Proseminar in Psychology. (5-0). Credit 5. I A review of the 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. II A review of the current status of the motivation, personality and social areas of psychology. Prerequisite: Graduate major or minor in psychology.

603. Motivation and Cognitive Processes. (3-0). Credit 3. I Selected topics in areas of motivation and higher mental processes, including symbolic processes in perceptual organization; consideration of learning and remembering, reasoning, and creativity.

604. Personality and Social Behavior. (3-0). Credit 3. II Study of cultural determinants of personality and complex social behavior with emphasis upon personality theories, role of society in formation and control of individual behavior, and experimental studies of psychotherapeutic approaches.

605. Clinical Psychology. (3-0). Credit 3. II Survey of clinical psychology; types of deviant behavior; diagnostic instruments, methods, and techniques; individual and group therapy theories, methods, and techniques, with special emphasis on behavior modification; professional roles and ethics of the clinical psychologist. Prerequisite: Psy. 306 and approval of instructor.

607. Experimental Psychology. (2-3). Credit 3. I Problems and techniques of investigating psychophysical, sensory, perceptual, and psycho-physiological processes. Prerequisites: Psy. 408 or equivalent; graduate classification.

609. Psychophysiology. (2-3). Credit 3. II Advanced review of current research and methodological procedures on physiological bases of sensation-perception, memory and learning, arousal-sleep-attention, emotions and motivation. Prerequisites: Psy. 408, 409.

610. Industrial Psychology. (3-0). Credit 3. II Comprehensive study of current research and literature in industrial psychology with emphasis on personnel selection, training of skilled and managerial personnel, men-machine systems, employee motivation and morale.

612. Behavior Modification. (3-0). Credit 3. I Principles of behavior theory and techniques of application to pathological and deviant behaviors. Prerequisite: Psy. 406 or approval of Department Head.

*Graduate Advisor

614. Practicum in Psychology. (2-3). Credit 3. I, II, S Practical on-the-job experience for graduate students. Activities will be guided by psychologists in the following areas: experimental social, clinical, experimental, and industrial. Supervision will be provided by members of University staff. Prerequisite: Approval of Department Head.

616. Modifying Problem Behavior. (3-0). Credit 3. S Principles and techniques of modifying aggressive, disruptive, hyperactive, underachieving, and other problem behaviors in natural settings with emphasis on the 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. II Comprehensive readings and detailed analysis of current research studies related to social psychology; review of research methods and studies related to current trends in applied areas, e.g., education, counseling, political studies, public offender analysis, etc. Prerequisites: Psy. 412; Soc. 411.

623. Standardized Tests and Measurements. (3-0). Credit 3. I, S Principles of psychological testing. Uses and critical evaluation of tests of achievement, intelligence, aptitude, and personality.

624. Individual Testing. (2-3). Credit 3. I, II, S 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.

634. Principles of Human Development. (3-0). Credit 3. I, II, S Biological, psychological, and cultural interrelationships in human development. Emphasis upon principles and methods as illustrated in research and theoretical contributions. Experiences in procedures of child study. Prerequisite: Graduate classification.

681. Seminar. (1-0). Credit 1. II Group study and discussion of current periodical literature not covered by formal course work. Psychology as a profession, ethical responsibilities.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problem in psychology or special topics to fit small group requirements. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis.

DEPARTMENT OF RANGE SCIENCE

T. J. Allen, J. D. Dodd, F. W. Gould, R. H. Haas, M. M. Kothmann, C. L. Leinweber, W. G. McCully, L. B. Merrill, R. V. Miller, B. J. Ragsdale, J. L. Schuster (Head)*, C. J. Scifres, F. E. Smeins.

Graduate studies lead to the M. Agr., M.S. and Ph.D. degrees in Range Science. Emphasis is placed upon a fundamental background in rangeland resources and supporting disciplines, and upon the ability to perform research of high quality.

Facilities and equipment are available for advanced instruction and student research in various phases of Range Science. Rangeland areas are available for field study of biosystematics, ecology, mineral cycling, range animal and plant nutrition, remote sensing, resource management and weed and woody plant control.

Graduate courses are designed to develop the skill 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

*Graduate Advisor

to interrelate course contents and research. Individually planned graduate programs assure sound training for each candidate in a specialized area of interest.

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. All candidates for the Ph.D. will demonstrate a reading knowledge of one (1) foreign language or a suitable substitute approved by the candidate's Advisory Committee.

(R.S.)

601. Range Resource Use. (3-0). Credit 3. II, S Inventory and management of range resources of North America with emphasis on Texas and the Southwest. Trends in range classification, practices, and economics. Field work arranged on individual basis. Prerequisite: Graduate classification in agriculture or related subject matter areas.

602. Ecology and Land Uses. (3-0). Credit 3. I Ecological foundations for sustained use of natural resources. Climate, edaphic, biotic, and cultural factors in land resource allocation. Land and cover viewed with respect to population dynamics, succession and climax, gradients and gradation, equilibria and imbalance. Prerequisite: Graduate classification in agriculture or in allied subjects.

605. Range Research Methods. (3-0). Credit 3. I Study of research methods in range management and related subjects. Review of scientific investigation in field and analysis of results. Prerequisite: Graduate majors and minors in range science.

606. Range Economics. (3-0). Credit 3. II Range management practices, land utilization, and ranch operation as they affect economics of livestock industry and nation. Prerequisite: Graduate majors and minors in range science.

607. Vegetation Influences. (3-0). Credit 3. I Interrelationships between ecological factors and vegetation, influence of forest and range vegetation on watershed management and soil conservation. Prerequisite: R.S. 316 or equivalent.

609. Plant and Range Ecology. (3-0). Credit 3. II Detailed study of plant communities, successions, and effect of various degrees of utilization in vegetation types and edaphic factors. Prerequisite: R.S. 316 or equivalent.

610. Range Grasses and Grasslands. (2-3). Credit 3. II Study of basic concepts of grass structure and classification, recent advances in agrostological research, genetical and ecological basis for patterns of variation and evolution in grasses. Prerequisites: R.S. 303, 316; or approval of Department Head.

611. Control of Noxious Range Plants. (3-0). Credit 3. I Advanced study of noxious and poisonous plants detrimental to good management of ranges in Texas and Southwest. Distribution, reproduction, dissemination, economic importance, and alternative methods for controlling these undesirable plants stressed. Field trips.

612. Range Management Practices, Policies, and Administration. (3-0). Credit 3. I Advanced studies dealing with development of policy through political process, national to local philosophical values and social goals, administrative decision making, and technical objectives. Emphasis on current policy problems related to land resource use. Prerequisite: R.S. 415 or equivalent.

681. Seminar. (1-0). Credit 1 each semester. I, II Current scientific work in range management and related subjects in American and foreign fields. Prerequisite: Majors and minors in range science.

685. Problems. Credit 1 to 4 each semester. I, II, S Course designed for investigations not included in student's research for thesis or dissertation. Problems selected in applied ecology, range management, or forestry. Lectures, conferences, field work, reports. Prerequisite: Graduate majors or minors in range science.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation. Prerequisite: Graduate majors in range science.

DEPARTMENT OF RECREATION AND PARKS

R. L. Bury*, C. A. Gunn*, L. Hodges, L. M. Reid (Head)*, H. D. Sessoms, F. W. Suggitt, C. S. Van Doren*

The Department of Recreation and Parks offers courses of study leading to the Master of Science, Master of Agriculture and Doctor of Philosophy degrees in Recreation and Resources Development and an interdisciplinary Master of Agriculture degree in Natural Resources Development. Emphases are available in the fields of recreation administration, park planning, recreational travel and tourism, economics of public and commercial enterprises, and regional resource development. Graduate study in recreation and parks is by nature highly interdisciplinary and the departmental graduate faculty is comprised of outstanding scholars with a depth and breadth of experience in research and varied fields of service which benefits the student with theoretical and applied approaches. Close cooperative relations exist with a large number of disciplines including sociology, regional and urban planning, forest science, wildlife and fisheries sciences, geography and management, affording a student unexcelled opportunities to build a highly relevant program in the field of his choice.

Graduate course offerings in the Department of Recreation and Parks are designed to provide scientific solutions to current and possible future problems encountered by administrators, educators and professional practitioners through the most recent valid and reliable techniques and methods of research and evaluation. The focus is upon the total leisure environment and its resource base. This encompasses fundamental and practical concepts associated with the planning and administration of recreation and park areas and systems. Included are studies in comprehensive recreation resource planning, quality and carrying capacity, user preferences and demand, agency administration, and alternative methods for meeting leisure needs.

Courses selected within the department and in supporting fields are designed to serve the individual needs of persons interested in teaching, extension, research or administration of recreation 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 man's critical need of open space, urbanization and utilization of leisure through recreational pursuits.

The Ph.D. language requirement will be determined by the student's Advisory Committee within the guidelines set by the department. Information on this subject can be obtained from the departmental office.

(R.P.)

601. Recreation and Leisure Concepts. (3-0). Credit 3. I, II, S Development of contrasting concepts of leisure and recreation in relation to current recreational trends and needs. Analysis of the contemporary role of recreation in society with emphasis on the implications of leisure-time utilization and necessary managerial responses. Prerequisite: Approval of Department Head.

603. Recreational Organization and Policy. (3-0). Credit 3. I Study of executive leadership in park departments and recreation agencies with particular emphasis on administration of recreation resources to meet human needs, decision making, and the structuring of organizational goals. Prerequisite: R.P. 403 or approval of Department Head.

607. Recreation and Park Design. (2-3). Credit 3. II Problem solutions dealing with contemporary and creative treatment of site development with emphasis on functional, aesthetic, and economic considerations. Prerequisite: R.P. 402 or equivalent.

*Graduate Advisor

609. Socio-Economic Issues in Outdoor Recreation. (3-0). Credit 3. I Advanced study of 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. II Study of basic concepts and methods necessary for identification and rational allocation of resources for recreation. Employs projections, attendance, and preference studies as tools of demand analysis. Includes study of demographic, mobility, and socio-economic factors as guide to recreation planning. Prerequisite: Approval of Department Head.

636. Travel and Tourism. (3-0). Credit 3. I Advanced study of tourism and recreational travel including its origins, present characteristics, and societal impacts, implication of non-business travel in the United States and the emerging importance of international recreation. Prerequisite: Approval of Department Head.

650. Recreation Resource Development. (3-0). Credit 3. II Presentation of the theory of resource planning and development and of the role and significance of recreation and tourism in the broader environmental context, coupled with an evaluation of relevant current and previous action programs in this country and elsewhere. Field trip required. Prerequisite: R.P. 603 or approval of Department Head.

681. Seminar. (1-0). Credit 1. I 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. I, II, S Required internship employment for the Master of Agriculture degree. Survey and application of principles of recreation and resources development. Studies of selected aspects of park and recreation management in an operational setting under the supervision of an approved agency. Prerequisite: Enrollment in Master of Agriculture program.

685. Problems. Credit 1 to 4 each semester. I, II, S Designed for investigations not included in student's research for thesis or dissertation. Problems selected in administration or management, recreation, or planning.

691. Research. Credit 1 or more each semester. I, II, S Research in recreation and resources for thesis or dissertation.

DEPARTMENT OF SOCIOLOGY AND ANTHROPOLOGY

V. M. Bryant, J. H. Copp (Head), A. G. Cosby, D. R. Davis, W. P. Kuvlesky, B. H. Nelson*, W. H. Orberle, D. C. Ruesink, A. Schaffer, R.Schaffer, R. L. Skrabanek, A. C. Stubbs

Graduates from accredited universities who meet the requirements of the Graduate Program in the Department of Sociology and Anthropology and the Graduate College may work toward the following advanced degrees: Master of Science in Sociology, Master of Agriculture in Rural Sociology, and Doctor of Philosophy in Sociology.

Students with degrees in fields other than sociology may be admitted provisionally at the Master's degree level but will normally be required to make up deficiencies. Students at the Doctor of Philosophy level will normally be expected

*Graduate Advisor

to have an advanced degree in sociology. Information on language requirement options can be obtained from the departmental office.

Areas of specialization in sociology currently stressed are: community and social organization; demography; sociological theory; social psychology; rural sociology, urban sociology, and research methodology.

A wide variety of research programs in the department affords the student wide choice in his research for a thesis or dissertation. To aid in financing graduate education, teaching and research assistantships and fellowships are available.

ANTHROPOLOGY
(Anth.)

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problems in anthropology. Prerequisite: Approval of instructor.

SOCIOLOGY
(Soc.)

601. Urban Sociology. (3-0). Credit 3. II Analytic and interpretive study of behavior and organization of urban and metropolitan groups. Prerequisite: Soc. 205, 206 or 613.

602. Rural Sociology. (3-0). Credit 3. II Application of sociological concepts to the rural environment. Emphasis on social change and its effect on rural social structures. Prerequisite: Soc. 205 or 12 hours of social science.

608. Social Organization. (3-0). Credit 3. I Analysis of human pluralities and groups, including nature of social cohesion and levels of communication. Consideration of structural and functional aspects of human groups from simplest informal to most complex formal types: voluntary associations, cliques, families, bureaucracies, societies. Prerequisites: Soc. 205 or equivalent; nine additional hours of social science.

609. Social Change. (3-0). Credit 3. I, S Systematic analysis of concepts, theories and processes significant to social change. Functional approach to diffusion by innovators and impact on institutions. Evaluation of motivations and resistance to change. Prerequisite: Approval of Department Head.

610. Sociological Theory. (3-0). Credit 3. II Advanced study of trends in theory-development in sociology, including comparative study of general sociological frameworks and application of these systems to particular substantive areas of sociology. Prerequisite: Soc. 611.

611. History of Social Thought. (3-0). Credit 3. I, II Social thought from ancient times to present. Evolvement of sociological theories and their contributions to modern sociology. Prerequisite: Soc. 205 or 12 hours of social science.

612. The Community. (3-0). Credit 3. II Problems, processes, and techniques of community development. Effective methods through community development for improving the general well-being of commmunity residents. Prerequisite: Twelve hours of social science.

613. Social Systems. (3-0). Credit 3. I, II Systematic presentation of contemporary sociology, including functional analysis of social structures within major conceptual frames of reference; social systems model. Prerequisite: Approval of Department Head.

615. Science and the City. (3-0). Credit 3. I, II Sociological analysis of the impact of science and technology on urban orgainization and disorganization; role of information technology and theory for improving urban policy and the urban environment. Prerequisite: Soc. 321 or its equivalent; or approval of instructor.

616. Occupational Sociology. (3-0). Credit 3. II Sociological analysis of changing occupational structures, labor force demography. Concepts in social structure relating to significance of work, job mobility, changing occupational ideologies, values, and choices. Prerequisites: Soc. 205; six additional hours of social science.

618. Sociology of Education. (3-0). Credit 3. II, S The school system and the democratic way of life. Relationship of education to social organization, social change, and social control. Analysis of role of education in society. Prerequisite: Soc. 205 or Ed.C.I. 215.

620. Human Ecology. (3-0). Credit 3. I Interrelationships between man and his social and natural environments; emphasis upon 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. I, S 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. Demography. (3-0). Credit 3. II, S Sources and characteristics of demographic data and the methods and problems of population data analysis. Prerequisite: Approval of Department Head.

623. Measurement of Sociological Parameters. (3-0). Credit 3. II Investigation of 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. II Analysis of 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. I Analysis of power structures; consideration of 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.

627. Stratification and Mobility. (3-0). Credit 3. I Theory and comparative analysis of systems of stratification, patterns of mobility, and societal influences on stratification and mobility in hinterland areas of pre-industrial and industrial societies. Prerequisite: Advanced graduate classification.

629. Demographic Theory. (3-0). Credit 3. II Demographic theories from pre-Malthusian thought to present, emphasizing theories concerning population growth; distribution and concentration; population composition and characteristics. Prerequisites: Soc. 412 or 622 and advanced graduate classification.

630. Seminar in Sociological Theory. (3-0). Credit 3. I, II, S Critical analysis of theoretical systems and models utilized in sociology. Major theories of social organizations, process, and action; and critical survey of more important limited theoretical models and schema. Prerequisite: Soc. 610.

631. Seminar in Sociological Research. (3-0). Credit 3. S Critical analysis of research procedures utilized by sociologists. Prerequisite: Soc. 623.

685. Problems. Credit 1 to 4 each semester. I, II, S Directed individual study of selected problem in field of sociology. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. I, II, S Initiation and completion of research project of approved scope for an advanced degree. Prerequisite: Approval of instructor.

DEPARTMENT OF SOIL AND CROP SCIENCES

J. E. Adams, W. B. Anderson, E. C. Bashaw, H. T. Blackhurst*, M. E. Bloodworth (Head), A. J. Bockholt, H. H. Bowen, R. D. Brigham, K. W. Brown, M. S. Brown, E. Burnett, E. E. Burns, C. M. Cater, L. E. Clark, J. W. Collier, J. P. Craigmiles, J. B. Dixon, R. L. Duble, E. F. Eastin, G. W. Evers, P. A. Fryxell, C. J. Gerard, E. C. Gilmore,

*Graduate Advisor

C. L. Godfrey, T. A. Hales, E. C. Holt, W. L. Hoover, L. R. Hossner, M. L. Kinman, R. J. Kohel, G. W. Kunze, J. E. Larsen, W. N. Lipe, P. J. Lyerly, T. E. McAfee, G. G. McBee, M. E. McDaniel, E. L. McWilliams, J. E. Matocha, K. F. Mattil, N. P. Maxwell, J. R. Melton, M. G. Merkle, O. G. Merkle, M. H. Milford*, J. F. Mills, G. A. Niles, A. E. Nightingale, R. D. Palmer, D. R. Paterson, B. A. Perry, F. C. Petr, L. M. Pike, K. B. Porter, R. C. Potts, T. R. Richmond, L. W. Rooney, D. T. Rosenow, R. H. Rucker, J. R. Runkles, K. F. Schertz, D. T. Smith, O. D. Smith, J. W. Stansel, R. D. Staten, J. B. Storey, A. R. Swoboda, N. A. Tuleen, C. H. M. van Bavel, R. W. Weaver, C. D. Welch, C. W. Wendt, E. L. Whitely, A. F. Wiese

AGRONOMY

The Agronomy Section of the Department of Soil and Crop Sciences offers graduate programs designed as preparation for careers in research, teaching, extension, and other professional work. Facilities and equipment are available for advanced study in the various phases of agronomy.

Terminal programs leading to the M.S. degree are offered in crop production, soil and crop management, soil conservation, and turf management. Thesis research in these phases may be of an applied nature. Also, a program of study leading to the degree of Master of Agriculture is designed to provide professional training in crops, soil, and turf management.

For those planning a career in research and teaching, a more basic program of study and research leading to the M.S. degree is recommended. Research problems for the Ph.D. degree in field crop science and soil science are expected to be basic in approach. There is no departmental language requirement for the Ph.D. degree.

Research is in progress in cytology, genetics and breeding of field and forage crops, as well as in the various phases of production. Soil investigations are in the areas of soil chemistry, fertility, genesis, microbiology, mineralogy, and physics.

Cooperative programs can be arranged with the Departments of Biochemistry and Biophysics and of Plant Sciences.

(Agro.)

601. Grain and Cereal Crops. (3-0). Credit 3. S Advanced study of grain and cereal ecology, utilization, physiology, and morphology, including critical review of world literature reporting recent investigations in this field.

602. Forage Crops. (3-0). Credit 3. I Advanced study of forage production, utilization, ecology, physiology, and morphology. Factors affecting initiation of regrowth and seed and forage quality. Review of world literature reporting recent investigations in this field.

603. Cytological and Histological Principles in Plant Breeding. (2-3). Credit 3. II 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. I Advanced study of development, morphology, constitution, and classification of soils. Prerequisites: Agro. 301, 411, or approval of instructor.

607. Field Study of Texas Soils. (4-6). Credit 6. S Field and laboratory course relating physical and chemical properties, description, classification, and management of major kinds of soils in Texas to agricultural and to urban and other nonagricultural uses. Tours and lectures held at research and other facilities throughout state. Prerequisites: Agro. 605 or approval of instructor; approval of Department Head. (Offered in 1972-73 and alternate years thereafter.)

*Graduate Advisor

611. Soils, Conservation and Man. (2-2). Credit 3. S Relates kinds, amounts and suitabilities of soils in Texas and world practices employed by man which conserve, abuse or deplete the resources in the context of expanding population and technology. Includes field trips to study conservation and use of soils in various land resource areas of Texas. Prerequisite: Approval of instructor.

612. Forage Crops Management. (3-0). Credit 3. II Advanced study of forage plant development, population dynamics and growth behavior patterns of forage grasses and legumes as they relate to or are influenced by environmental factors, both natural and imposed. Principles and practices of forage crops investigations with emphasis on current literature and concepts. Prerequisites: Agro. 308 or approval of instructor.

617. Advanced Soil Physics. (3-3). Credit 4. II Physical properties of soil including the dynamics of soil, water and ion movement, soil aeration and soil thermal relationships. Prerequisites: Agro. 445 or equivalent and a two-semester course in physics. (Offered in 1972-73 and in alternate years thereafter.)

618. Advanced Soil Analysis. (2-3). Credit 3. II Designed to familiarize student with more difficult problems of soil analysis and interpretation of data. Prerequisite: Agro. 422. (Offered in 1972-73 and in alternate years thereafter.)

620. Saline and Sodic Soils. (2-3). Credit 3. S Intensive and advanced study concerning 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, is also studied. Prerequisites: Agro. 445, 618; or approval of instructor.

621. Principles of Crop Ecology. (2-2). Credit 3. I Basic principles of crop ecology. Techniques for measuring rates of crop production. The effects of light, temperature and water supply on production rates. Laboratory and field training in the use of instruments suitable for experiments in field ecology. Prerequisites: P. Phy. 314, Met. 305.

622. Environmental Aspects of Crop-Water Relations. (3-0). Credit 3. II Review and synthesis of physical proceses 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 1973-74 and in alternate years thereafter.)

623. Experimental Crop Ecology. (2-3). Credit 3. II Principles of interactions between crop plants and their environments. Theoretical and experimental methods for studying rates of exchange of light, radiation, heat, water vapor and carbon dioxide by stands of crop plants, and their effects on crop productivity. Laboratory and field training in handling modern instruments used in field crop ecology experiments. Prerequisites: Agro. 440, R.S. 419, Met. 465 or equivalent.

624. Physical Chemistry of Soils. (3-3). Credit 4. I Physical chemistry of clay minerals and inorganic and organic soil colloids. Prerequisites: Agro. 617, 618, 626; Chem. 324. (Offered in 1974-75 and in alternate years thereafter.)

625. Colloidal Chemistry of Soils and Clays. (3-3). Credit 4. I Advanced study of colloidal surface properties of soils and clays. Effect of chemical and physical properties of colloids on adsorption of ions, organic molecules, gases and water. Laboratory emphasizes techniques for studying physio-chemical properties of colloids. Prerequisites: Agro. 624, 626; Chem. 324. (Offered in 1974-75 and in alternate years thereafter).

626. Soil Mineralogy. (3-3). Credit 4. I Study of crystal structures and properties of more important agricultural and industrial clays combined with identification techniques involving X-rays, differential thermal analysis, and electron microscopy.

627. Soil Fertility Relationships. (3-0). Credit 3. I Advanced study of behavior of nutrient elements in soils and plants. Emphasis placed on nitrogen, phosphorus and potassium. Prerequisites: Agro. 422; P.Phy. 314. (Offered in 1973-74 and in alternate years thereafter.)

630. Cereal Grains for Human Food. (3-3). Credit 4. II Includes discussion of 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. Laboratory includes use of instruments and techniques to evaluate cereal quality. Prerequisite: Approval of instructor.

631. Chemical and Physical Characteristics of Cereals. (3-0). Credit 3. I Properties of cereals and cereal products as affected by growth, storage, and physical, chemical, and biological factors. Discussion of dough structure and rheology and enrichment of cereal products. Prerequisite: Bi.Ch. 410. (Offered in 1974-75 and in alternate years thereafter.)

634. Oilseed Proteins for Foods. (3-0). Credit 3. S World production, composition, processing technologies, uses of products (oil, meal and protein concentrates) in feeds and foods emphasizing present and potential food applications of oilseed proteins. Prerequisites: Chem. 228, 317. (Offered in 1972-73 and in alternate years thereafter.)

635. Oil and Fat Food Products. (3-0). Credit 3. S 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. (Offered in 1972-73 and in alternate years thereafter.)

641. Plant Breeding I. (3-0). Credit 3. II Study of theoretical and practical aspects of plant breeding, including genetic basis. Application of breeding methods and interdisciplinary considerations in breeding problems. Prerequisites: Gen. 603; Stat. 602.

642. Plant Breeding II. (3-0). Credit 3. II Expectations of genetic improvement for different plant breeding methods with emphasis on relative efficiency for crops of different reproductive mechanisms. Genetic variances, covariances, and genotype-environment interaction components of variance utilized in planning selection procedures. Prerequisites: Agro. 641, Gen. 613, Stat. 619.

650. Chemical Weed Control. (2-3). Credit 3. I Detailed study of families of herbicides. Emphasis given to relationship of molecular structure to herbicidal activity, mode of action, pathways of degradation, and herbicidal interactions. Prerequisite: Agro. 450 or approval of instructor.

681. Seminar. (1-0). Credit 1 each semester. I, II 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. I, II, S 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. I, II, S Advanced problems in some phase of agronomy not directly related to thesis or dissertation.

691. Research. Credit 1 or more each semester. I, II, S Investigations leadig to thesis or dissertation.

FLORICULTURE

The fieldof research in floriculture and landscape horticulture 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 of Master of Science.

(Flor.)

609. Taxonomy of Ornamental Plants. (2-2). Credit 3. I Specialized study of genera, species, varieties, and clons of woody and herbaceous ornamental plants including identification, structure, use, and adaptability to climatic conditions in Southwest. Problems in taxonomy, physiology, and anatomy of these plants.

610. Tropical Foliage Plants. (2-2). Credit 3. II Intensive study of 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.

615. Greenhouse Problem Diagnosis. (2-0). Credit 2. II Diagnosis of routine problems encountered in management and maintenance of greenhouse facilities. Problems involved in propagation, care, and analysis of plants grown in greenhouses for scienttific investigations. Prerequisite: Graduate classification.

616. Plant Reproduction. (2-2). Credit 3. II, S Basic scientific principles underlying highly technical practices involved in reproduction of plants by sexual and asexual methods. Current developments in anatomical, morphological, and physiological factors involved in plant regeneration. Prerequisite: Flor. 424 or approval of instructor.

617. Landscape Horticulture. (2-3). Credit 3. I, S Relations of plants to landscape environments. Study of basic underlying scientific principles involved in improvement and maintenance of physical landscape environments in urban, suburban, and rural areas. Selection, culture, and maintenance of plants in the landscape; changing demands created by modern living. Prerequisite: Flor. 609 or approval of instructor.

684. Professional Internship. Credit 1 to 4. I, II, S 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, nursery technology, crops and landscape horticulture. Prerequisite: Approval of instructor.

685. Problems. Credit 1 to 4 each semester. I, II, S Individual problems or research not pertaining to thesis or dissertation. Prerequisite: Approval of instructor.

691. Research. Credit 1 or more each semester. I, II, S Research for thesis or dissertation.

HORTICULTURE

Advanced work in horticulture will be conducted in the major fields of fruit production, vegetable production, fruit and vegetable products and food technology. The minor work, which supports the thesis research, will usually include courses in at least two additional departments. 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 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. There is no language requirement for the Ph.D. degree.

(Hort.)

601. Environmental Relations of Fruit Plants. (3-3). Credit 4. I Principles of nutrition, water, and temperature related to management practices of fruits. Practice in soil moisture relationships, leaf analyses by flame spectrophotometry, and control of dormancy with growth regulators. (Offered in 1971-72 and in alternate years thereafter.)

602. Factors Influencing Fruit Production. (3-3). Credit 4. II Influence of light, growth regulators, pruning, and structural factors on fruit setting. Chromatographic separation, spectrophotometric identification, biological assay of endogenous growth regulators, chemical fruit setting, and hybridization. (Offered in 1970-71 and in alternate years thereafter.)

603. Structure of Vegetable Plants. (3-3). Credit 4. I Morphological and anatomical features of important groups of vegetable plants related to production and progressive improvement of crop.

604. Physiology of Vegetable Plants. (3-3). Credit 4. I Nutrition, light, vernalization, seed ttment, water, and temperature related to fruit setting and vegetable production. Current developments in hormones, herbicides, and greenhouse vegetable production.

614. Vegetable Propagation. (2-3). Credit 3. II Fundamental principles and practices of vegetable reproduction, factors affecting seed development. Handling, storing, and processing of vegetable seeds; the seed industry; breeding and trial grounds; seed certification, storage, and longevity. Prerequisite: Hort. 322 or approval of instructor.

615. Origin and Distribution of Horticultural Plants. (2-3). Credit 3. II Study of origin, distribution, identification, classification, and description of horticultural crops. Importance of genetic knowledge to continued improvement of horticultural crops. Prerequisite: Agro. 304 and/or approval of instructor.

644. Food Quality. (3-0). Credit 3. II Advanced studies on 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.

681. Seminar. (1-0). Credit 1. I, II 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.

684. Professional Internship. Credit 1 to 4. I, II, S 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 fruit and vegetable production, processing, handling and propagation. Prerequisite: Approval of instructor.

685. Problems. Credit 1 to 4 each semester. I, II, S Review of fundamental principles and methods in horticultural research. Practice involves instrumentation and techniques related to research problems.

691. Research. Credit 1 or more each semester. I, II, S Research in horticultural problems for thesis or dissertation.

SOIL CHEMISTRY

See the Agronomy Section of the Department of Soil and Crop Sciences.

SOIL PHYSICS

See the Agronomy Section of the Department of Soil and Crop Sciences.

INSTITUTE OF STATISTICS

J. G. Darroch, R. J. Freund*, C. E. Gates, H. O. Hartley (Director), H. H. Hunt, O. C. Jenkins, A. M. Kshirsagar, J. H. Matis, L. J. Ringer, W. B. Smith

The Institute of Statistics offers a graduate program leading to the Master of Science, Master of Statistics, or Doctor of Philosophy Degrees. 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 Masters degree program: the Master of Science which requires the preparation of a thesis and the Master of Statistics 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 a 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 Institute of Statistics requires its Ph.D. candidates to have reading knowledge in one foreign language or to take an equivalent approved "enrichment" program of coursework outside of the department.

(Stat.)

601. Statistical Analysis. (4-0). Credit 4. I, II, S 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 210.

602. Statistical Analysis. (4-0). Credit 4. I, II For students in life, agricultural, and social sciences. Review of basic statistical concepts and tests of hypotheses, analysis of variance, regression, and the analysis of count data; an introduction to the relationship between planned experimentation and these methods of analysis. Prerequisites: Stat. 406 or equivalent.

603. Biological Statistics Including Bio-Assay. (3-0). Credit 3. II Bio-assay for quantitative and quantal responses. Absolute and comparative potencies, dose-, time-, and dose x time response curves. Stationary and dynamic models for biological populations, prey-predator studies. Prerequisite: Stat. 601 or 602. (Offered in 1972-73 and in alternate years thereafter.)

*Graduate Advisor

604. Special Problems in Statistical Computations and Analysis. (3-0). Credit 3. II Computer algorithms for programming with emphasis on 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 602. Prerequisites: C.S. 201; Stat. 608 or 619.

606. Design of Experiments. (2-3). Credit 3. I 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. I Planning, execution, and analysis of sampling from finite populations; simple, stratified, multistage, and systematic sampling; ratio estimates. Prerequisite: Stat. 601 or 602.

608. Least Squares and Regression Analysis. (3-0). Credit 3. I, II 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 602.

609. Order Statistics and Non-Parametric Methods. (3-0). Credit 3. II Use of order statistics and other distribution-free statistics for estimation and testing hypotheses, exact non-parametric tests and measures of rank-correlation. Prerequisite: Stat. 601 or 602. (Offered in 1971-72 and in alternate years thehereafter.)

611. Theory of Statistics. (4-0). Credit 4. II The concept of probability, probability distribution, moment generating functions and limit theorems; the theory of estimation and testing hypotheses. Prerequisites: Math. 409; Stat. 414 or equivalent.

612. Theory of Linear Models. (3-0). Credit 3. I Theory of least squares, theory of general linear hypotheses and associated small sample distribution theory, analysis of multiple classifications. Prerequisites: Math. 416; Stat. 611 or equivalent.

613. Intermediate Theory of Statistics. (3-0). Credit 3. I 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. II Probability measures and distribution functions, random variables, characteristic functions, asymptotic distributions. Prerequisites: Math. 607, 608 and approval of instructor.

615. Stochastic Processes and Time Series. (3-0). Credit 3. I Stationary and nonstationary stochastic processes, autoregressive processes and correlogram analysis, harmonic-periodogram and spectral analysis. Markoff and diffusion processes. Prerequisites: Math. 409, 601; Stat. 611. (Offered in 1971-72 and in alternate years thereafter.)

616. Multivariate Analysis. (3-0). Credit 3. II 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 602, 611, 612.

617. Theory of Sampling. (3-0). Credit 3. I General randomization theory of multistage sampling of finite populations, sampling with and without replacement and with equal and unequal probabilities, ratio and regression estimates in multiphase sampling, analytic studies and multiframe problems. Prerequisites: Stat. 607, 611. (Offered in 1971-72 and in alternate years thereafter.)

618. Advanced Experimental Design. (3-0). Credit 3. II 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. (Offered in 1972-73 and alternate years thereafter.)

619. Analysis of Variance. (3-0). Credit 3. I, II 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 602.

621. Advanced Topics in Statistical Theory. (3-0). Credit 3. S 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. S 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. S 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. II Statistical theory and methods of modern stochastic control systems including those based on autoregressive Markoff and related dynamic models, adaptive optimization and control, evolutionary processes, response surface analysis including steepest ascent methods and associated statistical estimation theory. Prerequisites: I.En. 614; Stat. 601; or approval of instructor. (Offered in 1972-73 and in alternate years thereafter.)

628. Mathematical Programming I. (3-0). Credit 3. II Simplex methods and variants. Parametric and sensitivity analysis. Stochastic programming. Integer programming. Programming over time. Special algorithms. Prerequisites: Math. 423 or Stat. 412 or equivalent, and Math. 609, or approval of instructor.

629. Mathematical Programming II. (3-0). Credit 3. S Mathematical theory and methodology of nonlinear programming including convexity, Kuhn-Tucker theory, general duality, optimum control, development of computational algorithms. Prerequisite: Stat. 628 or approval of instructor.

632. Statistical Decision Theory. (3-0). Credit 3. I Decision rules, Bayes and minimax solutions, use of linear programming as a computational tool, sequences of decisions over time, sequential analysis. Prerequisites: Math. 609; Stat. 613. (Offered in 1971-72 and in alternate years thereafter.)

633. Statistical Information Theory. (3-0). Credit 3. I Elementary exposition of information theory; link between Shannon's, Wiener's, and Fisher's concepts of information. Concept of "entropy" and statistical applications, statistical error correction by least squares procedures. Some theorems on groups and finite fields, error correcting codes. Prerequisites: Math. 416; Stat. 613; or approval of instructor. (Offered in 1972-73 and in alternate years thereafter.)

634. Response Surface Design and Analysis. (3-0). Credit 3. II Definition of response surface and relation to multiple regression, optimum finding procedures, steepest ascent, PARTAN, modified Gauss-Newton methods, designs for response surface estimation, optimization of response surface designs for various criteria, the Box-Draper theory, discrimination among mechanistic models. Prerequisites: Stat. 606, 608. (Offered in 1971-72 and in alternate years thereafter.)

635. Application of Stochastic Processes to the Natural Sciences. (3-0). Credit 3. I Basic concepts, 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. (Offered in 1972-73 and in alternate years thereafter.)

636. Methods in Multivariate Analysis. (3-0). Credit 3. II 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, factor-principal component-analysis, canonical correlations. Prerequisites: Stat. 412 or equivalent, 619. (Offered in 1972-73 and in alternate years thereafter.)

641. Usage of Statistical Methodology I. (2-0). Credit 2. S Study of uses and abuses of some advanced statistical methodologies emphasizing appropriate and inappropriate usage and interpretation with minimal exposition of theory and computational techniques. Topics include: discrimination and classification, analysis of covariance structure, regression. Not primarily intended for statistics majors. Prerequisite: Stat. 608.

642. Usage of Statistical Methodology II. (2-0). Credit 2. S Study of uses and abuses of some advanced statistical methodologies emphasizing appropriate and inappropriate usage and interpretation with minimal exposition of theory and computational techniques. Topics include: non-parametric methods, time series and stochastic processes, concepts of experimental design. Not primarily intended for statistics majors. Prerequisite: Stat. 608.

685. Problems. Credit 1 to 4. I, II, S 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.

690. Theory of Statistical Research. (2-0). Credit 2. I, II, S 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. I, II, S Research for thesis or dissertation. Prerequisite: Graduate classification.

See Econometrics 660, 661, 663, 664 for descriptions of related courses.

DEPARTMENT OF URBAN AND REGIONAL PLANNING

J. R. Gardner*, W. W. Harper, J. H. Hinojosa (Head)*, J. J. McGraw,* E. J. Romieniec,W. C. Steward, R. F. White, D. G. Woodcock

The objective of the graduate program in the Department of Urban and Regional Planning is to provide the profession of planning and the State of Texas with competent professionals in the fields of urban and regional planning. In the process of making available to the student the appropriate facilities, programs and qualified faculty the Department becomes a center for the advancement and dissemination of knowledge in the art and science of planning.

Candidates for the degree of Master of Urban Planning are accepted, and encouraged to apply, from a broad range of disciplines and undergraduate programs. The work and attitude of the professional planner is interdisciplinary in nature; a close, effective relationship thus exists between student and faculty in planning with supporting programs in the social sciences, humanities, the arts, engineering sciences and architecture.

(Plan.)

601. Introduction to Urban Planning. (3-9). Credit 6. I, S General course dealing with cities as centers of civilization. Social, economic, and physical problems and opportunities of cities will be explored. Importance of general interdisciplinary approach will be stressed. Prerequisite: Approval of Department Head.

602. General Urban Development and Function. (3-9). Credit 6. II, S Students will prepare general comprehensive plan for urban area within visiting distance of College Station. After adequate research, data collection, analysis and synthesis, plans and programs will be developed for the planning area on group and individual basis. Prerequisite: Approval of Department Head.

*Graduate Advisor

603. Regional and Area Planning. (3-9). Credit 6. I, S General course of planning and its application to metropolitan and urban regions. Field trips and plans for Texas and the Southwest will be prepared. Areas other than those indicated may be studied provided adequate data is available. Prerequisite: Plan. 601, 602, or approval of Department Head.

604. Urban and Regional Planning. (3-9). Credit 6. II, S Continuation in depth of application of planning principles to student programs and projects distilled from previous work in Plan. 603. Prerequisite: Plan. 603, or approval of Department Head.

611. Environmental Studies. (3-0). Credit 3. I, S Interdisciplinary course offered to graduate students which introduces them to broad approach and view to man's environment. Program of analysis and design on individual and group basis of a study area. Prerequisite: Approval of Department Head.

613. Planning Methods and Techniques. (3-0). Credit 3. I, II, S Lectures and discussions dealing with existing and potential methods of research, data collection, and analysis. Seminars coordinating planning process with public policy and plan implementation will be emphasized. Prerequisite: Approval of Department Head.

615. Contemporary Urban Affairs. (3-0). Credit 3. I, II, S Lecture and discussion dealing with contemporary problems of urban and metropolitan areas: housing, employment, education, health, government, and others. Prerequisite: Approval of Department Head.

621. Concepts of Development Planning in Latin America. (2-3). Credit 3. I, II, S General review of literature and programs of development planning in Latin American countries; comparison and evaluation of programs; relevance of development planning in USA to Latin America; applicability of planning concepts and programs in developing countries to USA. Prerequisite: Approval of Department Head.

622. Development Planning in Latin America. (2-3). Credit 3. I, II, S Research and projects in Latin American development planning and application of methods, techniques, and programs as a continuation in depth of Plan. 621. Prerequisites: Plan. 621 or approval of Department Head.

629. Community Interactions and Communications. (3-0). Credit 3. I, II Identification and evaluation of interactions and communications among defined groups in community as they affect planning decisions. Study of communication media available to planner. Classroom simulation of interactions through gaming techniques. Presentation of attitudes to planning issues by officials and group spokesmen. Prerequisite: Approval of Department Head.

640. Law and Legislation Related to Planning. (3-0). Credit 3. I, II Lectures and discussions introducing student to legislative process and planning legislation. Emphasis is given to enabling legislation and legal tools of planner: zoning, subdivision ordinances, eminent domain, extraterritorial jurisdiction, and other related planning instruments will be reviewed. Prerequisite: Approval of Department Head.

654. Planning Administration and Management. (1-0). Credit 1. II, S Discussions by the faculty and others concerned with the activities of professional practice. Prerequisite: Approval of Department Head.

656. Housing and Community Facilities. (3-0). Credit 3. I, II, S Discussions of housing, its development, planning, marketing, designing, financing, and production. Student program dealing with urban renewal, neighborhood structure, and community facilities will be presented. Prerequisite: Approval of Department Head.

657. Urban Planning, Programming, Budgeting Systems. (3-0). Credit 3. I, II Lectures, discussions, and projects to give students a working knowledge of Urban PPBS as an alternative to traditional capital improvements programming. Includes organizational structure of governmental units, information gathering, program development and evaluations, program and financial plan, and program updating procedures as this pertains to urban land use planning. Prerequisite: Approval of Department Head.

658. Plan Implementation. (3-0). Credit 3. I, II Techniques of implementing major urban development programs and plans; concentration on capital budgeting and administrative controls. Zoning, sub-division regulation, housing codes, capital improvements programming; special attention to authority and impact of local, state, and federal government and to importance of citizen involvement. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1. I, II, S Presentation, review, and discussion of current practice and innovative programs in urban planning. Prerequisite: Approval of Department Head.

684. Professional Internship. Credit 1 to 8. I, II, S To complement the academic experience, special arrangements with public and private organizations will be made to locate students in responsible positions, where under proper guidance they may apply their theoretical knowledge. This experience will afford the student an opportunity to observe the interrelationship of decision making and the planning process. Prerequisite: A minimum of 24 hours toward the M.U.P. degree or approval of Department Head.

685. Problems. Credit 1 to 6 each semester. I, II, S Individual and group problems dealing with application of planning theory and practice. Opportunities will be presented the student to select foreign and domestic planning programs of special interest. Prerequisite: Plan. 603, or approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Research and dissertation. Prerequisite: Approval of Department Head.

DEPARTMENT OF VETERINARY ANATOMY

R. G. Greeley,* W. E. Haensly,* A. G. Kemler,* N. H. McArthur,* R. F. Sis (Head)*

(V.A.)

601. Anatomy. (1-9). Credit 4 each semester. I, II Topographical dissection of one of the following domestic animals — horse, cow, sheep, pig, dog or cat. Prerequisite: V.A. 202 or 302 or 305 or equivalent.

602. Histology. (2-6). Credit 4. I, II 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. II Study of gross, developmental, and microscopic anatomy of nervous systems of domestic animals. Prerequisite: V.A. 406 or approval of instructor.

606. Anatomy of Laboratory Animals. (1-9). Credit 4. II Gross and microscopic anatomy of laboratory animals. Prerequisite: V.A. 202 or 301 or 305 or equivalent.

608. Avian Anatomy. (1-9). Credit 4. II Gross and microscopic anatomy of chicken. Prerequisite: V.A. 202 or 301 or 305 or equivalent.

610. Microscopic Histochemistry. (2-6). Credit 4. II Theoretical and practical application of histochemistry in the microscopic study of animal cells, tissues, and organs. Prerequisite: Approval of instructor.

611. Histology. (2-6). Credit 4. I Detailed study of microscopic anatomy of organ systems of domestic animals; especially pertaining to ultrastructure, histochemistry, growth and age changes observed in cells, tissues and organs. Prerequisite: V.A. 303 or 602 or Biol. 343 or equivalent.

681. Seminar. (1-0). Credit 1. S Review and discussion of current scientific work in anatomy and related subjects. Prerequisite: Graduate major or minor in veterinary anatomy.

685. Problems. Credit 1 to 4 each semester. I, II, S Problems in either gross or microscopic anatomy along lines chosen by individual. Prerequisite: Approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Original research on selected thesis problem in anatomy. Prerequisite: Graduate major in veterinary antomy.

*Graduate Advisor

DEPARTMENT OF VETERINARY MEDICINE AND SURGERY

W. C. Banks,* C. L. Boyd, M. R. Calliham (Head),* E. W. Ellett, E. D. Gage, G. M. Gowing, J. C. Ramge,* W. L. Sippel

(V.M.S.)

601. Control of Diseases of Cattle. (3-0). Credit 3. II 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. I, II Special surgery of large or small animals. Prerequisite: D.V.M. degree.

612. Diagnostic Radiology. Credit 2 or 3 each semester. I, II, S Radiographic interpretation of large and small animals with special emphasis on film reading. Use of special techniques including contrast media and diagnostic aids discussed and demonstrated. Prerequisite: D.V.M. degree.

621. Reproductive Diseases of Female Domestic Animals. Credit 1 to 4. I, II, S Advanced study of diagnosis, treatment, and control of diseases primarily affecting reproduction in female domestic animal. Prerequisite: D.V.M. degree.

622. Andrology. Credit 1 to 4. I, II, S Advanced study of diagnosis, treatment, and control of diseases primarily affecting reproduction in male domestic animal, including study of evaluation of semen and its preparation for use by artificial insemination. Prerequisite: D.V.M. degree.

630. Small Animal Diagnostics. (0-3). Credit 1; (0-6). Credit 2; or (0-9). Credit 3. I, II, S Advanced training in arts and science of diagnosis. Clinical and theoretical diagnostic models utilized 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.

685. Problems. Credit 1 to 8 each semester. I, II Original investigations of problems in field of surgery, therapeutics, or radiology. Prerequisite: D.V.M. degree.

691. Research. Credit 1 or more each semester. I, II Research for thesis.

DEPARTMENT OF VETERINARY MICROBIOLOGY

J. E. Grimes, L. C. Grumbles (Head),* C. F. Hall, F. C. Heck, R. J. Hidalgo, K. L. Kuttler, D. H. Lewis, C. W. Livingston, Jr., S. McConnell, R. W. Moore, A. K. Sparks, R. A. Todorovic

Graduate programs leading to the Master of Science and Doctor of Philosophy degrees are desinged to prepare the graduate for research, teaching, diagnostic work and other related areas in veterinary microbiology. The aim of the program is to provide a comprehensive and balanced training in microbiology with emphasis on and application to animal microbiology. A broad program of research in many areas including bacteriology, immunology, virology, avian diseases and aquatic animal medicine.

*Graduate Advisor

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.

(V.Mi.)

643. Pathogenic Bacteriology. (3-4). Credit 4. II Study of pathogenic microorganisms, their cultural and biological characteristics and pathogenicity. Prerequisite: Minimum of eight hours of undergraduate microbiology.

646. Avian Virus Diseases. (3-3). Credit 4. I Study of viral diseases of poultry including methods of isolation and identification of causative agents. Practice consists of conducting postmortem examinations and special diagnostic procedures on birds received daily for necropsy. Prerequisite: D.V.M. degree or equivalent.

647. Virology. (3-3). Credit 4. II Detailed study of virus infections in animals, including types of infections, mode of transmission, intracellular pathology, epidemiology, isolation and identification of inciting agents. Practice includes tissue cultivation, animal inoculations, and diagnostic tests. Prerequisite: V.Mi. 438 or equivalent.

648. Medical Mycology. Credit 1 to 4. II Study of actinomycetes, yeasts, and molds that are pathogenic to man 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. I Comprehensive study of antigens and antiserums including their immunochemical applications and relationships. The in vitro antigen-antibody reactions related to diagnostic serology and the in vivo antibody reactions related to applied immunology. Prerequisites: V.Mi. 335, 438 or equivalent.

650. Experimental Microbiology. (3-3). Credit 4. I Familiarization, development and integration of techniques into experimental design of microbiologic investigation. Included are virus and protein purification, immunofluorescence, agar diffusion, immunoelectrophoresis, germ free animal techniques, microflora analysis and specialized serologic tests. Prerequisites: Bi.Ch. 410 or equivalent; eight hours of microbiology.

651. Bacteria and Fungi in Laboratory Animals. (3-3). Credit 4. I Comprehensive study of bacterial and fungal agents causing disease in laboratory animals. Prerequisites: V.Mi. 436 or equivalent and approval of instructor.

652. Laboratory Animal Virology. (3-3). Credit 4. II Comprehensive study of viral rickettsial agents infective for laboratory animals with particular emphasis on the etiologic agent, natural host range, identification, control and precautions necessary to prevent spread to man. Prerequisites: V.Mi. 438 or equivalent and approval of instructor.

660. Diseases of Marine Invertebrates. (4-0). Credit 4. I Response of invertebrates to noninfectious and infectious agents. Subject oriented and phylogenetic within each category. Prerequisites: 12 hours of biological science, including at least 3 hours of histology or microtechniques and approval of instructor.

661. Diseases of Fish. (3-4). Credit 4. II The etiology, epidemiology, pathology, symptoms, diagnosis, treatment and prevention of infectious diseases of propagated and wild fish. Prerequisite: Approval of Department Head.

681. Seminar. (1-0). Credit 1. I, S 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. I, II Problems course in microbiology. Prerequisites: D.V.M. degree; approval of Department Head.

691. Research. Credit 1 or more. I, II, S Research for thesis or dissertation.

DEPARTMENT OF VETERINARY PARASITOLOGY

R. R. Bell (Head)*, T. J. Galvin*

(V.Par.)

601. Parasitology. Credit 1 to 4 each semester. I Detailed study of more important helminth parasites of domestic and laboratory animals, including their identification, distribution, and life history. Prerequisite: V.Par. 483, 484 or equivalent.

603. Host — Helminth Relationship. (2-3). Credit 3. II 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. II Taxonomy, morphology, life cycle, physiology, distribution, genetics, host relations, methods, and diagnosis concerned with protozoan parasites affecting vertebrates, including man. Prerequisite: V.Par. 484 or Biol. 108 or 438 or Ento. 208 or equivalent.

685. Problems. Credit 1 to 4 each semester. I, II, S 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. I, II, S Research for thesis.

DEPARTMENT OF VETERINARY PATHOLOGY

L. G. Adams, W. W. Bay, C. H. Bridges (Head),* C. A. Gleiser, F. D. Maurer, K. R. Pierce, W. K. Read, R. M. Robinson, R. W. Storts

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.)

640. Mechanisms of Disease. (3-0). Credit 3. S Concepts of pathogenesis of disease in animals. Prerequisite: D.V.M. degree or equivalent.

641. Systemic Pathology. (2-4). Credit 4. I Study of 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. II Study of 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: D.V.M. degree and Bi.Ch. 604; or V.A. 302 and Bi.Ch. 604 with approval of instructor.

*Graduate Advisor

643. Applied Pathology. Credit 1 or more. I, II, S Student studies gross pathological changes at necropsies performed daily. Follows selected tissues through suitable histopathological techniques and corrects gross diagnosis in light of microscopic findings. Confirmatory bacteriologic methods utilized where indicated. Prerequisite: D.V.M. degree or equivalent.

645. Neoplastic Diseases. Credit 1 to 8. I, II, S 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. I, S In addition to study and interpretation of gross and microscopic lesions of central and peripheral nervous systems, major attention given in theory and practice of special laboratory techniques necessary to demonstrate such lesions. Prerequisite: D.V.M. degree or equivalent.

653. Diseases of Laboratory Animals. (2-2). Credit 3. II Study of pathology and pathogenesis of spontaneous infectious, parasitic, metabolic, and neoplastic diseases of laboratory animals. Prerequisites: V.Mi. 438; V.Par. 484; V.Pat. 444; V.P.P. 427; or equivalents.

658. Pathological Technique. Credit 1 to 6. I, II, S Art and science of preparing animal tissues, fluids, and exudates for microscopic or other special examination. Enrollment limited to number who can be accommodated in routine of departmental laboratory. Prerequisite: Fair knowledge of general chemistry.

681. Seminar. (1-0). Credit 1. I, II, S 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. I, II, S Advanced special problems concerned with pathogenesis and pathology of disease. Prerequisites: V.Pat. 444 or equivalent; approval of Department Head.

691. Research. Credit 1 or more each semester. I, II, S Research reported by writing of thesis or dissertation as partial requirement for M.S. or Ph.D. degree.

DEPARTMENT OF VETERINARY PHYSIOLOGY AND PHARMACOLOGY

E. M. Bailey, B. J. Camp, D. R. Clark, R. H. Davis,* J. W. Dollahite, D. Hightower, M. H. Hinds, J. D. McCrady (Head),* M. Szabuniewicz

The Ph.D. foreign language requirement shall be determined by the student's Advisory Committee.

(V.P.P.)

601, 602. Physiology. (3-3). Credit 4 each semester. I, II Recent phases of physiology, modern experimental methods. Work arranged to suit needs of student and in harmony with his previous training. Prerequisite: Basic courses in morphology and organic chemistry.

*Graduate Advisor

603. Endocrinology. (3-3). Credit 4. I Study of 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.

605, 606. Toxicology. (3-3). Credit 4 each semester. I, II Original investigations and detailed studies of poisons or poisonous plants and their effects on domestic animals. Prerequisite: Basic courses in biochemistry and physiology.

607, 608. Pharmacology. (3-3). Credit 4 each semester. I, II Modern methods of research in pharmacology and pharmaceutical processes. Original research in studying actions and uses of drugs. Prerequisites: V.P.P. 601 and approval of instructor.

611, 612. Physiology. (3-3). Credit 4 each semester. I, II Detailed study of specific phases of physiology of domestic animals. Prerequisites: V.A. 304; V.P.P. 429.

613. Cardiovascular and Respiratory Physiology. (3-3). Credit 4. I, II Detailed study of cardiovascular and respiratory 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. I, II 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. (2-0). Credit 2. S Detailed study of kidney and body fluids. Prerequisite: V.P.P. 601 or equivalent.

616. Neurophysiology. (3-0). Credit 3. S Detailed study of physiology of nervous system. Prerequisite: V.P.P. 602 or equivalent.

624. Surgery for Physiologists. (2-6). Credit 4. I, S The physiological applications of experimental mammalian surgery. Emphasizes a number of surgical procedures used in the preparation of classical experiments in physiology. Prerequisites: Graduate classification with 4 hours of mammalian anatomy and 4 hours of mammalian physiology; approval of instructor.

625. Physiological Measurements. (3-3). Credit 4. I Study of 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. II 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.

631. Instrumentation in Toxicological Analysis. (2-6). Credit 4. II Introduction to analytical methods in toxicology with particular reference to procedures using modern laboratory instruments. Prerequisites: Chem. 316, 319; V.P.P. 601 or equivalent.

632. Metabolic and Detoxication Mechanisms. (3-0). Credit 3. II Study of fate of foreign compounds with particular reference to their inhibitory and antagonistic action toward normal metabolic processes of the animal body. Prerequisites: Bi.Ch. 603; approval of instructor and Department Head.

634. Industrial and Environmental Toxicology. (3-0). Credit 3. II Study of hazards encountered from poisons contaminating environment. Prerequisite: Approval of instructor and Department Head.

635. Laboratory for Industrial and Environmental Toxicology. (0-6). Credit 2. II Study of experimental design and techniques used in industrial and environmental toxicology in different species of animals. Prerequisite: Approval of instructor and Department Head.

636. Regulatory Toxicology. (4-0). Credit 4. S Study of laws, rules, and regulations applicable to toxic materials; drugs, pesticides, chemical, air, water, and food pollutants. Course will include development of understanding of regulations; problems and techniques involved in evaluation of hazards; inspection, seizure, and prosecution. Prerequisite: Approval of instructor and Department Head.

645. Physiological Instrumentation. (2-3). Credit 3. II Evaluation, selection, and operation of modern physiological instruments in mammalian research. Emphasis on physiologic principles associated with data collected. Prerequisite: V.P.P. 602, 625 or approval of instructor.

681. Seminar. (1-0). Credit 1. I, II, S 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. I, II, S Problems in physiology, pharmacology, or toxicology. Prerequisite: D.V.M. degree or appropriate specialized training.

691. Research. Credit 1 or more each semester. I, II, S 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. I. Flowers (Head)*, A. B. Childers, Jr., C. A. Gleiser*, F. C. Heck, L. H. Russell, Jr.*

Graduate programs leading to the Master of Science and Doctor of Philosophy degrees are designed to prepare the graduate for research, teaching, regulatory and other related areas requiring the broad application of the principles of epidemiology and preventive medicine. The graduate programs in epidemiology and in laboratory animal medicine are both interdepartmental in nature. The research program varies from comparative medicine to food hygiene.

Foreign language requirements for candidates for the Doctor of Philosophy degree will be determined by the individual student's Advisory Committee.

(V.P.H.)

601. Food Hygiene. (3-4). Credit 4. I Study of causes and evidence of spoilage, and detection of adulterants in fresh, canned, and cured foods of animal origin. Prerequisite: V.P.H. 591 or approval of Department Head.

618. Food Toxicology. (3-0). Credit 3. I Study of the toxicity of various foods and food components, particularly food additives, chemical and microbial contaminants, genetically determined toxic foods. Principles and problems in evaluating safety of foods. Investigation of food associated disease incidents will be considered. Prerequisites: Approval of instructor and Department Head.

681. Seminar. (1-0). Credit 1. I, II Review and discussion of current scientific work and research in the field of veterinary preventive medicine, public health, and laboratory animal medicine. Prerequisite: Approval of Department Head.

685. Problems. Credit 1 to 4 each semester. I, II Problems course in veterinary public health. Prerequisite: D.V.M. degree or approval of Department Head.

691. Research. Credit 1 or more each semester. I, II Research reported by writing of thesis or dissertation as partial requirement for M.S. or Ph.D. degree. Prerequisite: Approval of Department Head.

*Graduate Advisor

DEPARTMENT OF WILDLIFE AND FISHERIES SCIENCES

E. D. Ables*, D. V. Aldrich, K. A. Arnold, B. W. Cain, R. D. Caldwell, W. J. Clark, W. B. Davis, J. R. Dixon*, J. M. Inglis*, H. D. Irby, W. H. Kiel, Jr., R. L. Noble, S. M. Ray, R. D. Reimer, D. J. Schmidly, R. K. Strawn*, J. G. Teer (Head)*, F. R. Walther, W. B. Wilson

Graduate programs leading to Master of Agriculture, Master of Science, and Doctor of Philosophy degrees are designed to prepare a graduate for college or university teaching, research, fishery and wildlife management, museum work, and conservation of renewable resources.

Lines in which this department is especially qualified to direct graduate research are: (1) ecology, life history, and management of vertebrates; (2) their distribution, morphology and taxonomy; (3) aquaculture, fisheries, and limnology. Facilities are available at the Texas A&M Moody College of Marine Sciences and Maritime Resources, 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 fresh-water and salt-water fisheries. The department has a research and reference collection of some 50,000 fish, 30,000 amphibians and reptiles, 8,000 birds, 25,000 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 the University's Moody College of Marine Sciences and Maritime Resources in 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.

All candidates for the Ph.D. degree must complete six hours of a 600-level course in a foreign language or may, at the discretion of their graduate advisory committees, complete nine hours in advanced level courses outside of their major fields of study.

(W.F.S.)

600. Field and Laboratory Methods. (1-6). Credit 3. II Designed to give secondary school teachers experience in field studies, organizing field notes, collecting and preserving vertebrate animals for teaching purposes. Emphasis on methods for maintaining live animals for classroom studies and for identifying animals collected. Training in preparing skeletons, corrosion models, cleared specimens, and in plastic embedding. Prerequisite: Eighteen hours of biological sciences.

601, 602. Vertebrate Systematics. (1-6). Credit 3 each semester. I, II Theory and practice of taxonomy as applied to vertebrates. Prerequisites: W.F.S. 311, 315, 401, or 402, depending on group selected.

603. Vertebrate Ecology. (2-3). Credit 3. II Ecology of the individual, population, and ecosystem, with consideration given to the epistemology of major ecological concepts. Emphasis given to theory evolved in the study of vertebrates.

*Graduate Advisor

604. Radioecology. (2-3). Credit 3. II Intended to familiarize students with ecological significance of radionuclides in nature with special emphasis on use of nuclides in studying bio-geochemical exchange between ecological compartments and ecological fate of elements. Not a rigorous course in radioisotope techniques. Prerequisites: Biol. 654; W.F.S. 603 or equivalent.

605. Systematic Ichthyology. (2-3). Credit 3. II Lectures and discussions of literature, fish taxonomy, classifications, and theories of teleostean phylogeny, zoogeography of fishes, and extensive field studies. Prerequisite: W.F.S. 311 or 312.

606. Systematic Herpetology. (2-3). Credit 3. II Study of distribution, evolution, speciation, and new systematics of amphibians and reptiles, including 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. I A study of the living birds of the world, including diversity, radiation, adaptation, distribution and past history. Considers contrasts both between the taxa and between the continental avifaunas. Prerequisites: W.F.S. 402 or equivalent.

609. Wildlife Research Methods. (3-0). Credit 3. I Study of research methods applied to wildlife management.

610. Systematic Mammalogy. (2-3). Credit 3. II Study of kinds, diversity, radiation, adaptation, and distribution of recent mammals of world, with special emphasis on adaptive diversity within taxa and adaptive similarities between taxa and between continental faunas. Prerequisite: W.F.S. 401 or equivalent.

611. Estuarine Ecology. (3-3). Credit 4. II, S Principles governing the relationships of estuarine organisms to their environment. Special attention devoted to such areas as productivity, adaptations to environment, community structure, and factors affecting the distribution and abundance of biota. Prerequisites: Invertebrate zoology and ichthyology or approval of instructor.

612. Marine Ichthyology. (2-3). Credit 3. II, S Taxonomy, classification, evolution and distribution of the fishes inhabiting estuarine and near shore regions of the oceans, particularly those in the western North Atlantic. Specific problems in taxonomy and distribution will be discussed. Prerequisites: W.F.S. 311, 312, or approval of instructor.

613. Shore and Estuarine Fishes. (0-9). Credit 3. II, S 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. Analytical Procedures in Limnology. (1-6). Credit 3. I Qualitative and quantitative methods of evaluating biological populations and communities in ponds, lakes, reservoirs, and streams; methods of measuring primary and secondary productivity in these environments; and analysis of the theory and applicability of new chemical analytical techniques. Prerequisites: C.E. 603 or Ocn. 401 or W.F.S. 414 or equivalent and Stat. 406 or equivalent.

615. Mariculture. (3-3). Credit 4. II Environmental, physiological, behavioral, and economic factors which determine the success of efforts to cultivate salt-water species having economic importance. Practices employed in various parts of the world to increase sustained yields of fishes, molluscs, and crustaceans considered. Prerequisites: Ichthyology and invertebrate zoology or approval of instructor.

620. Vertebrate Ethology. (3-0). Credit 3. II 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; interspecific competition; predator-prey relations.

681. Seminar. (1-0). Credit 1 each semester. I, II Important current developments in wildlife field with special reference to literature.

684. Professional Internship. Credit 1 to 4 each semester. I, II This course will give students opportunity for on-the-job training in fields of wildlife and fisheries sciences. The program will emphasize two main areas: commercial production of fresh-water and marine organisms for food, and environmental education. Prerequisite: Graduate classification in the Department of Wildlife and Fisheries Sciences.

685. Problems. Credit 2 to 6 each semester. I, II, S Credit adjusted in accordance with requirements of each individual case.

691. Research. Credit 1 or more each semester. I, II, S Original research on selected wildlife problem to be used in thesis or dissertation.

INDEX

Accounting, Department of: 75
Administrative Officers: v
Admission: 48; to D.E.D. program, 69
Adult and Continuing Education: 161
Advisory Committee: Master's level, 55, 56-57 *passim*; doctoral level, 64, 65, 66-69 *passim*
Aerospace Engineering, Department of: 76-78
Agricultural Economics, Department of: 78-80
Agricultural Education, Department of: 80-82
Agricultural Engineering, Department of: 82-83
Agricultural Finance: 78
Agronomy: 207
ALAMINOS (Research Ship): 142
American History: 147
Animal Breeding: 83
Animal Nutrition: 83
Animal Science, Department of: 84-86
Anthropology: 205
Architecture, Department of: 86-90
Assistantships: 71
Atomic Energy Commission: 72

Behavioral Engineering: 152
Biochemistry and Biophysics, Department of: 90-92
Bioengineering: 153
Biology, Department of: 92-96
Biophysics: 92
Board of Directors: v
Building Design: 87
Business Analysis and Research, Department of: 96
Building Use Fee: 52

Caesar Kleberg Research Program: 224
Candidacy for Doctoral Degree: admission to, 67
Center for Tectonophysics: 142
Center for Urban Programs: 123
Chemical Engineering, Department of: 97-99
Chemistry, Department of: 99-103
Civil Engineering, Department of: 103-108
College Student Personnel Program: 119
Community Education: 114
Computing Science: 154
Cooperative Graduate Programs: 48
Cooperative Extension Education: 161
Counseling Psychology Program: 119
Counselor Education Program: 119
Credits: requirements: 55, 57, 58, 59; transfer of: 55, 65
Curriculum and Instruction: 116-118
Cybernetic Engineering: 152
Cyclotron Institute: 99, 180, 189
Czech: 178

Dairy Manufacturing: 84, 109
Dairy Production: 84, 109
Dairy Science: 86
Data Processing Center: 84, 97, 123, 142, 153
Degree Program: 55, 65
Degrees: application for, 57, 68; types offered, 44-48
Dissertations: 67, 71
Doctor of Education: 68
Doctor of Environmental Design: 69
Doctor of Philosophy: 64-68
Double Registration: 50
Dykes Collection: 72

Econometrics: 112, 212
Economics, Department of: 109-113
Educational Administration, Department of: 113-116
Educational Curriculum and Instruction, Department of: 116-118
Educational Psychology, Department of: 119-122
Educational Technology: 149
Electrical Engineering, Department of: 122-125
Electric Power Institute: 123
Employees: registering as students, 50
Engineering: 126
Engineering Design Graphics, Department of: 126-127
Engineering Technology, Department of: 127-128
English, Department of: 128-131
Entomology, Department of: 132-133
Environmental Engineering: 103
Examinations. See final examinations; preliminary examinations.
Extension Courses: 55

Faculty: 1-40
Faculty-Staff Handbook: 50
Farm Management and Production Economics: 78
Feedlot Management: 133
Fees: 51-53
Fellowships: 71
Final Examinations: 57-62 *passim*, 68, 69
Financial Assistance: 71
Finance, Department of: 134
Floriculture: 209
Food Technology: 84, 135

Foreign Languages: 56, 59, 65-66
Foreign Students: 49
Forest Engineering: 103, 135
Forest Science, Department of: 135-136
French: 178

Genetics: 136-138, 192-193
Geodesy: 103
Geography, Department of: 138
Geology, Department of: 140
Geophysics, Department of: 142
Geotechnical Engineering: 103
German: 178
Graduation: 71
Graduate Advisors: 51
Graduate Assistantships: 71
Graduate College Organization: vii
Graduate Courses: defined, 48; listed by departments, 75-226
Graduate Credit: 51
Graduate Record Examination: 48

Health Center: 73
Health and Physical Education, Department of: 144-146
Health Physics: 90, 180
History, Department of: 146-149
Horticulture: 210-211
Housing: 53
Human Learning Research Laboratory: 119
Hygiene Engineering: 153

In absentia: credit for work in, 64; registration, 50
Industrial Distribution: 127
Industrial Education, Department of: 149-152; doctorate in, 69
Industrial Engineering, Department of: 152-160
Industrial Hygiene: 153
Industrial Safety: 153
Industrial Technology: 127
Institute for Solid State Electronics: 122
Interdisciplinary Education: 160-162
Interdisciplinary Engineering: 162-165
Interior Space Design: 87

Jeff Dykes Range Livestock Collection: 72

Kleberg Research Program: 224

Landscape Architecture: 165-166
Library Facilities: 72
Linguistics: 131
Livestock Production: 84, 166

Master of Agriculture: 57
Master of Architecture: 58
Master of Arts: 59
Master of Business Administration: 59
Master of Computing Science: 60
Master of Education: 60
Master of Engineering: 61
Master of Landscape Architecture: 61
Master of Science: 54-57
Master of Statistics: 61
Master of Urban Planning: 62
Management, Department of: 166-168
Marketing, Department of: 168-169
Married Student Apartments: 53
Mathematics, Department of: 169-172
Meat Industries: 172
Meat Science: 173
Mechanical Engineering, Department of: 173-175
Mechanics and Materials: 163
Meterorology, Department of: 175-178
Modern Languages, Department of: 178-179

National Aeronautics and Space Administration: 72
Natural Resources Development: 203
National Science Foundation Regular Traineeship Programs: 71
NDEA Title IV Program: 71
Nuclear Engineering, Department of: 180-182
Nuclear Science Center: 180

Oceanography, Department of: 182-187

Paleoecology: 140
Paleontology: 140
Petitions: 54
Petroleum Engineering, Department of: 187-188
Petrology: 140
Ph.D.: 64-68
Physical Education: 145
Physics, Department of: 188-191
Physiology of Reproduction: 84,191
Plant Breeding: 191
Plant Pathology: 193-194
Plant Physiology: 194-195
Plant Sciences, Department of: 192-195
Policy and Procedures Manual: 50
Political Science, Department of: 195-198
Polymer Research Center: 99
Poultry Science, Department of: 198-199
Preliminary Examinations: 66
Psychological Foundations of Education Program: 119
Psychological Services Laboratory: 119

Range Science, Department of: 201-202
Recreation and Parks, Department of: 203-204
Recreation and Resources Development: 203
Refunds: 52

Registration: 50
Remote Sensing Center: 123
Research Graduate Assistantships: 71
Residence Halls: 53
Residence Requirements: 54, 58-62 *passim*, 64
Resource and Real Estate Economics: 78
Rural Development and Agricultural Policy: 78
Russian: 179

Safety Education: 151
Scholarship: 53
Scholastic Record: 49
Sociology and Anthropology, Department of: 204-206
Soil and Crop Sciences, Department of: 206-211
Soil Chemistry: 211
Soil Physics: 211
Spanish: 179
Special Education Program: 119
Staff Members: limitations on, 56, 67
Statistics, Institute of: 212-215
Statistics: requirement in, 69
Structural Engineering: 103
Structural Mechanics: 103
Student Center Complex Fee: 52
Student Services: 52
Systems Development: 87

Tectonophysics, Center for: 142
Texas Education Agency: 113, 116
Texas State Board of Psychological Examiners: 120
Thermodynamics Research Center: 99
Thesis: proposals, 55; publication, 71; required, 57, 59, 62
Time limits: on degrees, 56, 64
Test of English as a Foreign Language: 50
TOEFL: 50
Transfer Courses: 55, 65
Transportation Engineering: 103
Tuition: 52
Turf Management: 207

Urban Design: 87
Urban Management: 103
Urban Planning: 103
Urban and Regional Planning, Department of: 215
University Health Center: 73

Veterinary Anatomy, Department of: 217
Veterinary Library: 73
Veterinary Medicine and Surgery, Department of: 218
Veterinary Microbiology, Department of: 218
Veterinary Parasitology, Department of: 220
Veterinary Pathology, Department of: 220
Veterinary Physiology and Pharmacology, Department of: 221
Veterinary Public Health, Department of: 223
Vocational Education: 69, 149

Wildlife and Fisheries Sciences, Department of: 224-226

2102