

ENVIRONMENTAL AND CIVIL ENGINEERING

Professor Laura J. Steinberg, **Chair**

Professors: Bijan Mohraz, Laura J. Steinberg; **Associate Professors:** Paul Krueger (**Mechanical Engineering**), David A. Willis (**Mechanical Engineering**); **Research Associate Professor:** Alfredo Armendariz; **Assistant Professors:** Khaled Abdelghany, Usama El Shamy, Jim T. Yu; **Senior Lecturer:** Roger O. Dickey; **Visiting Lecturer:** Jong-Wha Bai; **Adjunct Faculty:** Arthur Beck, Mark K. Boyd, Gerald R. Carney, Robert R. Casagrande, Weiping Dai, Betsy del Monte, James Duke, Ted Dumas, John Easton, Carl Edlund, Fawzi Elghadamsi, Andrew Felder, Edward Forest (Retired Chair), Anwar Hirany, Louis Hosek, Ron Jackson, Timothy L. Jacobs, James E. Langford, Donald L. Legg, Shannon K. McCall, Paul Martin, Jennifer O'Brien, Jon D. Rauscher, Cecil Smith (Professor Emeritus), D. Blair Spitzberg, John Stanley, Bennett Stokes, Patricia A. Taylor, Ken Thomas, Philip K. Turner, Dan Witliff, Scott Woodrow.

Undergraduate programs within the Department of Environmental and Civil Engineering educate and train leaders in the fields of environmental protection, resource management, construction and engineering design. Programs are tailored to the individual needs and interests of our students, so that students with interests in studying global climate change, protecting the quality of our drinking water, or designing the next generation of high-rise buildings or smart highways receive the training they need to excel in their careers. As part of their education, our students are paired with CEOs, business leaders, professional engineers, EPA directors or corporate attorneys in a mentoring program designed to propel students into promising careers.

Environmental and civil engineering are inextricably linked. While civil engineering focuses on the infrastructure of modern society, environmental engineering is concerned with the well-being and health of the population and the environment. Environmental and civil engineering entered the early 1900s as a single integrated discipline, when it was critical to address sanitary problems to protect public health, and to develop regional water supplies and the civil infrastructure to support rapid urbanization and early industrialization. Separate disciplines gradually emerged, evolving and broadening to address the overall quality and function of modern society—preserving the environment while enabling the realization of an enriched life through technology.

Environmental Engineering and Environmental Science Programs

Today, the environmental field is dynamic and wide-ranging, comprising many different disciplines and professional roles. Environmental engineering and science involve not only traditional water and wastewater management, but also the management of hazardous and radioactive materials, pollution prevention and waste minimization, innovative hazardous waste treatment and site remediation processes, environmental and occupational health, resource conservation and recovery, sustainable development of natural resources, and air quality management and pollution control. In addition, modern manufacturing, both domestic and worldwide, is focusing on products fabricated from recycled and natural materials that are both competitive and harmlessly degraded in the environment. The trend toward global manufacturing will grow stronger in the years ahead. Environmental challenges presented by this movement must be overcome if the economic and lifestyle benefits of globalization are to be extended to all peoples of the world.

The educational objectives of the environmental engineering program are consistent with the missions of the Environmental and Civil Engineering Department,

the Lyle School of Engineering, and the overall institutional mission of SMU and they were determined based on the needs of the program's various constituencies. The program prepares graduates to achieve the following educational objectives during the medium term of their professional careers:

1. assume important leadership positions in a globally competitive world.
2. fully participate either as engineering designers or managers in the public or private sectors.
3. pursue advanced academic or professional degrees in engineering, medicine, law, business, or public policy.
4. licensing as professional engineers.

The environmental engineering program prepares graduates for professional practice and advanced study through a focus in the following areas: (1) water supply and resources, (2) environmental systems and process modeling, (3) environmental chemistry, (4) wastewater management, (5) solid waste management, (6) hazardous waste management, (7) atmospheric systems and air pollution control and (8) environmental and occupational health.

Civil Engineering Program

Civil engineers are engaged in planning, design, construction, maintenance and management of the infrastructure of modern society. They are responsible for the design of water supply and wastewater treatment systems; transportation systems such as highways, railways, waterways, mass transit, airports, ports and harbors; dams, reservoirs and hydroelectric power plants; thermoelectric power plants; transmission and communication towers; high-rise buildings; and even aircraft and aerospace structures, shuttles and space stations. Every major structure critical to this country, and global society, depends on the work of civil engineers.

The mission of the civil engineering program is to prepare graduates for professional practice and advanced studies by focusing in the following areas: structural engineering, geotechnical engineering, transportation planning, environmental engineering, and water resources. Graduates will be equipped with the skills and knowledge necessary to be fully participatory members of civil engineering teams, and to contribute to civil engineering efforts conducted within the evolving global e n v i r o n m e n t .

The mission and educational objectives of the civil engineering program are consistent with the missions of the Environmental and Civil Engineering Department, the Lyle School of Engineering, and the overall institutional mission of SMU and they were determined based on the needs of the program's various constituencies. The program prepares graduates to achieve the following educational objectives during the medium term of their professional careers:

1. assume important leadership positions in a globally competitive world.
2. fully participate either as engineering designers or managers in the public or private sectors.
3. pursue advanced academic or professional degrees in engineering, medicine, law, business, or public policy.
4. licensing as professional engineers.

Degrees Offered

The Environmental and Civil Engineering Department offers undergraduate degrees as follows:

- Bachelor of Science in Environmental Engineering
- Bachelor of Science in Environmental Engineering with a Premedical Specialization
- Bachelor of Science in Environmental Science
- Bachelor of Science in Environmental Science with a Premedical Specialization
- Bachelor of Science in Civil Engineering

The undergraduate programs in environmental engineering and civil engineering are accredited by the Engineering Accreditation Commission of ABET, Inc., 111 Market Place, Suite 1050, Baltimore, MD 21202-4012; telephone (410) 347-7700. ABET does not provide accreditation for the discipline of environmental science.

Both the environmental and civil engineering programs are designed to prepare students for the Fundamentals of Engineering (FE) Examination, the first step toward licensure as a Professional Engineer (P.E.). Engineering design is integrated throughout the environmental and civil engineering curricula, each culminating in a major design experience based on the knowledge and skills acquired in earlier course work. In their senior year, the department's engineering students are required to take two terms of design where teams of two to four students work closely on practical projects sponsored by industry and government. Senior design projects incorporate engineering standards and realistic constraints including most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political. The department's engineering curricula ensure that students develop an understanding of the concepts of professional engineering practice including ethical responsibilities, effective oral and written communication, engineering management and entrepreneurship, functioning on multidisciplinary teams, procurement, bidding, interaction of design and construction professionals, professional licensing and the need for lifelong learning.

The B.S. degree in Environmental Science and the B.S. degree in Environmental Science with a Premedical Specialization are designed to meet the professional goals of students whose environmental interests are broader. These programs offer the student greater depth with respect to the sciences, and greater course flexibility with respect to electives.

Departmental Facilities

Departmental offices and instructional and research laboratories are located in the new, state-of-the-art J. Lindsay Embrey Engineering Building. Environmental teaching and research laboratories include dedicated space for air quality and meteorology, industrial hygiene, environmental microbiology and water quality. The air quality/meteorology and water quality laboratories are capable of conducting sophisticated chemical analyses of air samples, and assessing the quality of water supplies and wastes and the effectiveness of water and waste treatment procedures. Major equipment includes several spectrophotometers including atomic absorption (AA), inductively coupled plasma (ICP) emission for low-level heavy metals analysis, and two Hewlett-Packard gas chromatographs (GC). Other

equipment includes continuous ambient air monitoring equipment, a UV/visible spectrophotometer, pH and other specific ion meters, incubating ovens, microscopes, furnaces, centrifuges, dissolved oxygen meters, a Mettler titrator for chemical and acid/base surface experiments, several temperature control baths, and a tumbler for constant temperature studies. The air quality and meteorology laboratory includes state-of-the-art airflow, pressure, and volume measurement instrumentation. The industrial hygiene laboratory includes an inventory of the latest state-of-the-art personal monitoring equipment for assessing occupational exposure to a variety of industrial process stressors including: asbestos, noise, total and respirable dust, metals, radiation, and heat stress.

Civil engineering teaching and research laboratories include dedicated space for mechanics of materials/and structural engineering, hydraulics and hydrology, soil mechanics and geotechnical engineering, transportation materials, and intelligent transportation systems. Mechanics of materials/structural engineering lab equipment include a tension-compression testing machine with automatic data acquisition instrumentation and computer software, a torsion test machine, a bending test machine and a set of impact test equipment. Major hydraulics/hydrology laboratory equipment include a 5-meter open channel flume with various accessories (e.g., undershot weir, rotary undershot gate, sharp and broad-crested weirs, etc.), a basic hydraulics bench for fundamental fluid mechanics experiments (e.g., hydrostatic pressure forces, Bernoulli's theorem, pipe friction losses, etc.), and a hydrology study system for hydrology experiments (e.g., simulating rainfall over watersheds and measuring resulting outflow hydrographs, groundwater flow profiles, etc.). The Geotechnical Engineering laboratory has a fully-automated multi-purpose testing machine that can be used to conduct triaxial, consolidation, flexible-wall permeability, swelling, and unconfined compression tests. The lab also has a fully-automated direct shear test machine. Traditional geotechnical testing equipment such as sieve analysis, hydrometer, constant head/falling head permeameter, liquid and plastic limits, compaction and relative density are also available.

The Embrey Building also houses a dedicated computer-aided design (CAD) laboratory with AutoCAD software, and a general-use computer laboratory for the department's students including personal computers, high-resolution color monitors and laser printers. Computers in both the CAD and general-use laboratories are connected, through a high-speed network, to the computer systems of the Lyle School of Engineering and SMU, as well as off-campus systems via the Internet. The computer network provides access to general applications software and specialized software for engineering problems including air dispersion modeling, AutoCAD, hydrologic and hydraulic modeling for water resource systems, statistical analysis and stochastic modeling, structural analysis and design, transportation systems planning and analysis, and water quality modeling.

Bachelor of Science in Environmental Engineering

Curriculum Requirements		TCH
College Requirements:	Humanities, Social Sciences and SMU required courses	23
Mathematics and Statistics:	MATH 1337, 1338, 2339, 2343; STAT 4340 or 5340	15
Sciences:	Biology: BIOL 1402	

	Chemistry: CHEM 1113, 1114, 1303, 1304 Earth Science: ENCE 1331 Meteorology Physics: PHYS 1105, 1106, 1303, 1304	23
Curriculum Requirements		TCH
Engineering Science and Design	Computer Science and Engineering: CSE 1340 or 1341 Civil/Mechanical Engineering: ENCE 2310, 2331, 2342	12
Environmental Engineering and Design:	ENCE 1302, 2304, 2421, 3323, 3341, 3431, 3451, 4380, 4381, 5317, 5354, 5372	39
Environmental Technical Electives:	Selected with adviser approval	6
Engineering Leadership:	ENCE 3302 and two of CSE 4360, EMIS 3308, and 3309	9
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Minimum total hours required		127

**Bachelor of Science in Environmental Engineering
(Premedical Specialization)**

Curriculum Requirements		TCH
College Requirements:	Humanities, Social Sciences and SMU required courses	23
Mathematics and Statistics:	MATH 1337, 1338, 2339, 2343; STAT 4340 or 5340	15
Sciences:	Biology: BIOL 1401, 1402, 3304, 3350 Chemistry: CHEM 1113, 1114, 1303, 1304, 3117, 3118, 3371, 3372 Earth Science: ENCE 1331 Meteorology Physics: PHYS 1105, 1106, 1303, 1304	41
Engineering Science and Design:	Computer Science and Engineering: CSE 1340 or 1341 Civil/Mechanical Engineering: ENCE 2310, 2331, 2342	12
Environmental Engineering and Design:	ENCE 1302, 2304, 2421, 3323 3341, 3431, 3451, 4380, 4381, 5354, 5372	36
Environmental Technical Electives:	Selected with adviser approval	6
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Minimum total hours required		133

**Bachelor of Science in Environmental Engineering
and Bachelor of Science in Mathematics**

Curriculum Requirements		TCH
College Requirements:	Humanities, Social Sciences and SMU required courses	23
Mathematics and Statistics:	MATH 1337, 1338, 2339, 2343, 3315, 3337 and two advanced MATH electives selected with math adviser approval; STAT 4340 or 5340	27
Sciences:	Biology: BIOL 1402 Chemistry: CHEM 1113, 1114, 1303, 1304	

	Earth Science: ENCE 1331 Meteorology Physics: PHYS 1105, 1106, 1303, 1304	23
Curriculum Requirements		TCH
Engineering Science and Design	Computer Science and Engineering: CSE 1340 or 1341 Civil/Mechanical Engineering: ENCE 2310, 2331, 2342	12
Environmental Engineering and Design:	ENCE 1302, 2304, 2421, 3323, 3341, 3431, 3451, 4380, 4381, 5317, 5354, 5372	39
Advanced Environmental/ Mathematics Electives:	Choose two from; ENCE 5331, 5332, 5334; ME 5336	6
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Minimum total hours required		130

Bachelor of Science in Environmental Science

Curriculum Requirements		TCH
College Requirements:	Humanities, Social Sciences and SMU required courses	29
Mathematics and Statistics:	MATH 1337, 1338; STAT 4340 or 5340	9
Sciences:	Biology: BIOL 1401, 1402 Chemistry: CHEM 1113, 1114, 1303, 1304 Earth Science: ENCE 1331, GEOL 1301 Physics: PHYS 1105, 1106, 1303, 1304	30
Engineering Science:	Computer Science and Engineering: CSE 1340 or 1341, or EMIS 1307	3
Environmental Engineering:	Core: ENCE 1302, 2304, 2421 3302 Advanced: ENCE 3341, 3431, 3451, 5317 Management (Choose any 4 of the following 7): ENCE 5311, 5314, 5315, 5323, 5350, 5352, 5353	39
Environmental Technical Electives:	Selected with adviser approval	6
Technical and Engineering Leadership Electives:	Free electives	6
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Minimum total hours required		122

**Bachelor of Science in Environmental Science
(Premedical Specialization)**

Curriculum Requirements		TCH
College Requirements:	Humanities, Social Sciences and SMU required courses	29
Mathematics and Statistics:	MATH 1337, 1338; STAT 4340 or 5340	9
Sciences:	Biology: BIOL 1401, 1402, 3304, 3350 Chemistry: CHEM 1113, 1114, 1303, 1304, 3117, 3118, 3371, 3372 Earth Science: ENCE 1331, GEOL 1301 Physics: PHYS 1105, 1106, 1303, 1304	44
Engineering Science:	Computer Science and Engineering: CSE 1340 or 1341 or EMIS 1307	3

Environmental Engineering: Core: ENCE 1302, 2304, 2421, 3302
 Advanced: ENCE 3341, 3431, 3451
 Management (Choose any 4 of the following 7):
 5311, 5314, 5315, 5323, 5350, 5352, 5353 36

Curriculum Requirements TCH
 Environmental Technical
 Electives: Selected with adviser approval 3
 Technical or Engineering
 Leadership Elective: Free elective 3

Minimum total hours required 127

Bachelor of Science in Civil Engineering

Curriculum Requirements TCH

College Requirements: Humanities, Social Sciences and SMU required courses 23
 Mathematics and
 Statistics: MATH 1337, 1338, 2339, 2343; STAT 4340 or 5340 15
 Chemistry: CHEM 1113, 1114, 1303, 1304
 Sciences: Earth Science: GEOL 1301 or 1315
 Physics: PHYS 1105, 1106, 1303, 1304 19

Engineering Science
 and Design: Computer Science and Engineering: CSE 1340 or 1341
 Civil/Mechanical Engineering: ENCE 2320, 2331,
 2342/2142 13

Civil Engineering
 and Design: ENCE 1302, 2304, 2310, 2340/2140,
 3323, 3350, 4350, 4351, 4380, 4381, 4385, 5354, 5372,
 5378 43

Civil Engineering
 Technical Electives: Selected with adviser approval 6
 Engineering Leadership: ENCE 3302 and one of CSE 4360, EMIS 3308, and 3309 6

Minimum total hours required 125

**Bachelor of Science in Civil Engineering
 and Bachelor of Science in Mathematics**

Curriculum Requirements TCH

College Requirements: Humanities, Social Sciences and SMU required courses 23
 Mathematics and
 Statistics: MATH 1337, 1338, 2339, 2343, 3315, 3337 and two
 advanced MATH electives selected with math adviser
 approval; STAT 4340 or 5340 27

Sciences: Chemistry: CHEM 1113, 1114, 1303, 1304
 Earth Science: GEOL 1301 or 1315
 Physics: PHYS 1105, 1106, 1303, 1304 19

Engineering Science
 and Design: Computer Science and Engineering: CSE 1340 or 1341
 Civil/Mechanical Engineering: ENCE 2320, 2331,

2342/2142 13
 Civil Engineering
 and Design: ENCE 1302, 2304, 2310, 2340/2140,
 3323, 3350, 4350, 4351, 4380, 4381, 4385, 5354, 5372,
 5378 43

Curriculum Requirements TCH
 Advanced Civil
 Engineering/Mathematics: Choose two from; ENCE 5361, ENCE 5364; ME 5322 6

Minimum total hours required 131

Minor in Environmental Engineering

For approval of a minor in environmental engineering, the student should consult the Environmental and Civil Engineering Department. A minimum of 15 term credit hours in environmental engineering courses is required. One example of an approved set of courses that provides a broad introduction to environmental engineering is:

- ENCE 2304 Introduction to Environmental Engineering and Science
- ENCE 2421 Aquatic Chemistry
- ENCE 3431 Fundamentals of Air Quality I
- ENCE 4329 Design of Water and Wastewater Systems
- ENCE 5354 Environmental Engineering Principles and Processes

Based on the student's interests and background, other sets of environmental engineering courses may be substituted with the approval of the Environmental and Civil Engineering Department.

Minor in Civil Engineering

For approval of a minor in civil engineering, the student should consult the Environmental and Civil Engineering Department. A minimum of 15 term credit hours in civil engineering courses is required. One example of an approved set of courses, totaling 16 term credit hours, that provides an emphasis on structural analysis and design is:

- ENCE 2310 Statics
- ENCE 2340/2140 Mechanics of Deformable Bodies/Mechanics of Materials Laboratory
- ENCE 3350 Structural Analysis
- ENCE 4350 Structural Design
- ENCE 4385 Soil Mechanics and Foundations

Based on the student's interests and background, other sets of civil engineering courses may be substituted with the approval of the Environmental and Civil Engineering Department.

The Courses (ENCE)

1301. Environment and Technology: Ecology and Ethics. Students are introduced to the economic, engineering, ethical, political, scientific and social considerations of environmental decision-making and management. Local, regional and global topics will be examined. Students will take off-campus field trips.

1302. Introduction to Environmental and Civil Engineering. Students are introduced to the disciplines of environmental and civil engineering. Many of the hallmarks of modern society, including high-rise office buildings, increased lifespan, the virtual elimination of numerous diseases and reliable long-distance and public transportation systems are the result of work by environmental and civil engineers. Likewise, many problems presently confronting developing nations, including housing supply, food production, air and water pollution,

spread of disease, traffic congestion and flood control will be solved by environmental and civil engineers. The course emphasizes fundamental science, engineering and ecological principles and encourages the development of analytical and critical thinking skills with real-world problem solving.

1331. Meteorology. Meteorology is the science and study of the Earth's atmosphere and its interaction with the earth and all forms of life. Meteorology seeks to understand and predict the properties of the atmosphere, weather and climate from the surface of the planet to the edge of space. Appropriate for all interested undergraduates.

1378. Transportation Infrastructure. An overview and definitions of infrastructure elements with concentration on transportation. Principles of infrastructure planning and management. Congestion and performance measures. Relationship with economy, environment, safety, homeland security and technology.

2140. Mechanics of Materials Laboratory. Experiments in mechanics of deformable bodies, to complement ENCE 2340. Simple tension tests on structural materials, simple shear tests on riveted joints, stress and strain measurements, engineering and true stress, engineering and true strain, torsion testing of cylinders, bending of simple supported beams, deflection of simply supported beams, buckling of columns, strain measurements of pressure vessels, Charpy Impact tests, effect of stress concentrators. *Corequisite or Prerequisite:* ENCE 2340.

2142. Fluid Mechanics Laboratory. One three-hour laboratory session per week. Experiments in fluid friction, pumps, boundary layers, and other flow devices to complement lecture material of ENCE 2342. One credit hour. *Corequisite or Prerequisite:* ENCE 2342.

2304. Introduction to Environmental Engineering and Science. Introduction to a scientific and engineering basis for identifying, formulating, analyzing, and understanding various environmental problems. Material and energy balances are emphasized for modeling environmental systems and processes. Although traditional materials in air and water pollution are examined, emphasis is placed on contemporary topics such as hazardous waste, risk assessment, groundwater contamination, global climate change, stratospheric ozone depletion and acid deposition. Where appropriate, pertinent environmental legislation is described, engineering models are derived and applied, and treatment technologies introduced. *Prerequisites:* CHEM 1303 and MATH 1338.

2310. Statics. Equilibrium of force systems; computations of reactions and internal forces; determinations of centroids and moments of inertia; introduction to vector mechanics. *Prerequisite:* MATH 1337 or equivalent.

2320. Dynamics. Introduction to kinematics and dynamics of particles and rigid bodies; Newton's laws, kinetic and potential energy, linear and angular momentum, work, impulse, and inertia properties. *Prerequisite:* ENCE 2310 or equivalent.

2331. Thermodynamics. The first and second laws of thermodynamics and thermodynamic properties of ideal gases, pure substances, and gaseous mixtures are applied to power production and refrigeration cycles. *Prerequisite:* CHEM 1303, ENCE 2310, and MATH 2339.

2340. Mechanics of Deformable Bodies. Introduction to analysis of deformable bodies including stress, strain, stress-strain relations, torsion, beam bending and shearing stresses, stress transformations, beam deflections, statically indeterminate problems, energy methods and column buckling. *Prerequisite:* ENCE 2310.

2342 Fluid Mechanics. Fluid statics, fluid motion, systems and control volumes, basic laws, irrotational flow, similitude and dimensional analysis, incompressible viscous flow, boundary layer theory, and an introduction to compressible flow. *Prerequisites:* ENCE 2310, MATH 2339 and PHYS 1303. *Corequisite or Prerequisite:* MATH 2343.

2421. Aquatic Chemistry. Aspects of chemistry that are particularly valuable to the practice of environmental engineering are examined. A basic groundwork is provided for the quan-

titative analysis of water and wastewater systems. Fundamental methods of instrumental analysis are examined. Elements of thermodynamics, acid-base, redox, and colloidal chemistry are presented as appropriate. Laboratory sessions emphasize design, hands-on conduct of experimental procedures, and interpretation and statistical analysis of derived data. *Prerequisite:* CHEM 1303 and CHEM 1304.

3302. Engineering Communications. Both oral and written communications skills for engineers: engineering documents, writing standards and presentations; audience analysis; graphics; collaborative skills; and ethical issues. Students prepare several documents and presentations common in engineering practice. *Prerequisite:* Junior or Senior standing in engineering.

3323. Water Resources Engineering. The hydrologic cycle and associated atmospheric processes are introduced through derivation and practical application of the hydrologic budget equation encompassing precipitation, evaporation, transpiration, ground water flow and surface water runoff. Unit hydrographs and flood hydrograph routing are examined through application of hydrologic simulation models. Students are exposed to probabilistic analysis and extreme value theory for determination of flood and drought hazard. Interpretation and statistical analysis of climatologic, hydrologic, and other environmental data are emphasized. Concepts of professional engineering practice are introduced with emphasis on the need for professional licensing and on project management through all phases of a typical project including conception, planning, preparation of design drawings and specifications for bidding and procurement purposes, the interaction of design and construction professionals, and water resource systems operation. *Prerequisite:* ENCE 2304. *Corequisite or Prerequisite:* ENCE 2342.

3325. Ground Water Hydrology. The hydrologic cycle and the subjects of porosity and permeability are introduced. Flow theory and its applications, storage properties, the Darcy equation, flow nets, mass conservation, the aquifer flow equation, heterogeneity and anisotropy, regional vertical circulation, unsaturated flow, and recharge are examined. Well hydraulics, stream-aquifer interaction, and distributed- and lumped-parameter numerical models are considered, as are groundwater quality, mixing cell models, contaminant transport processes, dispersion, decay and adsorption, and pollution sources. *Prerequisites:* ENCE 2342 and MATH 2343.

3327. Principles of Surface Water Hydrology and Water Quality Modeling. The theory and applications of the physical processes of the hydrologic cycle are examined. Different types of water bodies – streams, rivers, estuaries, bays, harbors and lakes – are reviewed. The principal quality problems associated with bacteria, pathogens, viruses, dissolved oxygen and eutrophication, toxic substances, and temperature are examined in detail. Theoretical model approaches are emphasized. *Prerequisites:* ENCE 2421 and MATH 2343.

3341. Introduction to Solid and Hazardous Waste Management. Solid and hazardous waste are defined. Technology, health and policy issues associated with solid waste and hazardous materials are examined. Methods of managing solid and hazardous waste are introduced and regulations presented where appropriate. The characteristics of hazardous and solid waste materials, health frameworks, and the distribution of contaminants in the environment are reviewed. *Prerequisites:* ENCE 2304 and ENCE 2421.

3350. Structural Analysis. Emphasis on the classical methods of analysis of statically determinate and indeterminate structural systems. Computation of reactions, shears, moments, and deflections of beams, trusses and frames. Use of computers as an analytical tool. *Prerequisites:* ENCE 2340/ENCE 2140.

3353. Introduction to Environmental Toxicology. The physiological and biochemical effects of physical, chemical and biological processes are linked to factors present in the environment. Natural phenomena are described in terms of the carbon, oxygen, sulfur, phosphorus and heavy metal cycles. The processes by which anthropogenic chemicals enter the environment and their complex effects on living organisms are examined in detail. *Prerequisite:* BIOL 1402. *Corequisite or Prerequisite:* ENCE 5317 or equivalent.

3355. Environmental Impact Evaluation, Policy and Regulation. Methods for evaluating engineering projects on environmental quality are reviewed, as are environmental legislation and environmental quality indices. The strengths and weaknesses of government methodologies to protect the environment are reviewed. Pollution standards, marketable rights, taxes and citizen empowerment are considered. Economic analysis and other policy perspectives are considered. *Prerequisite:* ENCE 2304.

3431. Fundamentals of Air Quality I. The science, engineering, public health and economic aspects of air quality are covered. Topics include the sources of air pollutants, transport of pollutants in the environment, and atmospheric chemistry. The important properties and behavior of airborne particles and gases are reviewed. Also discussed are the science and national and international policies relating to greenhouse gas emissions, global climate change, and stratospheric ozone depletion. *Prerequisites:* CHEM 1303, MATH 1337 or equivalent, and PHYS 1303 or equivalent.

3451. Principles of Industrial Hygiene and Occupational Health. The recognition, evaluation and control of health hazards in the working environment are presented. Principles of industrial toxicology, risk assessment/management, occupational diseases, and occupational health standards are examined. The application of industrial hygiene principles and practice as well as the measurement and control of atmospheric contaminants are presented. The design and evaluation of occupational exposure controls are introduced. Lecture and three hours of laboratory. *Prerequisite:* CHEM 1304.

4329. Design of Water and Wastewater Systems. Physical, chemical and biological concepts and processes that are specific to public water supplies and municipal wastewater management are covered. Fluid mechanics is reviewed followed by an introduction to hydraulic modeling for design of water distribution networks and wastewater collection networks. Design and operation of treatment systems for both drinking water and municipal wastewater pollution control are covered. Process modeling is employed for completion of two design projects, one for a public water supply treatment plant and the other for municipal wastewater treatment plant. Field trips are conducted to a public water supply treatment plant and to a municipal wastewater treatment plant. *Prerequisites:* CHEM 1303, and ENCE 2304 and ENCE 2342.

4333. Fundamentals of Air Quality II. Fundamental and advanced topics in air quality are covered, building upon ENCE 3431. Atmospheric dispersion of pollutants is examined and modern computer models are used to predict transport. A thorough review of energy technology and energy policy is presented, focusing on the economics and environmental impacts of conventional and alternative methods of energy generation. The importance of indoor air quality is discussed, including the risks from radon and biological aerosols. Additional topics of current interest are presented. Each student prepares a term paper related to energy policy and the environment. *Prerequisites:* ENCE 2331 or equivalent, and ENCE 3431.

4350. Design of Steel Structures. Study of strength, behavior and design of metal structures; flexural and axial members, bolted and welded connections, and composite beams. *Prerequisite:* ENCE 3350.

4351. Design of Concrete Structures. Study of strength, behavior and design of reinforced concrete structures; members subjected to flexure. Shear and axial loads. Design of one-way slabs. *Prerequisite:* ENCE 3350.

4380. Environmental and Civil Engineering Design I. Students are responsible for completing a term-long environmental or civil engineering project for an industrial or regulatory client. The nature of design problems, constraints and analytical tools are examined in an applied setting. An integrated design process is employed including problem identification and formulation, project planning, evaluation of alternatives, internal peer review and design iterations, preparation of design drawings and specifications for bidding and procurement purposes, the interaction of design and construction professionals, and implementation of the completed project. *Prerequisites:* Senior standing and ENCE 3302.

4381. Environmental and Civil Engineering Design II. Students are responsible for completing a term-long environmental or civil engineering project for an industrial or regulatory client. Students function on multidisciplinary design teams that stress the need for personal and written communication skills, leadership, effective group participation, and creative problem solving. Concepts of professional engineering practice are reinforced by student participation in applied design problems including the need for professional licensing, the ethical responsibilities of licensed engineers, and the need for lifelong learning to stay abreast of changing technology and public policy through active participation in professional societies, self-study, and continuing education. Periodic progress reports and reviews and a final report are prepared and presented. Both the client and faculty assess the completed design project. *Prerequisite:* ENCE 4380.

4385. Soil Mechanics and Foundations. Introduction to the basic principles that govern the behavior of soils, foundations and other geotechnical engineering works. The central concepts covered include the index properties and classification of soils, soil permeability and pore water movement, stress distribution in soil and the effective stress concept, bearing capacity, compressibility, consolidation, settlement, shear strength, and soil engineering properties and their measurement. Geotechnical facilities introduced include foundations, retaining walls, tunnels, excavations, earth fill dams, pavements, stable earth slopes, sanitary landfills and environmental remediation projects. *Prerequisite:* ENCE 2340.

5050. Undergraduate Internship.

5090. ENCE Seminar. Lectures by invited speakers from industry and academia, including SMU faculty and students, dealing with engineering practice and research topics of current interest in environmental and civil engineering. All students, staff and faculty are invited.

5311. Environmental and Hazardous Waste Law. Federal environmental laws, with emphasis on laws dealing with hazardous substances, such as CERCLA and RCRA; regulations and the regulatory framework; definitions and substantive requirements; roles of the States and the Federal EPA; compliance and enforcement; case studies.

5312. Risk Assessment and Health Effects. Introduction to toxicology as it relates to environmental and health effects of hazardous materials; toxicological methodology; risk management factors including legal aspects; human health and ecological risk assessment and risk communication; emergency response; computer databases.

5313. Environmental Chemistry and Biology. Chemical and biochemical processes; controlling fate and transport of hazardous materials with emphasis on chemical equilibria; chemical thermodynamics; acid-base equilibria; precipitation and dissolution; oxidation-reduction processes; environmental transformations of organic materials; introductory taxonomy; microbial growth and kinetics; energy transfer; microbial ecosystems.

5314. Environmental Regulations and Compliance. Practical knowledge of federal and state environmental permitting processes and procedures is provided. Regulatory requirements are reviewed with emphasis on the 40 CFR regulations for water, air and solid and hazardous waste. Air, water, storm water and waste permits are reviewed, as well as permits-by-rule. Also explored are the consequences of noncompliance with regulations by presenting enforcement options available to government agencies.

5315. Integrated Waste Management. Comprehensive introduction to the fundamentals of the complex interdisciplinary field of hazardous waste management; current management practices; treatment and disposal methods; and site remediation. Topics include detailed case studies and design examples to evaluate the effectiveness of different treatment and containment technologies in addressing today's hazardous waste situations.

5317. Environmental Organic Chemistry. This course will examine the fundamental processes that govern transformations of organic chemicals in natural and engineering systems. The course will be divided into three parts: (1) organic chemistry overview, (2) physical transformations of organic compounds and (3) organic chemical reactions in the environment. The organic chemistry overview will provide knowledge regarding basic proper-

ties of organic compounds such as nomenclature and structures. Physical transformation of organic compounds will provide an understanding in processes (such as sorption and volatilization) that control the distribution of organic chemicals between different phases (such as air, water and soil). Environmentally-mediated reactions (such as hydrolysis and photolysis) that control the breakdown of organic chemicals will be the focus of chemical reactions.

5321. Physical and Chemical Waste Treatment. Waste minimization techniques and objectives are introduced. Chemical equilibrium and chemical reaction kinetics are thoroughly reviewed. Design and analysis equations and procedures are rigorously derived for chemical reactors and physical unit operations. The treatment objectives examined include (1) solids-liquid separation accomplished by coagulation and flocculation, sedimentation, filtration, flotation, and solids handling processes; (2) immiscible liquid separation brought about by emulsion breaking chemicals and gravity and flotation oil/water separators; (3) phase and species transformations through pH neutralization, chemical precipitation, chemical oxidation/reduction, air stripping, and solidification/stabilization; and, (4) solute separation and concentration achieved with activated carbon absorption, synthetic ion exchange resins, and membrane separation techniques.

5322. Biological Waste Treatment. Biological treatment topics include an overview of microbiology and microbial metabolism; kinetics of biological growth; aerobic suspended growth processes including the various modifications of the activated sludge process, aerated lagoons, and sequencing batch reactors; aerobic attached growth processes including trickling filters, biofilter towers, and rotating biological contactors; anaerobic processes including sludge digestion and liquid waste treatment with the anaerobic contact process and anaerobic filters; biosolids handling and disposal; composting; land treatment; *in situ* biotreatment and biotreatment of contaminated soils.

5323. Project Management. Role of project officer; systems and techniques for planning, scheduling, monitoring, reporting, and completing environmental projects; total quality management; project team management, development of winning proposals; contract management and logistics; case study application of project management to all environmental media and programs; community relations, risk communication, crisis management, consensus building, media, and public policy.

5325. Disaster Management. This course introduces the student to basic concepts in disaster management. Drawing on a range of sources from the textbook to the U.S. Disaster Response Plan to research papers, the course covers the fundamentals of preparedness, mitigation, response and recovery. An all-hazards approach is taken, providing analysis of natural, technological and man-made disasters. In addition to discussing basic theories of disaster management, the course introduces the student to key methods in the field, including simulation modeling, consequence analysis tools, design criteria, statistical and case study methods ("lessons learned") and risk analysis.

5327. Optimization and Reliability for Infrastructure and Environmental Systems. This course introduces the concepts of engineering systems optimization, reliability and risk assessment, and applies them to civil and environmental engineering systems. Topics include an introduction to engineering systems definition, classical methods of optimization, linear programming, integer programming, dynamic programming, nonlinear optimization, and reliability and risk concepts in engineering planning and design. Engineering applications will include transportation networks, fleet assignment, supply chain management, environmental engineering systems, fluid transport and water reservoir operation and structural engineering systems. Advanced topics will include an introduction to chance-constrained optimization and basic decomposition approaches and their application to real-world problems. *Prerequisite:* Graduate standing or permission of instructor.

5328. Introduction to Sustainability. This course introduces the student to basic concepts in sustainability. Drawing on a range of sources, including selected books and readings, the course explores the idea of total connectedness of resource use globally, with particular emphasis on the situation in North Texas. The course will address the issues of air quality

and energy supply, sustainable construction, water use, transit and other related areas of resource use and waste generation. Multiple guest lecturers will provide a series of multiple viewpoints and areas of specific expertise. *Prerequisite:* Graduate standing or permission of instructor.

5329. Methods and Technology for Sustainability. This course covers technologies and methods using in sustainable design and analysis. Areas covered include the scientific understanding of alternative energy systems, water reuse and supply and state-of-the-art materials created for sustainability. Also discussed are methods for assessing sustainability, including life-cycle assessment and the development of sustainable indicators. *Prerequisite:* Graduate standing, or permission of instructor.

5330. Design for Sustainability. This course introduces the student to the issues involved in creating a sustainable built environment. The course will address issues of resource use at the regional and project specific level. Specific techniques for designing and constructing sustainable buildings will be addressed. Systems of measurement for sustainable properties will be discussed on a comparative level, and the USGBC's LEED system will be specifically addressed. *Prerequisite:* Graduate standing or permission of instructor.

5331. Air Pollution Management and Engineering. This course covers the science, engineering, public health, and economic aspects of air quality. Students will develop in-depth understanding and broad knowledge of the sources and properties of air pollutants, air quality management, transport of pollutants in the environment, regulations of air quality, and the operation and design of air pollution control systems. In addition, the class will review the current status of science, policy and regulations on several selected topics such as urban smog, regional haze, greenhouse gas and global climate change, stratospheric ozone depletion, and mercury emissions and control. *Prerequisites:* CHEM 1304, MATH 1337 or equivalent, and PHYS 1303 or equivalent.

5332. Ground Water Hydrology and Contamination. Ground water hydrology; aquifer and well hydraulics; flow equations and models; implications for landfill design; sources and nature of ground water contaminants; monitoring and analysis; contaminant fate and transport; transport model for hazardous substances; ground water pollution control measures; containment and treatment; ground water quality management. *Prerequisite:* MATH 2343.

5333. Laboratory Methods in Environmental Engineering. This course provides students with hands-on, state-of-the-art experience with important experimental methods in environmental systems, evaluating the reliability and significance of parameter determinations. Covers instrumental and statistical methods used for characterization of water, air and soil quality. Introduction to treatability studies including reactor dynamics. The course format provides two hours of lecture and three hours of laboratory component. *Prerequisite:* ENCE 5313, or two terms of undergraduate chemistry.

5334. Fate and Transport of Contaminants. Development and application of fate and transport models for water-borne contaminants with focus on material balance principle; mass transport and transformation processes; modeling of lakes and reservoirs; stream modeling; general flow case; ground water models; water-sediment, water-soil, and water-air interfaces; multiphase and integrated modeling approaches; case studies.

5335. Aerosol Mechanics. Fundamental and advanced principles of airborne particles, including their physical properties, aerodynamic behavior, and their collection, measurement, and analysis. The course emphasizes the origins and properties of atmospheric aerosols and the design of air pollution equipment. *Prerequisites:* ENCE 3431, or ENCE 2342 or equivalent.

5340. Introduction to Solid Mechanics. Three-dimensional stress and strain, failure theories, introduction to two-dimensional elasticity, torsion of prismatic members, beams on elastic foundations, introduction to plates and shells, and energy methods. *Prerequisites:* ENCE 2340 and MATH 2343.

5350. Introduction to Environmental Management Systems. An in-depth introduction to

environmental management systems (EMS). Includes systems such as EMAS, Responsible Care, OSHA 18000, ISO 14000, and the Texas EMS program. Takes a step-by-step look at the ISO 14001 standard from the policy statement to the management review, and allows students to fully understand the Plan-Do-Check-Act approach of the system. Also introduces students to management system auditing, the requirements of a system auditor, and the certification process.

5351. Introduction to Environmental Toxicology. Toxicology is presented as it relates to environmental and health effects of hazardous materials. Toxicological methodologies, pharmacokinetics, mechanisms of action to toxicants, origin response to toxic substances, and relevant aspects of the occupational and regulatory environment will be examined. Specific topics include toxicology of metals, radiation, industrial solvents and vapors, pesticides, teratogens, mutagens and carcinogens. Risk communication and risk assessment are examined as they relate to toxic substance exposure.

5352. Management of Radioactive Hazards. Principles of radioactive material production, uses and hazards are presented with emphasis on their safe control and management. Topics in health physics and radiation protection related to the commercial nuclear industry are examined including uranium fuel production, light water reactor technologies, and industrial and medical uses of radioactive byproduct materials. Risk assessment methods and hazard management connected to the fuel cycles will be developed. The regulation of radioactive materials will be studied with emphasis on licensing of regulated industries, radioactive material transportation, radioactive waste management and disposal, radiological emergency preparedness and decommissioning. *Prerequisite:* ENCE 5313.

5353. Environmental Epidemiology. Introduction to the science of epidemiology. Design and conduct of studies examining health effects of environmental exposures. Strengths and limitations of research strategies and interpretation of study results. Areas of interest include air and water pollution, lead, and biological marker outcomes.

5354. Environmental Engineering Principles and Processes. Waste minimization and pollution prevention techniques and objectives are introduced. A comprehensive study is made of biological, chemical and physical principles and treatment strategies for controlling pollutant emissions. Equal emphasis is placed on underlying theory and practical engineering application of both common and innovative water and wastewater treatment processes. Design equations, procedures, and process models are rigorously derived for chemical/biological reactors and physical unit operations. Emphasis is placed on engineering analysis and application of process modeling techniques for design of unit processes to achieve specific treatment objectives. *Prerequisites:* CHEM 1303, ENCE 2304 and ENCE 2342, and MATH 2343.

5361. Matrix Structural Analysis and Introduction to Finite Element Methods. A systematic approach to formulation of force and displacement method of analysis; representation of structures as assemblages of elements; computer solution of structural systems. *Prerequisite:* ENCE 3350.

5362. Engineering Analysis with Numerical Methods. Applications of numerical and approximate methods in solving a variety of engineering problems. Examples include equilibrium, buckling, vibration, fluid mechanics, thermal science and other engineering applications. *Prerequisite:* Permission of instructor.

5363. Architectural and Structural Engineering. The basic principles of structural analysis and mechanics of deformable bodies are introduced. Structural systems and principles are presented with an emphasis on architectural design. Students will be provided with a conceptual introduction to structures emphasizing the integration of structural and architectural design. Case studies of buildings are presented and discussed. *Prerequisites:* ENCE 2310 and ENCE 2320.

5364. Introduction to Structural Dynamics. Dynamic responses of structures and behavior of structural components to dynamic loads and foundation excitations; single- and multi-

degree-of-freedom systems response and its applications to analysis of framed structures; introduction to systems with distributed mass and flexibility. *Prerequisite:* MATH 2343.

5365. Introduction to Construction Management. Construction practice techniques and current technological tools are examined. Included are cost estimating, bidding, contracts and contract bonds, risk and umbrella excess insurance, labor law and labor relations. Building codes and regulations are examined. Business methods with respect to managing project time and cost, including typical forms used in construction, are addressed.

5366. Introduction to Facilities Engineering Systems. The inter-relationships of fire protection, HVAC, electrical, plumbing, lighting, telecommunications, energy management systems for buildings are examined. A life-cycle approach examines each of these systems with respect to cost, durability, maintainability, operability and safety. Facility operations, facility maintenance and testing, and assessments are discussed.

5367. Telecommunications in Facility Planning. A thorough description of telecommunications technology is presented. Provides the student with a working knowledge of the fundamental concepts of telecommunications technology for both voice and data. Topics presented include digital communications, standards and protocols, ethernet, local area networks, fiber optics and voice technologies.

5368. Facilities Contract Management. A critical foundation and understanding is provided of the terminology, arts and skills of contracts and contract negotiation, review and preparation, as well as insurance and risk management. Attention is also given to lease analysis, licensing and permits, when and how bidding contracts are warranted, how to prepare specifications and their role in contract creation, and supplier and vendor management in the post-contractual process.

5369. Electrical, Mechanical and Piping Systems for Buildings. Mechanical and electrical systems for buildings are examined with emphasis on practical aspects of the subjects. Space planning and architectural considerations, including cost and environmental impact of the mechanical and electrical systems are presented. *Prerequisites:* Undergraduate introduction to electrical circuits, classical mechanics and fluid dynamics, or instructor's approval.

5370. Facility Planning. The overall planning process for construction projects is presented. The three divisions of planning: program planning, project planning and activity planning are presented in an integrated manner. Included are different modeling approaches for the planning process.

5371. Facility Financial and Asset Management. Financial analysis and reporting, concepts and methods of accounting, budgeting and evaluation of projects are examined. The role of facility managers in affecting corporate earnings and valuations is presented. The management of the facility over its entire life-cycle extending from planning and budgeting to the management of its assets and construction projects is included.

5372. Introduction to CAD. Provides students with hands-on, state-of-the-art experience with computer-aided drafting using AutoCAD to produce drawings used for engineering presentations and construction. Students will learn how to draw lines, curvilinear lines, use blocks and external references, write text, create plot files, and many other commands necessary to produce engineering drawings as used to construct environmental, civil and structural engineering projects.

5373. Prestressed Concrete. Theory and application of prestressed concrete members, time-dependent deflections and continuous prestressed beams. *Prerequisites:* ENCE 4350.

5375. Advanced Concrete Design. Behavior, analysis and design of concrete slender columns, two-way slab systems and deep beams. Yield line analysis for slabs. Design and behavior of shear walls, retaining walls and foundations systems. *Prerequisite:* ENCE 4350.

5377. Advanced Steel Design. Behavior and design of steel structures including general methods of plastic analysis, plastic moment distribution, steel frames, unbraced and braced

frames, and composite construction. *Prerequisites:* ENCE 4350.

5378. Transportation Planning and Traffic Engineering. This course is concerned mainly with the analysis and modeling of urban transportation systems. The course consists of three main parts. The first part provides an overview of main definitions and terminologies involved in the planning and modeling of urban transportation systems. The second part introduces the concept of urban transportation planning systems along with an overview of various models used in travel demand forecasting. The third part describes principles of traffic operations, analysis and control. *Prerequisite:* Basic principles of probability and statistics.

5383. Heating, Ventilating and Air Conditioning. Examines the science and practice of controlling environmental conditions through the use of thermal processes and systems. Specific applications include refrigeration, psychometrics, solar radiation, heating and cooling loads in buildings, and design of duct and piping systems. Theory and analysis are emphasized. *Prerequisites:* ENCE 2331, ENCE 2342 and ME 3332.

5384. Energy Management for Buildings. Procedures to select energy saving options for buildings are examined with emphasis on the practical aspects of the subject. Space planning, architectural considerations, cost and environmental impact of the mechanical and electrical systems are considered along with optimizing the life cycle cost of the proposed alternative. Software for life cycle cost and energy analysis are used to calculate energy consumption and compare energy features of proposed, audit-determined feasible changes to a building.

5385. Advanced Soil Mechanics. Physicochemical properties of soil and soil stabilization. Advanced theories of soil deformation and failure as applied to slope stability and lateral loads. Soil-water interaction in earthen dams. *Prerequisite:* ENCE 4385.

5386. Foundation Engineering. Application of soil mechanics principles to the design and construction of shallow and deep foundations. Topics include: subsurface investigation procedures to obtain soil parameters for design and construction of structure foundations, bearing capacity and settlement analyses, construction procedures, and soil improvement techniques. *Prerequisite:* ENCE 4385.

5387. Geotechnical Earthquake Engineering. This course provides fundamental knowledge and practical application of soil dynamics and geotechnical earthquake engineering. This includes an overview of seismic hazards, the fundamentals of vibration, wave propagation in elastic medium, properties of dynamically loaded soils, earthquake-induced ground motion, ground response analysis, lateral earth pressure on retaining walls, liquefaction of soils, and seismic stability of earth embankments. *Prerequisite:* ENCE 5364 Introduction to Structural Dynamics, or approval of the instructor.

5(1-4)9(1-2). Special Projects. Intensive study of a particular subject or design project, not available in regular course offerings, under the supervision of a faculty member approved by the department chair.