GENERAL INFORMATION

The Lyle School of Engineering, named in 2008 in honor of Dallas entrepreneur and industry leader Bobby B. Lyle, traces its roots to 1925, when the Technical Club of Dallas, a professional organization of practicing engineers, petitioned SMU to fulfill the need for an engineering school in the Southwest. In response to the club's request, the school began one of the first cooperative education programs in the United States, a program that continues today to put engineering students to work on real technical projects.

Included in the Lyle School of Engineering curricula are programs in civil engineering, computer engineering, computer science, electrical engineering, environmental engineering, mechanical engineering and management science. In 2000, a variety of programs known as Engineering and Beyond were introduced to provide the combination of a traditional engineering curriculum and selected leadership coursework designed to train engineering students for futures in management, entrepreneurship and beyond.

The Dallas area's national prominence in high technology and research has been beneficial to the Lyle School of Engineering and its students. Corporate support for the Lyle School has generated a remarkable array of equipment and laboratories. Recent additions include the AT&T Mixed Signals Lab, the Texas Instruments Digital Signal Processing Lab, the Procter and Gamble Biomedical Research Lab, and the Nokia Wireless Communication Lab. Other laboratories include the Laser Micromachining Laboratory, the Nanoscale Electro-Thermal Sciences Laboratory and the Enterprise Systems Design Laboratory. In addition, the Lyle School is the home of the following facilities:

Research Center for Advanced Manufacturing. RCAM provides the intellectual foundation for industry to collaborate with faculty and students to resolve generic, long-range challenges, thereby producing the knowledge base for steady advances in technology and their speedy transition to the marketplace.

Center for Laser Aided Manufacturing. CLAM addresses a number of research and development issues related to laser-aided intelligent manufacturing processes.

Center for Lasers and Plasmas for Advanced Manufacturing. The center conducts research of interest to the industry and SMU as part of a multiple university team and with support from the Industry and University Cooperative Research Centers Program of the National Science Foundation.

National Science Foundation Industrial/University Cooperation Research Center for Net-Centric Software and Systems. The Center for Net-Centric Software and Systems addresses fundamental software and systems research for the modeling, analysis, design, implementation, testing, deployment and evolution of net-centric and embedded systems.

Darwin Deason Institute for Cyber Security. The institute advances the science, policy, application and education of cyber security through basic and problem-driven, interdisciplinary research, and conducts broad programs of research that

- Apply an interdisciplinary approach to challenging problems and incorporate elements from disciplines not traditionally associated with cyber security, such as law, business and the social sciences.

- Create a science of cyber security and address priorities in the national arena.
- Help close the skills gap in cyber security by tapping into the innovation capabilities of students to meet the demand for trained cyber professionals.

Caruth Institute for Engineering Education. The institute develops programs that increase the number and diversity of students who graduate from U.S. high schools with both the enthusiasm and knowledge to pursue the engineering careers necessary for the U.S. to compete in a global economy.

Hunter and Stephanie Hunt Institute for Engineering and Humanity. More than 1 billion people around the world live on less than $1 per day; of those, 70 percent are women. The institute strives to change the standard of living for the world's poorest populations (including those in the U.S.), trains a new generation of engineers in modern engineering applications and provides a deep exposure to global economics, cultural awareness, collaborative leadership and principles of sustainability.

Hart Center for Engineering Leadership. The center was created in 2008 with the belief that the leadership and professional development of engineering students should not wait until after graduation. In fact, the Lyle School maintains that this development should coincide with students' technical training as they become aware of what it means to be ethical and credible professional engineers.

HCEL designs programs around the Lyle School's engineering leadership framework, which engages students in developing their personal, relational, positional and contextual leadership awareness and skills. HCEL training gives students the tools to grow personally and professionally their entire lives and includes the following curricula, programs and events:

Leadership Development

- Leadership assessment tools identify students' understanding of leadership attributes, leadership strengths and areas of interest.
- Leadership instruction developed in collaboration with Lyle faculty is imbedded in relational and experiential components of the Lyle School's engineering design courses.
- HCEL engineering ethics modules are infused in specific engineering classes.
- Leadership coaching is offered in group settings and is also available for individuals in some cases.
- The Student Engineering Joint Council holds retreats, events and leadership training.
- Lyle Engineering in the City offers community engagement and service learning activities.
- Partners in Leadership Mentoring pairs students with mid- to senior-level professionals.

Career Development

- Career coaching helps students research and prepare for interviews with engineering companies.
- MustangTRAK allows students to register for interviews and submit résumés online.
- Engineering Mock Interview Day acclimates students to the interviewing process in a riskless environment.

- The Lyle Engineering Connections career fair attracts globally recognized companies seeking to hire engineers for internship, co-op and full-time positions.
- Internships and co-ops integral to the Lyle School are directed by HCEL staff.

Professional Engineering Licensure

All senior-year engineering students are encouraged to take the first part of the examination for professional engineering licensure in the state of Texas. Information on the exam, testing locations, fees, materials and other exam-related information is available at www.ncees.org/exams/fe-exam.

Department Information

All programs of education and research in engineering are conducted through the Lyle School of Engineering. The school is organized into the following departments:

Civil and Environmental Engineering (CEE)
Computer Science and Engineering (CSE)
Electrical Engineering (EE)
Engineering Management, Information and Systems (EMIS)
Mechanical Engineering (ME)

Each curriculum is under the jurisdiction of the faculty of the department in which the program is offered.

The Lyle School of Engineering also offers graduate programs toward the degrees of Master of Science, Doctor of Engineering and Doctor of Philosophy.

The departments are the Lyle School of Engineering's basic operating and budgetary units. Each department is responsible for the development and operation of its laboratories at all levels of activity and for all purposes; for the content, teaching and scheduling of its academic courses; and for the conduct of research programs. The chief administrative officer of each department is the department chair, who reports directly to the dean. More information on the Lyle School of Engineering and its programs is available at www.smu.edu/lyle.

COOPERATIVE EDUCATION

The Lyle School of Engineering has a history of demonstrated commitment to the concept of cooperative education. The school was established in 1925 with a close relationship with the Technical Club of Dallas. Members of this group owned factories and engineering consulting firms and wanted to participate in the training and development of their incoming employees. The Technical Club asked SMU to include the Cooperative Education Program in the original design of the school.

SMU was one of the first universities in the Southwest to adopt this concept of practical education. From 1925 to 1965, all engineering undergraduate students participated in the SMU Co-op Program. Since 1965, the program has been optional.

The SMU Co-op Program is designed so each student can enhance his or her education and career by receiving professional training while alternating terms of classroom instruction. Participation in the program allows students to

- Confirm that they like working in their major.
- Discover the kind of work they like within their major.

- Establish a professional reputation.
- Earn the cumulative equivalent of one year of a new graduate's starting salary before graduation.
- Gain invaluable work experience when competing for full-time jobs upon graduation.

How the Cooperative Program Operates

Entry into the SMU Co-op Program is typically offered in the summer term after the sophomore year or the fall term of the junior year during the student's academic progression. Two sample terms of entry are shown below:

	5 Work Terms		
PLAN A	**Fall**	**Spring**	**Summer**
First Year	SMU	SMU	Free
Sophomore	SMU	SMU	Industry
Junior	Industry	SMU	Industry
Senior 4th	SMU	Industry	Industry
Senior 5th	SMU	SMU	

	4 Work Terms		
PLAN B	**Fall**	**Spring**	**Summer**
First Year	SMU	SMU	Free
Sophomore	SMU	SMU	Free
Junior	Industry	SMU	Industry
Senior 4th	SMU	Industry	Industry
Senior 5th	SMU	SMU	

Students who want to participate in the SMU Co-op Program should begin the application process during their first year to allow for career preparation. The application process includes attending Co-op Orientation, receiving interview skills training, résumé review, learning the job search process, and completing the Co-op Program application. The program director guides students through each step of the process.

Each applicant receives quality advising from the program's director. A direct result of advising is that the student gains a better understanding of individual options and a strategy for pursuing those options. The application process requires one or two hours per week for almost two terms. The process normally results in an offer of employment beginning in the summer term following the sophomore year or the fall term of the junior year.

Who May Apply?

Any Lyle School of Engineering undergraduate student in good standing who has enough time remaining before graduation to alternate at least three times between terms of full-time work and terms of full-time school may apply for the Co-op Program. Transfer students must be admitted and accepted to SMU before applying.

When to Apply

Many students choose to begin the application process during the first term of their first year. This early start is especially beneficial for students planning to participate in fraternity/sorority recruitment during the second term of their first year. Students should apply two or more terms before the work term begins. The first of these terms is for preparation; the second is for applying and interviewing with companies.

Policies of the Cooperative Engineering Education Program

Since 1925, the school has created and maintained numerous corporate relationships. Many factors contribute to these relationships, including the quality of SMU's academics and research, the achievements of alumni, and SMU's close proximity to high-tech corporations. Each SMU Co-op Program student directly benefits from the program's strong corporate relationships and bears an obligation to preserve these relationships by following the Co-op Program Undergraduate Student Agreement. The agreement balances the student's individual needs with the long-term goal of maintaining the program's corporate relationships for future SMU students. The terms of the program include, but are not limited to, the following:

- Students must maintain good standing with SMU and their employer at all times.
- All training jobs must be approved in advance by the SMU Co-op Program director.
- Before each work term begins, undergraduate students in the program must enroll in the appropriate program course for the term when they work, including summer.
- SMU charges no fees or tuition for these courses. Each course is graded on a pass/fail basis by the program's director. The courses do not count toward graduation. The course numbers for each work term are, respectively, ENGR 1099, 2099, 3099, 4099, 5099, 6099.
- Students enroll at SMU each term, including summers, once they begin the program's rotation between work and school.
- Co-op students take full-time class loads at SMU during alternating school terms.
- Co-op students do not work part-time for the employer during school terms.
- Co-op students complete all work terms with the same company unless decided otherwise.
- Once a student accepts a Co-op Program position, the student may switch positions within the sponsoring company with the approval of the company.
- Each student in the program completes his or her originally planned number and sequence of alternating work terms. The term of graduation must be a term of full-time study at SMU.
- Each student in the program accepts responsibility for knowing and following all SMU Co-op Program regulations and those of the participating employer.
- Students agree to complete all of their University required paperwork even while participating in the Co-op Program (e.g., FAFSA, CSS Profile, enrolling for classes, enrolling for housing, applying for graduation in their last senior term.

Co-op Certificate

SMU Co-op Program students who complete all of their originally planned and scheduled Co-op Program work terms in good standing with the University and the SMU Co-op Program Office receive a noncredit Cooperative Education Program Certificate to coincide with graduation. For additional information, students should contact the director of the SMU Co-op Program: phone 214-768-1845; email smucoop@engr.smu.edu.

UNDERGRADUATE ENGINEERING INTERNSHIP PROGRAM

The internship program allows full-time students to include a minimum of three terms of professional work experience during their study. Students must have obtained junior-level class status prior to participating in the internship program. Students cannot simultaneously enroll in a full-time load of coursework and participate in a full-time work experience. A full-time course of study is defined as 12 or more credit hours per term, and a full-time work experience is defined as a minimum of 37.5 hours worked per week. In order to maintain satisfactory academic achievement, students enrolled in a full-time course load shall not work more than a maximum of 20 hours a week. Students who are actively participating in a full-time work experience shall not enroll in more than nine credit hours per term. Zero hours of credit will be awarded for each term of internship. Participation in this program will not jeopardize the full-time status of international students. Students who wish to participate in this program need to

- Receive an internship job offer relating to their major.
- Provide a job description to the Hart Center for Engineering Leadership.
- Complete the Undergraduate Engineering Internship Program Agreement form.
- Obtain the following approvals: faculty adviser, department chair, director of Undergraduate Professional Experience Programs in the Hart Center and the International Student Office (for all international students).

Once the necessary approvals are obtained, the student must register for the Undergraduate Internship Program course that is designated by the student's department (CEE 5050, CSE 5050, EE 5050, EMIS 5050, ME 5050).

Within two weeks of the end of the term or at the end of the internship, whichever comes first, the student must submit a report outlining the activities and duties of the internship. The student will submit a copy of the report to the faculty adviser, the International Office (if applicable) and the director of Undergraduate Professional Experience Programs of the Lyle School of Engineering. The director of Undergraduate Professional Experience Programs, in consultation with the student's adviser, will assess the report and recommend a grade of *S* (Satisfactory) or *U* (Unsatisfactory) to the associate dean for the Office of Academic Affairs within two weeks of receiving the report. The student's work experience will be validated and recognized on the permanent transcript.

ADMISSION

Note: Detailed information regarding SMU's admission requirements, regulations and procedures is found in the Admission to the University section of this catalog.

Prospective students interested in undergraduate degrees in engineering apply for undergraduate admission to SMU as first-year or transfer students through the Office of Admissions, Southern Methodist University, PO Box 750181, Dallas TX 75275-0181. All first-year applicants admitted to SMU initially enter Dedman College. For students interested in majoring in engineering, a personal interview with Lyle School of Engineering's Undergraduate Enrollment Office is highly recommended. The Lyle School of Engineering Office of Undergraduate Student Experience and Enrollment Management can be reached at 214-768-3041.

High School Preparation

Because of the high standards of the Lyle School of Engineering and the rigorous character of its curricula, it is essential that the entering student be well prepared in basic academic subjects in high school. To be successful in SMU engineering programs, the student should have the following academic strengths:

1. Academic success in an appropriate program of study in high school.
2. Strong evidence of aptitude for math and science demonstrated through the high school curriculum.
3. A minimum SAT math sectional score of 600 or a minimum ACT math of 27.

While these guidelines do not guarantee admission to SMU, they should assist students interested in studying engineering at SMU.

Admission to Advanced Standing

Admission From Dedman College and Other Schools Within SMU

After completion of the engineering subset, students are admitted to the Lyle School of Engineering through an interschool transfer. These transfers are approved by the appropriate department chair and the associate dean of the Lyle School of Engineering. For admission, a student must have completed 24 credit hours and must demonstrate the ability to achieve academic success in engineering or applied science by attaining a 2.000 or higher cumulative GPA. For admission into the civil engineering, computer engineering, computer science, electrical engineering, environmental engineering or mechanical engineering program, a 2.500 or higher GPA – and for management science, a 3.000 or higher GPA – is required in the following courses: DISC 1312/2305, 1313/2306 or equivalent, MATH 1337, 1338 or equivalent and the courses as follows for each Lyle major:

Civil Engineering	CEE 1302, CEE/ME 2310
Computer Engineering	CSE 1341 and 1342, KNW 2300, and *C*- or better in all subset courses
Computer Science	CSE 1341 and 1342, KNW 2300, and *C*- or better in all subset courses
Electrical Engineering	EE 1350, EE 2381, CSE 1341, CHEM 1303, PHYS 1303 (minimum of two)
Environmental Engineering	CEE 1302, CEE/ME 2310
Management Science	EMIS 1360, CSE 1341 and 1342, and *C* or better in all subset courses (Once a student enters SMU, all remaining subset courses must be completed through enrollment at SMU.)
Mechanical Engineering	ME 1302, ME 1305 *or* CSE 1341, ME/CEE 2310 (minimum of two)

With the exception of courses repeated using the First-Year Repeat Policy, all attempts of subset courses are used in computing the civil engineering, computer science, computer engineering, electrical engineering, environmental engineering and mechanical engineering subset GPA. For the management science subset GPA, only the first graded attempt is included in the subset GPA except for courses repeated using the First Year Repeat Policy. The subset GPA for students who have Advanced Placement or International Baccalaureate credit is based upon the remaining graded subset courses. Current University grading policy, as summarized under Academic Forgiveness in the Grade Policies section of this catalog, permits forgiveness of academic work taken 10 or more years prior to the term of admission. Academic work forgiven under this policy will not be included in the subset GPA.

Admission by Transfer From Another Institution

Prospective transfer students interested in undergraduate degrees in engineering apply for undergraduate admission to SMU through the Office of Admissions, Southern Methodist University, PO Box 750181, Dallas TX 75275-0181. An undergraduate at a junior college, college or university may apply for transfer admission to SMU and the Lyle School of Engineering. Admission will be granted provided the prior academic records and reasons for transfer are acceptable to the Lyle School of Engineering. Transfer credit will be awarded in courses that have identifiable counterparts in curricula of the Lyle School of Engineering, provided they carry grades of *C-* or better. Transfer students will be expected to meet requirements equivalent to students admitted from Dedman College and other schools within SMU.

Transfer credit is awarded only for work completed at institutions that have regional or comparable accreditation. Because of the 60-term-hour SMU credit requirement for a bachelor's degree, there is a limit on the total amount of credit that may be applied toward a Lyle School of Engineering degree.

ACADEMIC REGULATIONS

Graduation Requirements for Baccalaureate Degrees

Graduation from the Lyle School of Engineering with a bachelor's degree requires the following standards of academic performance:

1. A passing grade must be received in every course in the prescribed curriculum.
2. An overall GPA of 2.000 or better must be attained in all college and university courses.
3. An overall GPA of 2.000 or better must be attained in all coursework attempted for the degree through enrollment at SMU.
4. An overall GPA of 2.000 or better must be attained in all coursework attempted for the degree in the major field of study.
5. A minimum of 122 term hours of credit must be attained, including the Universitywide requirements, and the requirements met for a major in engineering or applied science.

SMU and Lyle Credit Requirements

For graduation from the Lyle School of Engineering, 60 credit hours must be earned as SMU credit, including 30 credit hours in the major department or interdisciplinary program. Of the last 60 credit hours earned toward a degree, 45 must be completed through enrollment in courses offered by the faculty of the Lyle School of Engineering. Exceptions to this requirement will be made only under unusual circumstances at the discretion of the Lyle School of Engineering faculty.

The Major

A candidate for a degree must complete the requirements for a major in one of the departments of the Lyle School of Engineering. The applicable requirements of the major are those in effect during the academic year of matriculation, or those of a subsequent academic year. Coursework counting toward a major may not be taken pass/fail. Majors must be officially declared (or changed) through the Lyle Office of Undergraduate Studies.

Departmental Distinction Program

Students will be awarded departmental distinction by their major department upon successful completion of a special program of study, independent of their eligibility for Latin graduation honors or for graduation honors in the liberal arts. The special program of study leading to departmental distinction, undertaken in both the junior and senior years, requires independent reading and research beyond the regular departmental requirements for a degree. This award is conferred by the major department on the basis of criteria prescribed by the department, but all programs include the following requirements:

- A major GPA of 3.500 or higher.
- Successful completion of three hours of senior thesis approved by the academic adviser.
- Formation of a supervisory committee consisting of three members, with the chair being a resident tenured or tenure-track faculty member of the department, and a minimum of two full-time Lyle faculty members.
- Successful defense of the senior thesis, which consists of the presentation of the senior thesis in a public forum and subsequent oral examination by the supervisory committee to satisfy itself that the student performed the independent reading and conducted the research.

Currently, the Computer Science and Engineering Department and the Electrical Engineering Department offer departmental distinction programs.

Universitywide Requirements

All SMU undergraduate students share a common program of study designed to assure them of a broad liberal education regardless of their major. This requirement is designed to help each student learn to reason and think for oneself, become skilled in communicating and understanding, understand both the social and the natural worlds and one's own place and responsibilities in these environments, and understand and appreciate human culture and history in various forms, including religion, philosophy and the arts. Students should see the Universitywide Requirements section of this catalog for more information.

Dual Degree Programs

The Lyle School of Engineering offers concurrent dual degree programs with other SMU schools. Students may design and pursue a second major or minor degree program in consultation with their academic adviser.

PROGRAMS OF STUDY

The Lyle School of Engineering offers the following degrees:

Bachelor of Science in Civil Engineering
Bachelor of Science in Computer Engineering
Bachelor of Science in Electrical Engineering
Bachelor of Science in Environmental Engineering
Bachelor of Science in Mechanical Engineering
Bachelor of Science (Computer Science)
Bachelor of Science (Management Science)
Bachelor of Arts (Computer Science)

Engineering work can be classified by function, regardless of the branch, as follows: research, development, design, production, testing, planning, sales, service, construction, operation, teaching, consulting and management. The function fulfilled by an engineer results in large measure from personal characteristics and motivations, and only partially from his or her curriculum of study. Nonetheless, while engineering curricula may be relatively uniform, the modes of presentation tend to point a student toward a particular large class of functions. Engineering curricula at SMU focus generally on engineering functions that include research, development, design, management and teaching – functions ordinarily associated with additional education beyond the bachelor's degree.

The Lyle School of Engineering undergraduate programs in civil engineering, computer engineering, electrical engineering, environmental engineering and mechanical engineering are accredited by the Engineering Accreditation Commission of ABET, www.abet.org. The undergraduate computer science program that awards the degree Bachelor of Science is accredited by the Computing Accreditation Commission of ABET. The undergraduate computer science program that awards the degree Bachelor of Arts is not accredited by a Commission of ABET. ABET does not provide accreditation for the discipline of management science.

Description of Courses

Courses offered in the Lyle School of Engineering are identified by a two-, three- or four-letter prefix code designating the general subject area of the course, followed by a four-digit number. The first digit specifies the approximate level of the course as follows: 1 – first year, 2 – sophomore, 3 – junior, 4 – senior and 5 – senior. The second digit denotes the credit hours associated with the course. The last two digits specify the course numbers. Thus, CSE 4381 denotes a course offered by the Department of Computer Science and Engineering at the senior (4) level, having three credit hours, and with the course number 81. The prefix codes are as follows:

CEE	Department of Civil and Environmental Engineering
CSE	Department of Computer Science and Engineering
EE	Department of Electrical Engineering
EMIS	Department of Engineering Management, Information and Systems
ENGR	Lyle School of Engineering Multidisciplinary Studies
ME	Department of Mechanical Engineering

CIVIL AND ENVIRONMENTAL ENGINEERING

Associate Professor Khaled F. Abdelghany, **Chair**

Professor: Halit Üster. **Associate Professors:** Khaled F. Abdelghany, Usama S. El Shamy, Andrew N. Quicksall, David A. Willis. **Assistant Professors:** S. Sevinc Sengor, Brett Story, Wenjie Sun. **Lecturer:** John H. Easton. **Adjunct Faculty:** Jane C. Ahrens, Samir Bougacha, Mark K. Boyd, Robert Casagrande, Weiping Dai, H. Elizabeth del Monte, Roger O. Dickey, Edward Forest, Hope Hagar, Anwar Hirany, Sina Iman, Kalpalatha (Latha) Kambham, Mehedy Mashnad, Steven D. McCauley, Mofid Nakhaei, Sally R. Pinon, Jon D. Rauscher, Bennett Stokes, Patricia A. Taylor, Philip K. Turner, Rumanda K. Young, Jessie Marshall Zarazaga.

General Information

Undergraduate programs within the Department of Civil and Environmental 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 CEE students, so that students with interests in studying global climate change, protecting the quality of the 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, CEE students are paired with CEOs, business leaders, professional engineers, Environmental Protection Agency directors or corporate attorneys in a mentoring program designed to propel students into promising careers.

Civil and environmental 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. Civil and environmental engineering functioned as a single integrated discipline in the early 1900s 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.

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 on 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 contributors to civil engineering efforts conducted within the evolving global economy.

The mission and educational objectives of the civil engineering program are consistent with the missions of the Civil and Environmental Engineering Department, the Lyle School of Engineering, and the overall institutional mission of SMU, and 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 as 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.

Environmental Engineering Program

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, focuses on using recycled and natural materials to fabricate products that are competitive in the marketplace 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 Civil and Environmental Engineering Department, the Lyle School of Engineering, and the overall institutional mission of SMU, and 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 as 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.

Degrees Offered

The CEE Department offers undergraduate degrees as follows:

- Bachelor of Science in Civil Engineering
- Bachelor of Science in Civil Engineering
  and Bachelor of Science with a major in mathematics (dual degrees)
- Bachelor of Science in Environmental Engineering
- Bachelor of Science in Environmental Engineering
  and Bachelor of Science with a major in mathematics (dual degrees)
- Bachelor of Science in Environmental Engineering with a premedical specialization

The Engineering Accreditation Commission of ABET, www.abet.org, has accredited the undergraduate programs in civil engineering and environmental engineering. Both the civil and environmental engineering programs are designed to prepare students for the Fundamentals of Engineering Examination, the first step toward licensure as a professional engineer. Engineering design is integrated throughout the civil and environmental engineering curricula, each culminating in a major design experience based on the knowledge and skills acquired in earlier coursework. 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, participation on multidisciplinary teams, procurement, bidding, the interaction of design and construction professionals, professional licensing, and the need for lifelong learning.

Departmental Facilities

CEE departmental offices and instructional and research laboratories are located in the new, state-of-the-art J. Lindsay Embrey Engineering Building, which is certified as a Leadership in Energy and Environmental Design Gold Building in LEED's internationally recognized green building certification program. Environmental teaching and research laboratories include dedicated space for air quality and meteorology, industrial hygiene, environmental microbiology, soil and water quality, and contaminant modeling. The air quality and meteorology laboratory includes modern airflow, pressure and volume measurement instrumentation. The industrial hygiene laboratory includes an inventory of the latest 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. The contaminant modeling laboratory provides space to conduct experiments for water quality assessment, to develop innovative biological and chemical treatment processes that remove and degrade potentially harmful contaminants, to develop multicomponent reactive transport modeling of contaminants in the groundwater and subsurface environments, and to analyze groundwater flow regimes and fate and transport of contaminants in the subsurface.

The environmental teaching and research laboratories have sophisticated analytical capabilities for performing chemical analyses of air samples and for assessing the quality of water supplies and wastes and the effectiveness of water and waste treatment procedures. Major equipment includes a Thermo Scientific ozone analyzer, a Dynamax absorbance detector, a Hach DR 2500 scanning spectrophotometer for water quality analysis of numerous parameters, a Thermo Scientific inductively coupled plasma mass spectrometer, a PerkinElmer Fourier transform infrared spectrometer with attenuated total reflectance, a Dionex ion chromatography unit, a Cary bio UV-visible spectrometer with temperature control, and an Agilent gas chromatography and mass spectrometry unit for identifying and measuring numerous organic and inorganic compounds in environmental samples. Other miscellaneous equipment includes continuous ambient air monitoring devices, 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. An autoclave, microscopes and a UV light reader support basic engineering microbiological work.

Civil engineering teaching and research laboratories include dedicated space for mechanics of materials and structural engineering, hydraulics and hydrology, geotechnical engineering and transportation materials, and intelligent transportation systems. The Structural and Mechanics of Materials Laboratory is equipped for instruction and research on the behavior of materials under various loading conditions such as fatigue, impact, hardness, creep, tension, compression and flexure. This lab is equipped with an Instron 5582 universal materials testing machine, a Tinius-Olsen tension and compression test machine, a Didactec and a Tecquipment torsion test machine, a deflection test machine for simply supported beams, and a cantilever beam bending and deflection test apparatus. Major hydraulics and hydrology laboratory equipment includes a 5-meter open channel flume with various accessories (e.g., undershot weir, rotary undershot gate, and sharp and broad-crested weirs), a basic hydraulics bench for fundamental fluid mechanics experiments (e.g., hydrostatic pressure forces, Bernoulli's theorem and pipe friction losses), and a hydrology study system for hydrology experiments (e.g., simulating rainfall over watersheds and measuring resulting outflow hydrographs, and groundwater flow profiles). The geotechnical engineering and transportation materials laboratory has a Geocomp soil testing equipment automated set, a Geocomp direct residual shear test system automated set, a pocket penetrometer and the torvane shear device, and liquid and plastic limit devices. 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 laboratory with AutoCAD software and a general-use computer laboratory with personal computers, high-resolution color monitors and laser printers for use by the department's students. Computers in 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 to 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, ArcGIS, 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 Civil Engineering

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within the civil engineering curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	34
MATH 1337, 1338, 2339, 2343	
STAT 4340 *or* 5340	
CHEM 1303/1113, 1304/1114	
GEOL 1301 *or* 1315 *or* ANTH 2363	
PHYS 1303/1105, 1304/1106	
Engineering Science and Design	10
CEE 2320, 2331, 2342/2142	
Civil Engineering and Design	46
CEE 1302, 2304, 2310, 2340/2140, 2372, 3310, 3323, 3350, 3385, 4350, 4351, 4380, 4381, 5354, 5378	
Civil Engineering Technical Electives	6
Selected with adviser's approval.	
Engineering Leadership	6
CEE 3302; one from CSE 4360; EMIS 3308, 3309	
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Bachelor of Science in Civil Engineering and Bachelor of Science With a Major in Mathematics

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	46
MATH 1337, 1338, 2339, 2343, 3315 or 3316, 3337	
Two advanced MATH electives approved by math adviser	
STAT 4340 *or* 5340	
CHEM 1303/1113, 1304/1114	
GEOL 1301 *or* 1315 *or* ANTH 2363	
PHYS 1303/1105, 1304/1106	
Engineering Science and Design	10
CEE 2320, 2331, 2342/2142	
Civil Engineering and Design	46
CEE 1302, 2304, 2310, 2340/2140, 2372, 3310, 3323, 3350, 3385, 4350, 4351, 4380, 4381, 5354, 5378	
Advanced Civil Engineering/Mathematics	6
Two from CEE 5361, 5364; ME 5322	
	108

Bachelor of Science in Environmental Engineering

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within the environmental engineering curriculum are distributed as follows:

Requirements for the Degree	*Credit Hours*
Mathematics and Science	38
MATH 1337, 1338, 2339, 2343	
STAT 4340 *or* 5340	
CEE 1331 *or* 2322, 5418	
CHEM 1303/1113, 1304/1114	
PHYS 1303/1105, 1304/1106	
Engineering Science and Design	9
CEE 2310, 2331, 2342	
Environmental Engineering and Design	42
CEE 1302, 2304, 2421, 2372, 3310, 3323, 3341, 3431, 3451, 4380, 4381, 5317, 5354	
Environmental Technical Electives	6
Selected with adviser's approval.	
Engineering Leadership	9
CEE 3302; two from CSE 4360; EMIS 3308, 3309	
	104

Bachelor of Science in Environmental Engineering and Bachelor of Science With a Major in Mathematics

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	50
MATH 1337, 1338, 2339, 2343, 3315 or 3316, 3337	
Two advanced MATH electives approved by math adviser	
STAT 4340 *or* 5340	
CEE 1331 *or* 2322, 5418	
CHEM 1303/1113, 1304/1114	
PHYS 1303/1105, 1304/1106	
Engineering Science and Design	9
CEE 2310, 2331, 2342	
Environmental Engineering and Design	42
CEE 1302, 2304, 2372, 2421, 3310, 3323, 3341, 3431, 3451, 4380, 4381, 5317, 5354	
Advanced Environmental / Mathematics Electives	6
Two from CEE 5331, 5332, 5334; ME 5336	
	107

Bachelor of Science in Environmental Engineering With a Premedical Specialization

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Specialization	*Credit Hours*
Mathematics and Science	56
MATH 1337, 1338, 2339, 2343	
STAT 4340 *or* 5340	
BIOL 1401, 1402, 3304, 3350	
CEE 1331 *or* 2322	
CHEM 1303/1113, 1304/1114, 3371/3117, 3372/3118	
PHYS 1303/1105, 1304/1106	
Engineering Science and Design	9
CEE 2310, 2331, 2342	
Environmental Engineering and Design	39
CEE 1302, 2304, 2372, 2421, 3310, 3323, 3341, 3431, 3451, 4380, 4381, 5354	
Environmental Technical Electives	6
Selected with adviser's approval.	
	110

Minor in Civil Engineering

For approval of a minor in civil engineering, the student should consult the Civil and Environmental Engineering Department. A minimum of 15 term credit hours in civil engineering courses are required. The following is an example of an approved set of courses, totaling 16 term credit hours, that provides an emphasis on structural analysis and design: **CEE 2310, 2340/2140, 3350, 3385, 4350.** Based on the student's interests and background, other sets of civil engineering courses may be substituted with the approval of the Civil and Environmental Engineering Department.

Minor in Environmental Engineering

For approval of a minor in environmental engineering, the student should consult the Civil and Environmental Engineering Department. A minimum of 15 term credit hours in environmental engineering courses are required. The following is an example of an approved set of courses that provides a broad introduction to environmental engineering: **CEE 2304, 2421, 3323, 3431, 5354.** Based on the student's interests and background, other sets of environmental engineering courses may be substituted with the approval of the Civil and Environmental Engineering Department.

Minor in Global Development

Students may earn a minor in global development through the Civil and Environmental Engineering Department, supported by the Hunter and Stephanie Hunt Institute for Engineering and Humanity. A total of 18 term credit hours are required, with a minimum of six term credit hours at or above the 3000 level. All students are required to complete the introductory course CEE 1326. A depth component of six term credit hours must be completed in one of the following concentration areas:

Environmental Resources: CEE 2304, 2421, 3323, 3341, 3353, 5321, 5322
Political, Cultural and Economic Issues: EMIS 3309; CEE 3355, 5311, 5325, 5328
Technology and Innovation: CEE 1302; ME 1303; CEE 5327, 5329–30, 5378, 5384

An additional six hours of breadth are required, satisfied by taking one course from each of the two remaining concentrations. Students complete the capstone experience requirement by taking CEE 5391. The primary intent of the capstone experience is to incorporate site-based service learning opportunities for students through internships arranged by the Hunter and Stephanie Hunt Institute for Engineering and Humanity at the Lyle School of Engineering. Other opportunities, such as research, may also be accommodated based on individual student interests and career goals.

The Courses (CEE)

CEE 1301 (3). ENVIRONMENT AND TECHNOLOGY: ECOLOGY AND ETHICS. Introduces the economic, engineering, ethical, political, scientific, and social considerations of environmental decision-making and management. Examines local, regional, and global topics. Students take off-campus field trips.

CEE 1302 (3). INTRODUCTION TO CIVIL AND ENVIRONMENTAL ENGINEERING. Introductory course that emphasizes fundamental science, engineering, and ecological principles. Students develop their analytical and critical thinking skills with real-world problem-solving. Many of the hallmarks of modern society (e.g., high-rise office buildings, increased life span, 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, environmental and civil engineers are at work on the many problems currently confronting developing nations: housing supply, food production, air and water pollution, spread of disease, traffic congestion, and flood control.

CEE 1326 (3). INTRODUCTION TO GLOBAL DEVELOPMENT. An interdisciplinary approach in addressing issues of international development. Explores the role and impact of economic, sociopolitical, and scientific principles on issues of the developing world. Lectures focus on the historical underpinning of current trends, theory, and practice of multidisciplinary development, modern issues facing the developing world, and potential courses of action.

CEE 1331 (3). 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.

CEE 1378 (3). TRANSPORTATION INFRASTRUCTURE. An overview and definitions of infrastructure elements, with a focus on transportation. Also, principals of infrastructure planning and management, and congestion and performance measures. Includes relationships with the economy, the environment, safety, homeland security, and technology.

CEE 2140 (1). MECHANICS OF MATERIALS LABORATORY. Experiments in mechanics of deformable bodies, to complement CEE 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, and the effect of stress concentrators. *Prerequisite or corequisite:* CEE/ME 2340.

CEE 2142 (1). FLUID MECHANICS LABORATORY. One 3-hour laboratory session per week. Experiments in fluid friction, pumps, boundary layers, and other flow devices to complement lecture material of CEE 2342. *Corequisite or prerequisite:* CEE/ME 2342.

CEE 2304 (3). INTRODUCTION TO ENVIRONMENTAL ENGINEERING AND SCIENCE. Introduction to a scientific and engineering basis for identifying, formulating, analyzing, and understanding various environmental problems, with a focus on material and energy balances for modeling environmental systems and processes. Examines traditional materials in air and water pollution, and emphasizes contemporary topics such as hazardous waste, risk assessment, groundwater contamination, global climate change, stratospheric ozone depletion, and acid deposition. Where appropriate, describes pertinent environmental legislation, derives and applies engineering models, and introduces treatment technologies. *Prerequisites:* CHEM 1303, MATH 1338.

CEE 2310 (3). STATICS. Equilibrium of force systems, computations of reactions and internal forces, determinations of centroids and moments of inertia, and introduction to vector mechanics. *Prerequisite:* MATH 1337 or equivalent.

CEE 2320 (3). DYNAMICS. Introduction to kinematics and dynamics of particles and rigid bodies; Newton's laws; kinetic and potential energy; linear and angular momentum; and work, impulse, and inertia properties. *Prerequisite:* CEE/ME 2310 or equivalent.

CEE 2322 (3). FIELD METHODS FOR SOIL AND WATER ANALYSIS. Covers topics related to environmentally relevant fieldwork and field data analysis, with emphasis on field and lab practical experiences that are supplemented with necessary lecture. Addresses surface water and groundwater collection as well as the analysis of coliform bacteria, basic water quality parameters, and inorganic contaminants. Topics also include soil collection and analysis, sanitation and water systems in the field, mapping, basic GIS, and systems planning. *Prerequisite:* Sophomore or above standing.

CEE 2331 (3). FUNDAMENTALS OF THERMAL SCIENCE (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. *Prerequisites:* MATH 2339, CHEM 1303, CEE/ME 2310, PHYS 1303.

CEE 2340 (3). 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:* CEE/ME 2310.

CEE 2342 (3). 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:* CEE/ME 2310, MATH 2339, PHYS 1303. *Prerequisite or corequisite:* MATH 2343.

CEE 2372 (3). INTRODUCTION TO CAD. Provides hands-on, state-of-the-art experience with computer-aided drafting using AutoCAD to produce drawings used for engineering presentations and construction. Students draw lines and curvilinear lines, use blocks and external references, write text, create plot files, and apply many other commands necessary to produce engineering drawings as used to construct environmental, civil, and structural engineering projects.

CEE 2421 (4). AQUATIC CHEMISTRY. Examines aspects of chemistry that are particularly valuable to the practice of environmental engineering. Provides basic groundwork for the quantitative analysis of water and wastewater systems, and covers fundamental methods of instrumental analysis. Presents elements of thermodynamics, acid-base, redox, and colloidal chemistry as appropriate. Laboratory sessions emphasize design, hands-on conduct of experimental procedures, and interpretation and statistical analysis of derived data. *Prerequisites:* CHEM 1303, 1304.

CEE 3302 (3). ENGINEERING COMMUNICATIONS. Both oral and written communications skills for engineers: engineering documents, writing standards, and presentations. Includes 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.

CEE 3310 (3). COMPUTATIONAL METHODS FOR CIVIL AND ENVIRONMENTAL ENGINEERING APPLICATIONS. Applications of numerical analysis and computer programming techniques to civil and environmental engineering problems. Review of mathematical background is presented with emphasis on numerical modeling and computer-oriented solutions for engineering applications. Topics covered include precision and accuracy, errors, roots of equations, solution of linear algebraic equations, statistics and curve fittings, and numerical integration and differentiation. Also reviews examples from different areas of practice in civil and environmental engineering, including stress transformation, numerical integration to obtain beam deflection, numerical solution of Euler's buckling equation, roots of the equation for fluid flow in frictional pipe, optimization techniques applied to minimum potential energy, and solutions to the system of equations representing force-displacement relationship of a structure or the concentration of carbon monoxide in a space. *Corequisite:* MATH 2343.

CEE 3323 (3). WATER RESOURCES ENGINEERING. Introduces the hydrologic cycle and associated atmospheric processes through derivation and practical application of the hydrologic budget equation, encompassing precipitation, evaporation, transpiration, groundwater flow, and surface water runoff. Examines unit hydrographs and flood hydrograph routing through application of hydrologic simulation models. Exposes students 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. Introduces concepts of professional engineering practice, with emphasis on the need for professional licensing and 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:* CEE 2304. *Prerequisite or corequisite:* CEE/ME 2342.

CEE 3325 (3). GROUNDWATER HYDROLOGY. Introduces the hydrologic cycle and the subjects of porosity and permeability. Examines 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. Considers well hydraulics, stream-aquifer interaction, and distributed- and lumped-parameter numerical models, as well as groundwater quality, mixing cell models, contaminant transport processes, dispersion, decay and adsorption, and pollution sources. *Prerequisites:* MATH 2343, CEE/ME 2342.

CEE 3327 (3). PRINCIPLES OF SURFACE WATER HYDROLOGY AND WATER QUALITY MODELING. Examines the theory and applications of the physical processes of the hydrologic cycle. Reviews different types of water bodies (streams, rivers, estuaries, bays, harbors, and lakes). Examines the principal quality problems associated with bacteria, pathogens, viruses, dissolved oxygen and eutrophication, toxic substances, and temperature. Emphasizes theoretical model approaches. *Prerequisites:* CEE 2421, MATH 2343.

CEE 3341 (3). INTRODUCTION TO SOLID AND HAZARDOUS WASTE MANAGEMENT. Examines technology, health, and policy issues associated with solid waste and hazardous materials. Introduces methods of managing solid and hazardous waste and presents regulations where appropriate. Also, the definition and characteristics of hazardous and solid waste materials, health frameworks, and the distribution of contaminants in the environment. *Prerequisites:* CEE 2304, 2421.

CEE 3350 (3). STRUCTURAL ANALYSIS. Emphasis on the classical methods of analysis of statically determinate and indeterminate structural systems. Also, computation of reactions, shears, moments, and deflections of beams, trusses, and frames. Students use computers as an analytical tool. *Prerequisites:* CEE/ME 2340, 2140.

CEE 3353 (3). INTRODUCTION TO ENVIRONMENTAL TOXICOLOGY. The physiological and biochemical effects of physical, chemical, and biological processes are linked to factors present in the environment. Describes natural phenomena in terms of the carbon, oxygen, sulfur, phosphorus, and heavy metal cycles. Examines the processes by which anthropogenic chemicals enter the environment and their complex effects on living organisms. *Prerequisite:* BIOL 1401. *Prerequisite or corequisite:* CHEM 3371.

CEE 3355 (3). ENVIRONMENTAL IMPACT EVALUATION, POLICY, AND REGULATION. Reviews methods for evaluating engineering projects on environmental quality. Also, environmental legislation, environmental quality indices, and the strengths and weaknesses of government methodologies to protect the environment. Considers pollution standards, marketable rights, taxes, citizen empowerment, and economic analysis and other policy perspectives. *Prerequisite:* CEE 2304.

CEE 3385 (3). SOIL MECHANICS AND FOUNDATIONS. Introduction to the basic principles governing the behavior of soils, foundations, and other geotechnical engineering works. Central concepts 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:* CEE/ME 2340. *Prerequisite or corequisite:* CEE/ME 2342.

CEE 3431 (4). FUNDAMENTALS OF AIR QUALITY I. Covers the science of air quality and its engineering, public health, and economic aspects. Topics include the sources of air pollutants, transport of pollutants in the environment, and atmospheric chemistry. Reviews the important properties and behavior of airborne particles and gases. Also, 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.

CEE 3451 (4). INDUSTRIAL HYGIENE AND OCCUPATIONAL HEALTH. Presents the recognition, evaluation, and control of health hazards in the working environment. Examines principles of industrial toxicology, risk assessment and/or management, occupational diseases, and occupational health standards. Also, the application of industrial hygiene principles and practice and the measurement and control of atmospheric contaminants. Introduces the design and evaluation of occupational exposure controls. Lecture and 3 hours of laboratory. *Prerequisite:* CHEM 1304.

CEE 4329 (3). DESIGN OF WATER AND WASTEWATER SYSTEMS. Covers physical, chemical, and biological concepts and processes that are specific to public water supplies and municipal wastewater management. Reviews fluid mechanics, and introduces hydraulic modeling for the design of water distribution networks and wastewater collection networks. Also, covers the design and operation of treatment systems for drinking water and for municipal wastewater pollution control. Students visit a public water supply treatment plant and a municipal wastewater treatment plant, and they employ process modeling to complete a design project for each type of plant. *Prerequisites:* CHEM 1303, CEE 2304, CEE/ME 2342.

CEE 4333 (3). FUNDAMENTALS OF AIR QUALITY II. Covers fundamental and advanced topics in air quality, building upon CEE 3431. Examines atmospheric dispersion of pollutants and uses modern computer models to predict transport. Presents a thorough review of energy technology and energy policy, focusing on the economics and environmental impacts of conventional and alternative methods of energy generation. Discusses the importance of indoor air quality, including the risks from radon and biological aerosols. Presents additional topics of current interest. Each student prepares a term paper related to energy policy and the environment. *Prerequisites:* CEE/ME 2331 or equivalent, CEE 3431.

CEE 4350 (3). 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:* CEE/ME 3350.

CEE 4351 (3). DESIGN OF CONCRETE STRUCTURES. Study of strength, behavior, and design of reinforced concrete structures; members subjected to flexure; shear and axial loads; and design of one-way slabs. *Prerequisite:* CEE/ME 3350.

CEE 4380 (3). CIVIL AND ENVIRONMENTAL ENGINEERING DESIGN I. Students complete a term-long environmental or civil engineering project for an industrial or regulatory client, and they examine the nature of design problems, constraints, and analytical tools in an applied setting. Employs an integrated design process that includes problem identification and formulation, project planning, the evaluation of alternatives, internal peer review and design iterations, the preparation of design drawings and specifications for bidding and procurement purposes, the interaction of design and construction professionals, and the implementation of the completed project. *Prerequisites:* Senior standing and CEE 3302.

CEE 4381 (3). CIVIL AND ENVIRONMENTAL ENGINEERING DESIGN II. Students complete a term-long environmental or civil engineering project for an industrial or regulatory client. The client and faculty assess the completed design project. Multidisciplinary design teams stress the need for personal and written communication skills, leadership, effective group participation, and creative problem-solving. Reinforces concepts of professional engineering practice through student participation in applied design problems. Also, 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. Students prepare and present periodic progress reports, reviews, and a final report. *Prerequisite:* CEE 4380.

CEE 5050 (0). UNDERGRADUATE INTERNSHIP. This course represents a term of industrial work experience for noncooperative education students. The course designates a student as full time for the term, but it carries no academic credit. Registration for the course is the same as for other SMU courses except that no tuition is charged. The course grade is determined by a written report submitted by the student at the end of the term and graded by the student's adviser.

CEE 5090 (0). CEE 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.

CEE 5191 (1). 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.

CEE 5192 (1). 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.

CEE 5291 (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.

CEE 5292 (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.

CEE 5311 (3). ENVIRONMENTAL AND HAZARDOUS WASTE LAWS. Federal environmental laws, with emphasis on laws dealing with hazardous substances, such as the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act. Also, regulations and the regulatory framework, definitions and substantive requirements, roles of the states and the federal Environmental Protection Agency, compliance and enforcement, and case studies.

CEE 5312 (3). RISK ASSESSMENT AND HEALTH EFFECTS. Introduction to toxicology as it relates to environmental and health effects of hazardous materials. Covers risk management factors, including the legal aspects. Also, toxicology methodology, human health and ecological risk assessment, risk communication, emergency response, and computer databases.

CEE 5313 (3). ENVIRONMENTAL CHEMISTRY AND BIOLOGY. Covers chemical and biochemical processes, chemical thermodynamics, acid-base equilibria, precipitation and dissolution, oxidation-reduction processes, environmental transformations of organic materials, introductory taxonomy, microbial growth and kinetics, energy transfer, and microbial ecosystems. Also, controlling fate and transport of hazardous materials, with emphasis on chemical equilibria.

CEE 5314 (3). 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 hazardous waste. Air, water, storm water, and waste permits are reviewed, as well as permits-by-rule. Also explored are the consequences of non-compliance with regulations by presenting enforcement options available to government agencies.

CEE 5315 (3). INTEGRATED WASTE MANAGEMENT. Comprehensive introduction to the fundamentals of the complex interdisciplinary field of hazardous waste management. Covers current management practices, treatment and disposal methods, and site remediation. Includes detailed case studies and design examples to evaluate the effectiveness of different treatment and containment technologies in addressing today's hazardous waste situations.

CEE 5317 (3). ENVIRONMENTAL ORGANIC CHEMISTRY. Examines the fundamental processes that govern the transformation of organic chemicals in natural and engineering systems. Includes an overview of organic chemistry, with a focus on the basic properties of organic compounds, such as nomenclature and structures. Covers the physical transformations of organic compounds to provide an understanding of processes (e.g., sorption and volatilization) that control the distribution of organic chemicals between different phases such as air, water, and soil. Also, organic chemical reactions in the environment, with an emphasis on environmentally mediated reactions (e.g., hydrolysis and photolysis) that control the breakdown of organic chemicals.

CEE 5319 (3). SOIL CHEMISTRY AND MINERALOGY. Examines soil solution chemistry and reactivity. Covers distribution and significance of common soil minerals, weathering, and general solid phase reactivity. Lab covers mineral structures, techniques of mineral identification, and solution-solid phase partitioning. *Prerequisite:* CEE 2421 or permission of instructor.

CEE 5321 (3). PHYSICAL AND CHEMICAL WASTE TREATMENT. Introduces waste minimization techniques and objectives, and thoroughly reviews chemical equilibrium and chemical reaction kinetics. 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 and/or reduction, air stripping, and solidification and/or stabilization; and 4) solute separation and concentration achieved with activated carbon absorption, synthetic ion exchange resins, and membrane separation techniques.

CEE 5322 (3). BIOLOGICAL WASTE TREATMENT. Topics include an overview of microbiology and microbial metabolism, the kinetics of biological growth, and aerobic suspended growth processes, including the various modifications of the activated sludge process, aerated lagoons, and sequencing batch reactors. Also, aerobic attached growth processes such as trickling filters, biofilter towers, and rotating biological contactors. Covers anaerobic processes, including sludge digestion and liquid waste treatment with the anaerobic contact process and anaerobic filters. Examines biosolids handling and disposal, composting, land treatment, in situ biotreatment, and biotreatment of contaminated soils.

CEE 5323 (3). PROJECT MANAGEMENT. Covers the role of the project officer, and the systems and techniques for planning, scheduling, monitoring, reporting, and completing environmental projects. Also, total quality management, project team management and development of winning proposals, and contract management and logistics. Includes case study application of project management to all environmental media and programs, community relations, risk communication, crisis management, consensus building, media, and public policy.

CEE 5324 (3). GEOGRAPHICAL INFORMATION SYSTEMS AND MAPPING. Introduces modern GIS software and tools, including map design, geodatabases, geospatial and attribute data, geocoding, and simple spatial analysis. Students use research-based projects to explore GIS as a tool for innovative spatial thinking and as a catalyst for sustainable strategies.

CEE 5325 (3). DISASTER MANAGEMENT. Introduction to basic concepts in disaster management and to key methods in the field, including simulation modeling, consequence analysis tools, design criteria, statistical and case study methods (lessons learned), and risk analysis. Students draw on a range of sources (the textbook, the U.S. National Response Plan, research papers, etc.) to explore the fundamentals of preparedness, mitigation, response, and recovery. An all-hazards approach is taken, providing analysis of natural, technological, and man-made disasters.

CEE 5326 (3). SUSTAINABLE TRANSPORTATION. Covers planning and operations management of sustainable transportation systems with a focus on energy efficiency. Provides an integrated overview of main concepts and issues related to developing sustainable transportation systems for urban areas, freight transportation, and aviation. Also, advanced topics related to vehicle technologies, alternative energy, and smart cities. Presents findings from national and international case studies. *Prerequisite:* Senior standing or permission of instructor.

CEE 5327 (3). OPTIMIZATION AND RELIABILITY FOR INFRASTRUCTURE AND ENVIRONMENTAL SYSTEMS. 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 include transportation networks, fleet assignment, supply chain management, environmental engineering systems, fluid transport and water reservoir operation, and structural engineering systems. Advanced topics include an introduction to chance-constrained optimization and basic decomposition approaches

CEE 5328 (3). INTRODUCTION TO SUSTAINABILITY. Introduces basic concepts in sustainability. Students draw on a range of sources, including selected books and readings, to explore the idea of total connectedness of resource use globally, with particular emphasis on the situation in North Texas. Addresses the issues of air quality and energy supply, sustainable construction, water use, transit and other related areas of resource use, and waste generation. Guest lecturers provide a series of multiple viewpoints and areas of specific expertise. *Prerequisite:* Graduate standing or permission of instructor.

CEE 5329 (3). METHODS AND TECHNOLOGY FOR SUSTAINABILITY. Covers technologies and methods used in sustainable design and analysis. Topics include the scientific understanding of alternative energy systems, water reuse and supply, and state-of-the-art materials created for sustainability. Also, methods for assessing sustainability, including life cycle assessment and the development of sustainable indicators. *Prerequisite:* Graduate standing or permission of instructor.

CEE 5330 (3). DESIGN FOR SUSTAINABILITY. Introduces the issues involved in creating a sustainable built environment. Addresses issues of resource use at the regional and project-specific level, specific techniques for designing and constructing sustainable buildings, and the USGBC's LEED system. Students discuss systems of measurement for sustainable properties on a comparative level. *Prerequisite:* Graduate standing or permission of instructor.

CEE 5331 (3). AIR POLLUTION MANAGEMENT AND ENGINEERING. Covers the science, engineering, public health, and economic aspects of air quality. Students develop an in-depth understanding and broad knowledge of the sources and properties of air pollutants, air quality management, fate and transport of pollutants in the environment, regulations of air quality, and the operation and design of air pollution control systems. Reviews the 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.

CEE 5332 (3). GROUNDWATER HYDROLOGY AND CONTAMINATION. Groundwater hydrology, aquifer and well hydraulics, flow equations and models, implications for landfill design, sources and nature of groundwater contaminants, monitoring and analysis, contaminant fate and transport, transport model for hazardous substances, groundwater pollution control measures, containment and treatment, and groundwater quality management. *Prerequisite:* MATH 2343.

CEE 5333 (3). LABORATORY METHODS IN ENVIRONMENTAL ENGINEERING. Provides 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. Also, introduces treatability studies, including reactor dynamics. Provides 2 hours of lecture and 3 hours of laboratory component. *Prerequisite:* CEE 5313 or two terms of undergraduate chemistry.

CEE 5334 (3). FATE AND TRANSPORT OF CONTAMINANTS. Covers the development and application of fate and transport models for waterborne contaminants, with a focus on the material balance principle. Includes mass transport and transformation processes, lake and reservoir modeling, stream modeling, general flow case, groundwater models, multiphase and integrated modeling approaches, and case studies. Also, water-sediment, water-soil, and water-air interfaces.

CEE 5335 (3). AEROSOL MECHANICS. Fundamental and advanced principles of airborne particles, including their physical properties; aerodynamic behavior; and collection, measurement, and analysis. Emphasizes the origins and properties of atmospheric aerosols and the design of air pollution control equipment. *Prerequisite:* CEE 3431, CEE/ME 2342, or equivalent.

CEE 5340 (3). INTRODUCTION TO SOLID MECHANICS. Three-dimensional stress and strain, failure theories, introduction to two-dimensional elasticity, torsion of prismatic members, beams on elastic foundation, introduction to plates and shells, and energy methods. *Prerequisites:* CEE/ME 2340, MATH 2343.

CEE 5350 (3). INTRODUCTION TO ENVIRONMENTAL MANAGEMENT SYSTEMS. An in-depth introduction to environmental management systems. Includes systems such as EMAS, Responsible Care, OHSAS 18000, ISO 14000, and the Texas EMS program. Takes a step-by-step look at the ISO 14002 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 management system auditing, the requirements of a system auditor, and the certification process.

CEE 5351 (3). INTRODUCTION TO ENVIRONMENTAL TOXICOLOGY. Presents toxicology as it relates to environmental and health effects of hazardous materials. Examines toxicological methodologies, pharmacokinetics, mechanisms of action to toxicants, origin response to toxic substances, and relevant aspects of the occupational and regulatory environment. Topics include toxicology of metals, radiation, industrial solvents and vapors, pesticides, teratogens, mutagens, and carcinogens. Also, risk communication and risk assessment as they relate to toxic substance exposure.

CEE 5352 (3). MANAGEMENT OF RADIOACTIVE HAZARDS. Presents principles of radioactive material production, uses, and hazards, with emphasis on their safe control and management. Examines topics in health physics and radiation protection related to the commercial nuclear industry, including uranium fuel production, light water reactor technologies, and industrial and medical uses of radioactive byproduct materials. Develops risk assessment methods and hazard management connected to the fuel cycles. Studies the regulation of radioactive materials, with a focus on the licensing of regulated industries, radioactive material transportation, radioactive waste management and disposal, radiological emergency preparedness, and decommissioning. *Prerequisite:* CEE 5313.

CEE 5353 (3). ENVIRONMENTAL EPIDEMIOLOGY. Introduction to the science of epidemiology. Covers the design and conduct of studies examining the health effects of environmental exposures, and the strengths and limitations of research strategies and interpretation of study results. Includes air and water pollution, lead, and biological marker outcomes.

CEE 5354 (3). ENVIRONMENTAL ENGINEERING PRINCIPLES AND PROCESSES. Introduces waste minimization and pollution prevention techniques and objectives. Includes a comprehensive study of biological, chemical, and physical principles and treatment strategies for controlling pollutant emissions, with equal emphasis on underlying theory and practical engineering application of both common and innovative water and wastewater treatment processes. Includes rigorous derivation of design equations, procedures, and process models for chemical and/or biological reactors and physical unit operations. Places emphasis on engineering analysis and application of process modeling techniques for design of unit processes to achieve specific treatment objectives. *Prerequisites:* CHEM 1303, CEE 2304, CEE/ME 2342, and MATH 2343.

CEE 5361 (3). MATRIX STRUCTURAL ANALYSIS AND INTRODUCTION TO FINITE ELEMENT METHODS. A systematic approach to the formulation of force and displacement method of analysis, the representation of structures as assemblages of elements, and computer solution of structural systems. *Prerequisite:* CEE/ME 3350 or permission of instructor.

CEE 5362 (3). 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.

CEE 5363 (3). ARCHITECTURAL AND STRUCTURAL ENGINEERING. Introduces the basic principles of structural analysis and mechanics of deformable bodies. Presents structural systems and principles, with an emphasis on architectural design. Provides students with a conceptual introduction to structures, emphasizing the integration of structural and architectural design. Discusses case studies of buildings. *Prerequisites:* CEE/ME 2310, 2320.

CEE 5364 (3). INTRODUCTION TO STRUCTURAL DYNAMICS. Examines the dynamic responses of structures and the behavior of structural components to dynamic loads and foundation excitations. Also, single- and multidegree-of-freedom systems response and its applications to analysis of framed structures. Introduces systems with distributed mass and flexibility. *Prerequisite:* MATH 2343.

CEE 5365 (3). INTRODUCTION TO CONSTRUCTION MANAGEMENT. Examines construction practice techniques, current technological tools, and building codes and regulations. Includes cost estimating, bidding, contracts and contract bonds, risk and umbrella excess insurance, labor law, and labor relations. Addresses business methods with respect to managing project time and cost, including the typical forms used in construction.

CEE 5366 (3). INTRODUCTION TO FACILITIES ENGINEERING SYSTEMS. Examines the interrelationships of fire protection, HVAC, electrical, plumbing, lighting, telecommunications, and energy management systems for buildings. Uses a life cycle approach to examine the cost durability, maintainability, operability, and safety of each system. Also, facility operations, facility maintenance and testing, and assessments.

CEE 5367 (3). TELECOMMUNICATIONS IN FACILITY PLANNING. Presents a thorough description of telecommunications technology, and provides the student with a working knowledge of its fundamental concepts for voice and data. Topics include digital communications, standards and protocols, Ethernets, local area networks, fiber optics, and voice technologies.

CEE 5368 (3). FACILITIES CONTRACT MANAGEMENT. Provides a critical foundation and understanding of the terminology, arts, and skills of contracts and contract negotiation, review, and preparation, as well as insurance and risk management. Also, 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 postcontractual process.

CEE 5369 (3). ELECTRICAL, MECHANICAL, AND PIPING SYSTEMS FOR BUILDINGS. Examines mechanical and electrical systems for buildings, with emphasis on practical aspects of the subjects. Presents space planning and architectural considerations, including cost and environmental impact of the mechanical and electrical systems. *Prerequisites:* Undergraduate introduction to electrical circuits, classical mechanics, and fluid dynamics or instructor consent.

CEE 5370 (3). FACILITY PLANNING. Covers the overall planning process for construction projects and presents the three divisions of planning (program planning, project planning, and activity planning) in an integrated manner. Includes different modeling approaches for the planning process.

CEE 5371 (3). FACILITY FINANCIAL AND ASSET MANAGEMENT. Examines financial analysis and reporting, concepts and methods of accounting, budgeting, and evaluation of projects. Presents the role of facility managers in affecting corporate earnings and valuations. Includes the management of the facility over its entire life cycle, extending from planning and budgeting to the management of its assets and construction projects.

CEE 5373 (3). PRESTRESSED CONCRETE. Theory and application of prestressed concrete members' time-dependent deflections. Also, continuous prestressed beams. *Prerequisite:* CEE/ME 4350.

CEE 5375 (3). ADVANCED CONCRETE DESIGN. Behavior, analysis, and design of concrete slender columns, two-way slab systems, and deep beams; yield line analysis for slabs; and design and behavior of shear walls, retaining walls, and foundation systems. *Prerequisite:* CEE/ME 4350.

CEE 5377 (3). ADVANCED STEEL DESIGN. The behavior and design of steel structures, including general methods of plastic analysis, plastic moment distribution, steel frames, unbraced and braced frames, and composite construction. *Prerequisite:* CEE/ME 4350.

CEE 5378 (3). TRANSPORTATION PLANNING AND TRAFFIC ENGINEERING. Focuses on the analysis and modeling of urban transportation systems. Includes an overview of main definitions and terminologies involved in the planning and modeling of urban transportation systems. Introduces the concept of urban transportation planning systems along with an overview of various models used in travel demand forecasting. Describes the principles of traffic operations, analysis, and control. *Prerequisite:* Knowledge of the principles of probability and statistics.

CEE 5379 (3). HIGHWAYS DESIGN AND SAFETY. Provides an overview of the principals of highways design and traffic safety. Topics include highways functional classification, design control and criteria, driver performance, sight distance, horizontal and vertical alignments, cross section elements, design of freeways, intersections and interchanges, traffic safety, and environmental impact assessment.

CEE 5380 (3). MANAGEMENT OF INDUSTRIAL AND MISSION-CRITICAL FACILITIES. Efficient industrial centers require balanced consideration with respect to facility design and function. Mission-critical component management and information technology systems are designed for exceptionally reliable performance and efficient operation. This course emphasizes the component systems that are designed to maintain a high level of function. Covers electrical and mechanical reliability, efficiency, readiness, robustness, and flexibility, and the management of the information technology systems. Explores strategies designed to eliminate costly downtimes, with emphasis on standby generators; automatic transfer switches; uninterruptable power supplies; fuel, fire, and battery systems; energy security; and environmental and cooling technologies. Presents the implementation of sustainable technology, green certifications, and alternative energy strategies that are compatible with the mission-critical requirements of the facility. Includes operational approaches to reduce energy requirements for power and cooling, mandated safety standards, and environmental codes.

CEE 5381 (3). SITE SELECTION FOR INDUSTRIAL AND MISSION-CRITICAL FACILITIES. Efficient industrial centers and facilities with mission-critical subsystems such as datacenters require balanced considerations with respect to facility design and site location. Site location plays an integral role in creating successful projects that especially support high reliability and promote sustainable design. While the important factors may vary from site to site, in any given instance a single factor can undermine the success of an otherwise excellent project. Ready availability and proper site selection that minimizes risk of disruption are particularly important factors for successful operation. Covers siting considerations, including power needs, electrical mix, weather patterns, building codes, proximity to the workforce and transportation, and other topics that bear on reliable operation. Emphasizes strategies of site selection to adequately safeguard hardware and mission-critical data.

CEE 5383 (3). 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. Emphasizes theory and analysis. *Prerequisites:* CEE/ME 2331, 2342; ME 3332.

CEE 5384 (3). ENERGY MANAGEMENT FOR BUILDINGS. Examines procedures to select energy savings options for buildings, with emphasis on the practical aspects of the subject. Considers space planning, architectural considerations, cost, and environmental impact of the mechanical and electrical systems along with optimizing the life cycle cost of the proposed alternative. Software for life cycle cost and energy analysis is used to calculate energy consumption and compare energy features of proposed, audit-determined feasible changes to a building.

CEE 5385 (3). 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, and soil and water interaction in earthen dams. *Prerequisite:* CEE 3385.

CEE 5386 (3). FOUNDATION ENGINEERING. Covers the 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:* CEE 3385.

CEE 5387 (3). GEOTECHNICAL EARTHQUAKE ENGINEERING. Provides fundamental knowledge and practical application of soil dynamics and geotechnical earthquake engineering. Includes an overview of seismic hazards, the fundamentals of vibration, wave propagation in an elastic medium, the properties of dynamically loaded soils, earthquake-induced ground motion, ground response analysis, lateral earth pressure on retaining walls, the liquefaction of soils, and seismic stability of earth embankments. *Prerequisite:* CEE 5364 or approval of instructor.

CEE 5388 (3). GROUNDWATER AND SEEPAGE. Examines fundamental principles of flow through porous media and related engineering problems. Topics include the saturated seepage theory and flow nets, the unsaturated flow theory, suction-saturation and saturation-hydraulic conductivity relationships, the principle of effective stress, laboratory and field testing methods for determining material characteristics, and numerical models for flow-related engineering problems. *Prerequisite:* CEE 3385 or equivalent.

CEE 5391 (3), 5392 (3), CEE 5491 (4), CEE 5492 (4). 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. *Prerequisite:* Junior or senior standing required.

CEE 5418 (4). ENGINEERING MICROBIOLOGY. Examines aspects of microbiology that are particularly valuable to the practice of environmental engineering. Specific areas of focus include enzyme and growth kinetics, cell structure and physiology, process of biotransformation, microbial and/or environmental interactions, and biogeochemical cycles. Elements of molecular biology and biotechnology are also presented as appropriate. Students gain a basic understanding and appreciation of microbial processes that are applicable in the field of environmental engineering. *Prerequisites:* CHEM 1303 and 1304, or equivalent.

COMPUTER SCIENCE AND ENGINEERING

Professor Sukumaran V.S. Nair, **Chair**

Professors: Frederick R. Chang, David W. Matula, Sukumaran V.S. Nair, Stephen A. Szygenda, Mitchell A. Thornton, Jeff Tian. **Associate Professors:** Jennifer A. Dworak, Daniel W. Engels, Ira Greenberg, LiGuo Huang. **Assistant Professors:** Eric C. Larson, Tyler W. Moore. **Senior Lecturer:** Frank P. Coyle. **Lecturers:** Donald E. Evans, Theodore W. Manikas. **Clinical Technical Professor:** Mark Fontenot. **Adjunct Faculty:** Jeffrey D. Alcantara, Eduardo Blanco, Andrew W. Blanton, Timmothy Boyd, William A. Bralick, Jr., Ben A. Calloni, Hakki C. Cankaya, Christian P. Christensen, Darin DeRita, Maya El Dayeh, Aaron L. Estes, Dennis J. Frailey, Manal Houri, Kenneth R. Howard, Mihaela Iridon, Bhanu Kapoor, Mohamed M.I. Khalil, Kamran Z. Khan, R. Mallik Kotamarti, Paul Krier, Karl C. Lewis, Lun Li, D. Kall Loper, Matthew R. McBride, Lee D. McFearin, Freeman L. Moore, Anurag Nagar, Padmaraj M.V. Nair, Robert S. Oshana, John J. Pfister, Leonid Popokh, Sohail Rafiqi, Mohamed O. Rayes, Luis G. Resendis, Gheorghe M. Spiride, Raymond E. Van Dyke.

General Information

The Department of Computer Science and Engineering at SMU offers academic programs in computer engineering and computer science. Faculty specializations include computer architecture, data mining, knowledge engineering, software engineering, design and analysis of algorithms, parallel processing, database management, very large-scale integration computer-aided design methods, bioinformatics, computer networks, data and network security, mobile computing, theory of computation, and computer arithmetic. The educational objectives of the undergraduate programs in the CSE Department are to produce graduates who become productive professionals in an information technology discipline, pursue graduate or professional degrees, are successful entrepreneurs and managers, have a broad knowledge and wide range of interests, are valuable members of their general community and take a leadership role in their chosen field. As such, the programs are designed to ensure that graduates have the following abilities:

For graduates with degrees in computer science

a) The ability to apply knowledge of computing and mathematics to software design and computing problems.

b) The ability to analyze a problem, and identify and define the computing requirements appropriate to its solution.

c) The ability to design, implement and evaluate a computer-based system, process, component or program to meet desired needs.

d) The ability to function effectively on teams to accomplish a common goal.

e) An understanding of professional, ethical, legal, security and social issues and responsibilities.

f) The ability to communicate effectively with a range of audiences both in an oral and written form.

g) The broad liberal arts education necessary to analyze the local and global impact of computing on individuals, organizations and society.

h) The recognition of the need for and the ability to engage in continuing professional development and lifelong learning.

i) The ability to use the techniques, skills and modern computing and software engineering tools necessary for computing practice.

For graduates with degrees in computer engineering

a) The ability to apply knowledge of mathematics, science and engineering to software and hardware design problems.

b) The ability to design and conduct experiments and to analyze and interpret data related to software and hardware design solutions.

c) The ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

d) The ability to function on multidisciplinary teams using current computer engineering tools and technologies.

e) The ability to identify, formulate and solve engineering problems based on a fundamental understanding of concepts of computer engineering topics.

f) An understanding of personal, professional and ethical responsibility.

g) The ability to communicate effectively both in an oral and written form.

h) The broad liberal arts education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.

i) The recognition of the need for and the ability to engage in lifelong learning.

j) A knowledge of contemporary issues in computer engineering.

k) The ability to use the techniques, skills and modern engineering tools necessary for computer engineering practice.

The CSE Department is engaged in an ongoing assessment process that evaluates the success in meeting these outcomes and enhances the development of the program.

Degrees

The CSE Department offers undergraduate degrees as follows:

Bachelor of Science – major in computer science
Bachelor of Science – major in computer science with a premedical specialization
Bachelor of Science in Computer Engineering
Bachelor of Arts – major in computer science

The undergraduate program in computer engineering is accredited by the Engineering Accreditation Commission of ABET, www.abet.org. The undergraduate computer science program that awards the degree Bachelor of Science is accredited by the Computing Accreditation Commission of ABET. The undergraduate computer science program that awards the degree Bachelor of Arts is not accredited by a Commission of ABET.

Dual Degree Program

The Lyle School of Engineering offers a dual degree with the Meadows School of the Arts that leads to the degrees of B.A. in music and B.A. in computer science. Students should contact the department for additional details. Other dual majors can be arranged in consultation with an adviser.

4+1 Master's Degree Program

The 4+1 Program allows students to complete both B.S. and M.S. degrees in five years. In the CSE Department, students may participate in the 4+1 Program in either the computer science or computer engineering area. Up to nine total credit hours of graduate courses may be applied toward fulfilling the student's undergraduate program requirements. For additional information, students should contact the undergraduate program director.

Teaching Certification

Computer science majors interested in earning a teaching certificate should contact the Simmons School of Education for information on additional course and student teaching requirements.

Computer Facilities

Students in the CSE Department have access to a wide range of facilities and equipment. The department's computing environment has evolved into an Ethernet-based network of personal computers and servers. General-use UNIX servers that run OSF1 and Linux are available. A wireless network is also available throughout the CSE facilities. Windows-based PC labs are used during the first two years of coursework.

Curriculum in Computer Science

Computers play an ever-increasing role in society. Their use permeates all other academic disciplines and industrial arenas. Computer science is the study of the concepts and theory surrounding computer design and software construction. The SMU undergraduate program in computer science is designed to give students a solid understanding of these concepts, providing them with the technical knowledge needed to pursue either an advanced degree or a challenging career in the computer industry. The diversity of the Lyle School of Engineering computer environment exposes undergraduate computer science students to many different hardware and software systems.

To study and use computers, one must communicate with them through a variety of software interfaces, including programming languages. At SMU, the student will study several high-level languages – such as C++ and Java – that simplify the use of computers. In addition, students are exposed to a variety of computer-aided software engineering tools. Assembly languages and operating systems (such as Linux/UNIX) for microcomputers, mainframes and supercomputers are studied to provide an understanding of the architecture and organization of a digital computer. Mathematical topics such as discrete mathematics, graph theory, and Boolean and linear algebra are included in required undergraduate classes so that students may better understand the internal structure of the computer and the effective utilization of its languages.

Knowledge of the computer's internal structure is important to understanding its capabilities. Thus, computer science students take courses in assembly language, computer logic and computer organization. Courses in systems programming and operating systems extend this structural study into the "software" of the computer. A required sequence of software engineering courses prepares students for advanced systems and software applications.

Many of the computer science core courses (CSE 2341, 3345, 3353, 4345, 4351 and 4352) contain major project-oriented components to prepare students for applying their theoretical knowledge in teams.

The free electives in the B.A. in computer science program can be used to individually tailor a student's study plan. For example, students who want a program even more intensive than the computer science major could satisfy their free electives with more computer science courses. Students interested in a broader education could satisfy these electives with courses offered by any department in the University.

The B.S. degree allows students to major in any of five concentration tracks or to pursue a general program where they can choose nine hours of computer science electives. The research track allows students to participate in an undergraduate research project of their choice. Like graduate students, undergraduate students majoring in research are required to perform independent research in an area of their choice (with a tenure-track faculty member as an adviser), document the research results and present the results of the research in a presentation open to the entire University community. The security track facilitates a more in-depth study of software security issues. The data-intensive computing track introduces concepts of data storage and analysis necessary for many modern applications. The software engineering track focuses on software design and testing. The game development track is provided in collaboration with SMU Guildhall.

Curriculum in Computer Engineering

Computer engineering deals with computers and computing systems. Computer engineers must be capable of addressing problems in hardware, software and algorithms, especially those problems whose solutions depend upon the interaction of these elements. Career opportunities for computer engineers require a broad range of knowledge. The design and analysis of logical and arithmetic processes that are the basis of computer science provide basic knowledge. Computer engineering courses are concentrated on the interacting nature of hardware and software. Basic electrical engineering is a clear foundation for computer engineers.

Bachelor of Science With a Major in Computer Science

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, term credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	32
MATH 1337, 1338, 3353	
CSE 2353, 3365 (MATH 3315) or MATH 3316, CSE 4340	
(Students may fulfill the CSE 4340 requirement by taking any one of CSE/STAT 4340, EMIS 3340, *or* STAT 5340.)	
PHYS 1303/1105, 1304/1106	
6 credit hours from the following:	
ANTH 2315, 2363	
BIOL 1401, 1402	
CHEM 1303/1113, 1304/1114	
GEOL 1301, 1305, 1307, 1308, 1313, 1315	
PHYS 3305	

Requirements for the Major (continued)	*Credit Hours*
Computer Science Core	47
CSE 1341, 1342, 2240, 2341, 3330, 3339, 3342, 3345, 3353, 3381, 4344, 4345, 4351, 4352, 4381, 5343	
Tracks and Electives	9–18
Research (9 credit hours)	
CSE 4397, 5350	
3 credit hours of track electives approved by adviser	
Data-Intensive Computing (9 credit hours)	
CSE 5330, 5331	
3 credit hours of track electives approved by adviser	
Software Engineering (9 credit hours)	
CSE 5314, 5319	
3 credit hours of track electives approved by adviser	
Game Development (18 credit hours)	
CSE 4051 (but not CSE 4351, 4352 from the list above)	
HGAM 5200, 5201, 5202, 5221, 5222, 5292, 5311, 5312 (Must be admitted to Guildhall Professional Certificate program and attend class at SMU Guildhall.)	
Security (9 credit hours)	
CSE 5339, 5349	
3 credit hours of track electives approved by adviser	
General (9 credit hours)	
Three 3-hour, 4000-level or above CSE courses approved by adviser	
Engineering Leadership	6
CSE 4360 and CEE 3302, EMIS 3308, *or* CSE 5317	
Electives	6
Advanced electives in the Lyle School of Engineering.	
	100–103

Note: All computer science majors must earn a grade of *C*- or better in the computer science core courses and CSE 2353 in fulfillment of the requirements for the major. Students choosing the game development track do not take CSE 4351 and 4352 and have a total degree requirement of 103 hours.

Bachelor of Science With a Major in Computer Science (Premedical Specialization)

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	56
MATH 1337, 1338, 3353	
CSE 2353, 3365 (MATH 3315) or MATH 3316, CSE 4340 (Students may fulfill the CSE 4340 requirement by taking any one of CSE/STAT 4340, EMIS 3340, *or* STAT 5340.)	
BIOL 1401, 1402, 3304, 3350	
CHEM 1303/1113, 1304/1114, 3371/3117, 3372/3118	
PHYS 1303/1105, 1304/1106	

Requirements for the Major (continued)	*Credit Hours*
Computer Science	44
CSE 1341, 1342, 2240, 2341, 3330, 3342, 3345, 3353, 3381, 4344, 4345, 4351, 4352, 4381, 5343	
Engineering Leadership	6
CEE 3302	
CSE 4360	
	106

Bachelor of Arts With a Major in Computer Science

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	18
MATH 1337, 1338	
CSE 2353	
PHYS 1301 *or* 1303	
STAT 2331	
3 credit hours from the following:	
ANTH 2315, 2363	
BIOL 1303, 1304, 1308, 1401, 1402	
CHEM 1301, 1303, 1304	
GEOL 1301, 1305, 1307, 1308, 1313	
PHYS 1303, 1304, 1314, 3305	
Computer Science	47
CSE 1341, 1342, 2240, 2341, 3330, 3342, 3345, 3353, 3381, 4344, 4345, 4351, 4352, 4381, 5343	
3 credit hours from the following:	
CSE 5314, 5320, 5330, 5339, 5341, 5342, 5344, 5345, 5348, 5349, 5350, 5359, 5376, 5380, 5381, 5382, 5385, 5387	
Engineering Leadership	9
CEE 3302	
CSE 4360	
EMIS 3308 *or* CSE 5317	
Free Electives	19
Must be approved by adviser.	
	93

Bachelor of Science in Computer Engineering

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the term credit hours within this curriculum are distributed as follows:

Requirements for the Degree	*Credit Hours*
Mathematics and Science	34
MATH 1337, 1338, 2343, 3353	
CSE 2353, 3365 (MATH 3315) or MATH 3316, CSE 4340 (Students may fulfill the CSE 4340 requirement by taking any one of CSE/STAT 4340, EMIS 3340, *or* STAT 5340.)	

Requirements for the Degree (continued)	Credit Hours
Mathematics and Science (continued)	
CHEM 1303	
PHYS 1303, 1304/1106	
3 credit hours from the following:	
ANTH 2315, 2363	
BIOL 1401, 1402	
CHEM 1113, 1304/1114	
GEOL 1301, 1305, 1307, 1308, 1313, 1315	
PHYS 3305	
Computer Engineering Core	49
CSE 1341, 1342, 2240, 2341, 3339, 3353, 3381, 4344, 4351, 4352, 4381, 5343, 5387	
EE 2322/2122, 2350, 2370/2170	
Tracks	9
Hardware (three of the following)	
CSE 5380, 5381; CSE 5385 *or* EE 5385; CSE 5356 *or* EE 5356	
Software Engineering (three of the following)	
CSE 3345; 4345; 5314, *or* 5316, *or* 5319	
Networking (three of the following)	
CSE 5344, 5348, 5349; EE 5376	
Security	
CSE 5339, 5349	
3 credit hours of track electives approved by adviser	
General	
Three 3-hour, 4000-level or above CSE courses approved by adviser	
Engineering Leadership	6
CEE 3302, EMIS 3308, *or* CSE 5317	
CSE 4360	
Electives	6
Advanced electives in the Lyle School of Engineering.	
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Note: All computer engineering majors must earn a grade of *C*- or better in the computer engineering CSE core courses and CSE 2353 in fulfillment of the requirements for the major.

Minor in Computer Science

A student majoring in computer engineering may not minor in computer science. The following computer science courses are required: **CSE 1341, 1342, 2341, 2353.** Elective courses can be any six hours of CSE courses numbered 3000 or above as approved by the computer science minor adviser.

Minor in Computer Engineering

A student majoring in computer science may not minor in computer engineering. The following computer science courses are required: **CSE 1341, 1342, 2240, 2341, 2353, 3381.**

The Courses (CSE)

CSE 1340 (3). INTRODUCTION TO COMPUTING CONCEPTS. Introduction to computer concepts, program structures, object-oriented programming, and interactive application development. Extensive programming projects emphasizing logical control structures and the use of libraries.

CSE 1341 (3). PRINCIPLES OF COMPUTER SCIENCE. Introduces the fundamental concepts of computer science and object-oriented design of reusable modules. Covers basic object-oriented concepts of composition, inheritance, polymorphism, and containers. First course for computer science and computer engineering majors and minors.

CSE 1342 (3). PROGRAMMING CONCEPTS. Introduces the constructs provided in the C/C++ programming language for procedural and object-oriented programming. Computation, input and output, flow of control, functions, arrays and pointers, linked structures, use of dynamic storage, and implementation of abstract data types. *Prerequisite:* C- or better in CSE 1341 or equivalent, a grade of at least 4 on the AP Computer Science A Exam, or departmental consent.

CSE 2240 (2). ASSEMBLY LANGUAGE PROGRAMMING AND MACHINE ORGANIZATION. Computer-related number systems, machine arithmetic, computer instruction set, low-level programming, addressing modes, and internal data representation. *Prerequisite or corequisite:* C- or better in CSE 1341.

CSE 2341 (3). DATA STRUCTURES. Emphasizes the object-oriented implementation of data structures and associated algorithms, including sorting algorithms, linked lists, stacks, queues, binary trees, and priority queues. Introduces graphs and algorithm analysis, and covers object-oriented software engineering strategies and approaches to programming. *Prerequisite:* C- or better in CSE 1342 or equivalent.

CSE 2353 (3). DISCRETE COMPUTATIONAL STRUCTURES. Logic, proofs, partially ordered sets, and algebraic structures; introduction to graph theory and combinatorics; and applications of these structures to various areas of computer science. *Prerequisite:* C- or better in CSE 1341.

CSE 3330 (3). DATABASE CONCEPTS. Covers fundamental information management and database systems concepts, including information models and systems, data modeling, relational database design, query languages, and various language APIs for accessing database systems. Contains a major design and implementation project. May include topics from information privacy and security, information retrieval, data mining, and multimedia information systems. *Prerequisites:* C- or better in CSE 2341, 2353.

CSE 3339 (3). INFORMATION ASSURANCE AND SECURITY. Provides a broad introduction to information assurance and security. Students gain a foundational understanding of the protection of information assets and explore a broad spectrum of topics in the field. Covers a range of technical topics (e.g., network security, systems security, access control, cryptography) as well as nontechnical topics (e.g., management, legal issues, policy, ethics, history). *Prerequisite:* C- or better in CSE 2341 or equivalent.

CSE 3342 (3). PROGRAMMING LANGUAGES. Provides an understanding of how advances in hardware and networks have influenced the design and capabilities of programming languages from the 1950s to the present. Covers major programming paradigms (procedural, declarative, object-oriented, and functional) and requires problem-solving using a variety of languages. Topics include the history of programming languages, the Chomsky language hierarchy, the development of formal models for specifying languages, data structures for programming language implementation, and the ways different languages deal with problem of concurrency in a world of multicore and distributed computing. *Prerequisite:* C- or better in CSE 2341.

CSE 3345 (3). GRAPHICAL USER INTERFACE DESIGN AND IMPLEMENTATION. Introduction to the concepts underlying the design and implementation of graphical user interfaces, with emphasis on the psychological aspects of human-computer interaction. Structured around lectures, case studies, and student projects. Introduces event-driven programming concepts, including the Java API, applications, applets, interfaces, graphics, basic and advanced GUI components, HTML, and multithreading. *Prerequisite:* C- or better in CSE 2341 or equivalent.

CSE 3353 (3). FUNDAMENTALS OF ALGORITHMS. Introduces algorithm analysis; big-Oh, omega, and theta notation; and algorithm classification by efficiency. Also, basic algorithm design strategies and approaches to problem-solving (e.g., greedy, divide and conquer, and dynamic programming), an introduction to graph algorithms, and intractability. *Prerequisites:* C- or better in CSE 2341, 2353.

CSE 3365 (3). INTRODUCTION TO SCIENTIFIC COMPUTING. An elementary survey course that includes techniques for root-finding, interpolation, functional approximation, linear equations, and numerical integration. Gives special attention to MATLAB programming, algorithm implementations, and library codes. Students registering for this course must also register for an associated computer laboratory. *Prerequisites:* C- or better in MATH 1338 or 1340, and in CSE 1341 or 1342. *Corequisite:* MATH 3353.

CSE 3381 (3). DIGITAL LOGIC DESIGN. Covers the history of logic and its application to digital switching circuitry. Topics include algebraic, combinational, and sequential circuitry. Emphasizes programmable logic and hardware description languages for modeling, synthesis, and simulation. Introduces the controller plus datapath architecture present in the majority of modern information processing circuits. Requires a weekly corequisite laboratory. *Prerequisites:* C- or better in CSE 2240, 2353 or permission of instructor.

CSE 4051 (0). GAMING DESIGN PROJECT. Requires students enrolled in HGAM 5292 to produce appropriate reports and other design documentation material resulting from their HGAM 5292 design experience, including design requirements, specifications, test plans, and other relevant documentation as required for assessing the design experience. *Corequisite:* HGAM 5292.

CSE 4090 (0). SENIOR PROJECT.

CSE 4190 (1). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4191 (1). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4192 (1). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4193 (1). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4194 (1). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4197 (1). RESEARCH EXPERIENCE FOR UNDERGRADUATES. Provides research experience for junior/senior undergraduate students. Permission from the advising CSE faculty member is required before registration. *Prerequisites:* Junior/senior standing; computer science or computer engineering major with GPA above 3.000.

CSE 4290 (2). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4291 (2). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4292 (2). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4293 (2). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4294 (2). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4297 (2). RESEARCH EXPERIENCE FOR UNDERGRADUATES. Provides research experience for junior/senior undergraduate students. Permission from the advising CSE faculty member is required before registration. *Prerequisites:* Junior/senior standing; computer science or computer engineering major with GPA above 3.000.

CSE 4340 (3). STATISTICAL METHODS FOR ENGINEERS AND APPLIED SCIENTISTS. Basic concepts of probability and statistics useful in the solution of engineering and applied science problems. Topics include probability, probability distributions, data analysis, sampling distributions, estimation, and simple tests of hypothesis. *Prerequisites:* C- or better in MATH 1337, 1338.

CSE 4344 (3). COMPUTER NETWORKS AND DISTRIBUTED SYSTEMS. Introduces network protocols, layered communication architecture, wired and wireless data transmission, data link protocols, network routing, TCP/IP and UDP, email and the World Wide Web, distributed computing, mutual exclusion, linearizability, locks, and multithreaded computing. *Prerequisite:* C- or better in CSE 2341.

CSE 4345 (3). SOFTWARE ENGINEERING PRINCIPLES. Introduction to software system development and an overview of development models and their stages. Also, system feasibility and requirements engineering, architecture and design, validation and verification, maintenance, and evolution. Includes project management and a review of current software engineering literature. Student teams design and implement small-scale software systems. Contains class presentations and a major design experience. *Prerequisite:* C- or better in CSE 2341.

CSE 4351 (3). SENIOR DESIGN I. First part of a project course, with a major design component. Students participate in a multidisciplinary group project team. Topical, project-related discussions include project team organization, project planning and scheduling, management, testing and validation methods, and the importance of lifelong learning. *Prerequisite:* CSE senior standing.

CSE 4352 (3). SENIOR DESIGN II. Second part of a project course, with a major design component. Students participate in a multidisciplinary group project team. Topical, project-related discussions include project team organization, project planning and scheduling, management, testing and validation methods, and the importance of lifelong learning. *Prerequisite:* CSE 4351.

CSE 4360 (3). TECHNICAL ENTREPRENEURSHIP. Demonstrates the concepts involved in the management and evolution of rapidly growing technical endeavors. As part of a team, the student participates in active learning by doing, by making mistakes and developing solutions, and by observing mistakes and approaches made by other teams. Credit will not be given for both CSE 4360 and EMIS 8358. *Prerequisite:* Senior standing or permission of instructor.

CSE 4381 (3). DIGITAL COMPUTER DESIGN. Machine organization, instruction set architecture design, memory design, control design: hardwired control and microprogrammed control, algorithms for computer arithmetic, microprocessors, and pipelining. *Prerequisite:* C- or better in CSE 3381.

CSE 4386 (3). HARDWARE DESIGN PROJECT. A project course with a major design component. Students participate in a multidisciplinary group project team. Topical, project-related discussions include the hardware design and manufacturing process, hardware description languages, modular design principles, quantitative analysis, industrial standards and interfaces, and the importance of lifelong learning. The group project provides the major design experience for students in the hardware track of the computer engineering program. *Prerequisite:* C- or better in CSE 4381.

CSE 4391 (3). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4392 (3). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4393 (3). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4394 (3). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4397 (3). RESEARCH EXPERIENCE FOR UNDERGRADUATES. Provides research experience for junior/senior undergraduate students. Permission from the advising CSE faculty member is required before registration. *Prerequisites:* Junior/senior standing; computer science or computer engineering major with GPA above 3.000.

CSE 4490 (4). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4491 (4). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4492 (4). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4493 (4). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 4494 (4). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

CSE 5050 (0). UNDERGRADUATE INTERNSHIP.

CSE 5096 (0). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

CSE 5111 (1). INTELLECTUAL PROPERTY AND INFORMATION TECHNOLOGY. Presents fundamentals in the nature, protection, and fair use of intellectual property, including patent, copyright, trademark, trade secret, and antitrust principles, with an emphasis on Internet, software, databases, and digital transmission technologies. Investigates the open source and creative commons alternatives for disseminating intellectual property. Examines the professional and ethical responsibilities of the engineer, scientist, manager, and creative artist, and their opportunities regarding intellectual property. Also, investigates the rapid change in types and uses of intellectual property spawned by computers, digital media, e commerce, and biotechnology.

CSE 5190 (1). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5191 (1). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5192 (1). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5193 (1). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5194 (1). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5196 (1). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

CSE 5290 (2). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5291 (2). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5292 (2). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5293 (2). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5294 (2). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5296 (2). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

CSE 5311 (3). FUNDAMENTALS OF COMPUTER SCIENCE. A comprehensive foundation course covering the major aspects of computer science. Covers hardware and software fundamentals, operating systems concepts, data structures, discrete structures, algorithms, and programming languages. Also, addresses issues related to software engineering and object-oriented programming. Prepares students without a computer science background for the master's program in software engineering at SMU.

CSE 5313 (3). SOFTWARE CONFIGURATION MANAGEMENT. Successful software development and maintenance requires an understanding and application of many activities and functions throughout the software engineering process. One of the key areas is software configuration management. Students explore the principles and practices of the software configuration management function and mandatory role, including how CM is defined, planned, implemented, and measured over the life cycle of any development or maintenance project. Focuses on understanding specific roles of project team members and the tasks they plan and execute: managers who must support the CM efforts; project managers who must plan and design the CM system for their projects; those who implement the system; those who manage and administer the system; and the testers, engineers, and quality assurance personnel who are affected by the system. *Prerequisites:* CSE major and junior, senior, or graduate-level standing.

CSE 5314 (3). SOFTWARE TESTING AND QUALITY ASSURANCE. Examines the relationship of software testing to quality, with an emphasis on testing techniques and the role of testing in the validation of system requirements. Topics include module and unit testing, integration, code inspection, peer reviews, verification and validation, statistical testing methods, error prevention and detection, project metrics selection and implementation, testing principles, formal models of testing, and performance monitoring, and measurement. Also, defining test plans and strategies that map to system requirements. *Prerequisites:* C- or better in all previous CSE courses and senior standing. It is strongly recommended that students have software engineering experience.

CSE 5316 (3). SOFTWARE REQUIREMENTS. Focuses on defining and specifying software requirements that can be used as the basis for designing and testing software. Topics include use cases for describing system behavior, formal methods, specifying functional versus nonfunctional requirements, and the relationship of requirements to software testing. *Prerequisites:* C- or better in all previous CSE courses and senior standing.

CSE 5317 (3). LEADERSHIP FOR ARCHITECTING SOFTWARE SYSTEMS. Principles of leadership and software architecture in building large software systems or leading large teams. Involves a mix of personal assessment, reflection, and the development of leadership and influence skills and concepts unique to each student. Examines the process of developing large software systems in a constantly changing commercial environment. *Prerequisite:* Junior standing or higher.

CSE 5319 (3). SOFTWARE ARCHITECTURE AND DESIGN. Software development requires both an understanding of software design principles and a broader understanding of software architectures that provide a framework for design. The course explores the role of design in the software life cycle, including different approaches to design, design trade-offs, and the use of design patterns in modeling object-oriented solutions. It also focuses on important aspects of a system's architecture, including the division of functions among system modules, synchronization, asynchronous and synchronous messaging, interfaces, and the representation of shared information. *Prerequisites:* C- or better in all CSE courses and senior standing.

CSE 5320 (3). ARTIFICIAL INTELLIGENCE. Introduces basic principles and current research topics in artificial intelligence. Formal representation of real-world problems; search of problem spaces for solutions; and deduction of knowledge in terms of predicate logic, nonmonotonic reasoning, and fuzzy sets. Application of these methods to important areas of artificial intelligence, including expert systems, planning, language understanding, machine learning, neural networks, computer vision, and robotics. *Prerequisites:* C- or better in CSE 3342, 3353.

CSE 5323 (3). MOBILE APPLICATIONS FOR SENSING AND LEARNING. Equips students with the practical skills necessary to develop mobile applications that take advantage of the myriad sensing and control capabilities of modern smartphones. Focuses on interfacing with phone hardware, efficient computing on the phone and in the cloud using virtualized servers, and efficient analysis of the peripheral sensor streams of today's smartphones. Students integrate real-time control and/or automation using a third-party hardware platform to interface with the mobile platform. *Prerequisite:* CSE 1342.

CSE 5330 (3). FILE ORGANIZATION AND DATABASE MANAGEMENT. Surveys current database approaches and systems, principles of design, and use of these systems. Includes query language design, implementation constraints, applications of large databases, survey of file structures and access techniques, and use of a relational DBMS to implement a database design project. *Prerequisite:* C- or better in CSE 3330.

CSE 5331 (3). AN INTRODUCTION TO DATA MINING AND RELATED TOPICS. Introduces various data mining and related concepts. Reinforces all material covered through hands-on implementation exercises and uses a high-level, applied study of data mining techniques. *Prerequisite:* C- or better in CSE 3330.

CSE 5333 (3). QUANTIFYING THE WORLD. In the global information age, data can be leveraged to rapidly answer previously unanswerable questions. Students explore how to make sense of the large amounts of data frequently available, from hypothesis formation and data collection to methods of analysis and visualization. Includes ways to set up Internet-level measurements and formulate testable hypotheses; ways to automatically gather, store, and query large datasets; and ways to apply statistical methods (descriptive and predictive) and information visualization to collected datasets. Students learn to use Python and R programming languages to carry out data collection, analysis, and visualization. Culminates in a final project using real data of the students' choosing.

CSE 5337 (3). INFORMATION RETRIEVAL AND WEB SEARCH. Introduces the field of information retrieval, with an emphasis on its application in Web search, and the basic concepts of stemming, tokenizing and inverted indices, text similarity metrics, and the vector-space model. Students study popular Web search engines and apply the concepts in several Java-based programs. *Prerequisite:* CSE 3353.

CSE 5338 (3). SECURITY ECONOMICS. Introduces 1) economics as a tool for understanding and managing information security and 2) the techniques of analytic and empirical modeling. Students review key information security challenges and technologies in order to reason about the topics economically, and they explore economic concepts such as rationality, markets, and information. Presents models and metrics of security investment, cost-benefit analysis techniques, and techniques for empirical investigation and measurement of cybercrime. Students design security games to capture the strategic interaction between defenders and between attackers and defenders. Includes the implications for public policy. *Prerequisite:* CSE 3353 or junior standing if not a declared CSE major.

CSE 5339 (3). COMPUTER SYSTEM SECURITY. Students investigate a broad selection of contemporary issues in computer security, including an assessment of state-of-the-art technology used to address security problems. Topics include sources for computer security threats and appropriate reactions, basic encryption and decryption, secure encryption systems, program security, trusted operating systems, database security, network and distributed systems security, administering security, and legal and ethical issues. *Prerequisite:* CSE 5343.

CSE 5340 (3). SERVICE-ORIENTED COMPUTING. Service-oriented computing is the computing paradigm that utilizes services as fundamental elements for developing applications. Service providers expose capabilities through interfaces. Service-oriented architecture maps these capabilities and interfaces so they can be orchestrated into processes. Fundamental to the service model is the separation between the interface and the implementation, such that the invoker of a service need only (and should only) understand the interface; the implementation can evolve over time, without disturbing the clients of the service. *Prerequisites:* Senior or graduate standing. Programming experience is required.

CSE 5341 (3). COMPILER CONSTRUCTION. Reviews programming language structures, loading, execution, and storage allocation; compilation of simple expressions and statements; organization of a compiler, including compile- and run-time symbol tables, lexical analysis, syntax analysis, code generation, error diagnostics, and simple code optimization techniques; and use of a recursive high-level language to implement a complete compiler. *Prerequisites:* C- or better in CSE 3342, 3353.

CSE 5342 (3). CONCEPTS OF LANGUAGE THEORY AND THEIR APPLICATIONS. Formal languages and their relation to automata; introduction to finite-state automata, context-free languages, and Turing machines; theoretical capabilities of each model; applications in terms of grammars, parsing, and operational semantics; and decidable and undecidable problems about computation. *Prerequisite:* C- or better in CSE 3342 or permission of instructor.

CSE 5343 (3). OPERATING SYSTEMS AND SYSTEMS SOFTWARE. Theoretical and practical aspects of operating systems: overview of system software, timesharing and multiprogramming operating systems, network operating systems and the Internet, virtual memory management, interprocess communication and synchronization, file organization, and case studies. *Prerequisites:* C- or better in CSE 2240, 3353.

CSE 5344 (3). COMPUTER NETWORKS AND DISTRIBUTED SYSTEMS II. Introduces network protocols, layered communication architecture, multimedia applications and protocols, quality of service, congestion control, optical networks, DWDM, network survivability and provisioning, and wireless networks. An interdisciplinary project requires the use of currently available network design and simulation tools. *Prerequisite:* C- or better in CSE 4344.

CSE 5345 (3). ADVANCED APPLICATION PROGRAMMING. Advanced programming techniques that span a range of programming languages and technologies. Includes server-side application development, client GUI implementation, application frameworks, design patterns, model-based development, and multithreading. The specific programming language or languages covered may vary from term to term. *Prerequisite:* CSE 3345 or consent of instructor.

CSE 5346 (3). CLOUD COMPUTING. Explores architectures for cloud computing, and provides hands-on experience with virtualization technologies. Topics include cloud computing architectures such as infrastructure as a service, platform as a service, and software as a service. Covers programming models for cloud computing, the fundamentals of virtualization technologies that enable scalability, and an introduction to the security and energy efficiency challenges of cloud computing. *Prerequisite:* CSE 4381.

CSE 5347 (3). XML AND THE ENTERPRISE. XML, the Extensible Markup Language, is used to define vocabularies for a wide range of applications such as software configuration, data exchange, and Web-based protocols. Provides a detailed examination of XML as an enterprise technology, with a focus on APIs, interfaces, and the standards that drive this technology, including DTDs and XML Schema to structure XML data, XSLT to transform XML, XML protocols for distributed computing, and XML security initiatives. Students gain a broad understanding of XML and the technical issues and trade-offs among different alternatives for processing XML. *Prerequisites:* An understanding of object-oriented concepts and familiarity with Java and/or C++.

CSE 5348 (3). INTERNETWORKING PROTOCOLS AND PROGRAMMING. Processing and interprocess communications, UNIX domain sockets, fundamentals of TCP/IP, Internet domain sockets, packet routing and filtering and firewall, SNMP and network management, client-server model and software design, remote procedure call (XDR, RPC, DCE), design of servers and clients, networking protocols for the World Wide Web, and internetworking over new networking technologies. *Prerequisites:* C- or better in CSE 4344, 5343 and C programming.

CSE 5349 (3). DATA AND NETWORK SECURITY. Covers conventional and state-of-the-art methods for achieving data and network security. Private key and public key encryption approaches are discussed in detail, with coverage of popular algorithms such as DES, Blowfish, and RSA. In the network security area, the course covers authentication protocols, IP security, Web security, and system-level security. *Prerequisite:* C- or better in CSE 4344.

CSE 5350 (3). ALGORITHM ENGINEERING. Algorithm design techniques; methods for evaluating algorithm efficiency; data structure specification and implementation; applications to fundamental computational problems in sorting and selection, graphs and networks, scheduling and combinatorial optimization, computational geometry, and arithmetic and matrix computation; introduction to parallel algorithms and to computational complexity; and a survey of NP-complete problems. Emphasizes developing the student's facility to design efficient algorithms. *Prerequisite:* C- or better in CSE 3353.

CSE 5356 (3). VLSI DESIGN AND LABORATORY. Explores the design aspects involved in the realization of CMOS integrated circuits from device up to the register subsystem level. Addresses major design methodologies, with emphasis on structured, full-custom design. Also, the MOS device, CMOS inverter static characteristics, CMOS inverter dynamic characteristics, CMOS transistor fabrication technology, combination logic circuit, alternative static logic circuit, sequential logic circuit, dynamic logic circuit, propagation delay and interconnect, power dissipation and design for low power, memory device (DRAM, SRAM, ROM), ESD protection, packaging, testing, and VLSI design flow. Students use state-of-the-art CAD tools to verify designs and develop efficient circuit layouts. *Prerequisites:* C- or better in EE 2181, 2381, 3311.

CSE 5359 (3). SOFTWARE SECURITY. As software is delivered across networks and Web-based environments, security is critical to successful software deployment. This course focuses on software security issues that pertain to the network application layer in the classic OSI model. At the network application layer, issues related to encryption, validation, and authentication are handled programmatically rather than at the network level. Students work with APIs for cryptography, digital signatures, and third-party certificate authorities. The course also explores issues related to XML and Web services security by examining standards and technologies for securing data and programs across collaborative networks. *Prerequisite:* Programming experience in Java and/or C++.

CSE 5360 (3). INTRODUCTION TO 3-D ANIMATION. Introduces computer graphics, with an emphasis on the popular software package Maya. Focuses on the user interface, creation of 3-D geometry using polygonal techniques, materials and textures, kinematics, animation, and camera and lighting techniques. Explores the various aspects and fundamentals of computer graphics. Students gain a core understanding of the workflow necessary to create 3-D imagery. Assignments require students to combine a variety of techniques to become familiar with the computer animation production process. *Prerequisite:* Junior standing or higher. May not be used for credit in a graduate degree program in CSE without adviser's approval.

CSE 5369 (3). HARDWARE SECURITY AND TROJAN DETECTION. Introduces several contemporary topics in hardware security, with a particular emphasis on hardware Trojans. Other topics include physically unclonable functions, the problem of counterfeiting, security implications of design for testability in hardware, intellectual property protection, and secure coprocessors and smart cards. *Prerequisite:* C or better in CSE 3381 or equivalent.

CSE 5376 (3). INTRODUCTION TO TELECOMMUNICATIONS. Overview of public and private telecommunications systems; traffic engineering; switching; transmission; signaling; channel capacity; media characteristics; Fourier analysis and harmonics; modulation; electromagnetic wave propagation and antennae, modems, and interfaces; digital transmission systems; T1 carriers; digital microwave; satellites; fiber optics and synchronous optical networking; and integrated services digital networks.

CSE 5380 (3). VLSI ALGORITHMS. Introduces problems, algorithms, and optimization techniques used in the design of high-performance VLSI design. Emphasis on algorithms for partitioning, placement, floor planning, wire routing, and layout compaction. *Prerequisites:* C- or better in CSE 3353, 3381.

CSE 5381 (3). COMPUTER ARCHITECTURE. Introduces the state of the art in uniprocessor computer architecture, with a focus on the quantitative analysis and cost-performance trade-offs in instruction set, pipeline, and memory design. Topics include quantitative analysis of performance and hardware costs, instruction set design, pipeline, delayed branch, memory organization, and advanced instruction-level parallelism. *Prerequisite:* C- or better in CSE 4381.

CSE 5382 (3). COMPUTER GRAPHICS. Hardware and software components of computer graphics systems: display files, 2-D and 3-D transformations, clipping and windowing, perspective, hidden-line elimination and shaping, interactive graphics, and applications. *Prerequisite:* C- or better in CSE 3353.

CSE 5385 (3). MICROCONTROLLER ARCHITECTURE AND INTERFACING. Emphasizes the design of embedded systems using microcontrollers. Briefly reviews microcontroller architecture. Includes hierarchical memory systems and interfacing of memory and peripherals, industry standard bus interfaces and other applicable standards, and topics in real-time operating systems and system-level design considerations. The corequisite laboratory requires students to develop software using assembler and high-level languages. *Prerequisite:* CSE 3381 or EE 3181, 3381.

CSE 5387 (3). DIGITAL SYSTEMS DESIGN. Modern topics in digital systems design, including the use of HDLs for circuit specification and automated synthesis tools for realization. Programmable logic devices are emphasized and used throughout the course. Includes heavy laboratory assignment content and a design project. *Prerequisite:* C- or better in CSE 3381 or in EE 2381.

CSE 5390 (3). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5391 (3). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5392 (3). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5393 (3). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5394 (3). SPECIAL TOPICS. Individual or group study of selected topics in computer science. *Prerequisite:* Permission of instructor.

CSE 5396 (3). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

ELECTRICAL ENGINEERING

Professor Dinesh Rajan, **Chair**

Professors: Jerome K. Butler, Marc P. Christensen, Scott C. Douglas, Delores M. Etter, Gary A. Evans, W. Milton Gosney, Alireza Khotanzad, Panos E. Papamichalis, Behrouz Peikari, Dinesh Rajan, Mitchell A. Thornton. **Associate Professors:** Gyungsu Byun, Joseph D. Camp, Carlos E. Davila, James G. Dunham, Ping Gui, Choon S. Lee. **Assistant Professor:** Mohammad Khodayar. **Senior Lecturer:** M. Scott Kingsley. **Adjunct Faculty:** Hakki C. Cankaya, Sudipto Chakraborty, Joseph R. Cleveland, John Fattaruso, Hossam H. H'mimy, Kaushik Josiam, Shantanu Kangude, Clark D. Kinnaird, Christopher Pilcher, Kaiser Saeed, Kamakshi Sridhar, Jennifer Webb.

General Information

The discipline of electrical engineering is at the core of today's technology-driven society. Personal computers, computer-communications networks, integrated circuits, optical technologies, digital signal processors and wireless communications systems have revolutionized the way people live and work, and extraordinary advances in these fields are announced every day. Because today's society truly is a technological one, a degree in electrical engineering offers exceptional opportunities for financial security, personal satisfaction and an expansion of the frontiers of technology. The Department of Electrical Engineering at SMU offers a full complement of courses at the bachelor's degree level in communications, networks, digital signal processing, optoelectronics, electromagnetics, microelectronics, and systems and control.

The mission of the department is as follows:

Through quality instruction and scholarly research, to engage each student in a challenging electrical engineering education that prepares graduates for the full range of career opportunities in the high-technology marketplace and enables them to reach their fullest potential as a professional and as a member of society.

Departmental goals include the following:

- Becoming one of the nation's leading electrical engineering departments by building peaks of excellence in the fields of communications/signal processing and micro/optoelectronics and by being a leader in innovative educational programs.
- Offering undergraduate curricula that equips graduates for careers that require ingenuity, integrity, logical thinking, and the ability to work and communicate in teams, and for the pursuit of graduate degrees in engineering or other fields such as business, medicine and law.
- Offering world-class Ph.D. programs that prepare graduates for academic careers, for research careers in the high-technology industry or for technical entrepreneurship.
- Promoting lifelong learning animated by a passion for the never-ending advance of technology.

The educational objectives of the Electrical Engineering Department undergraduate program are to enable graduates to do the following:

- Be successful in understanding, formulating, analyzing and solving a variety of electrical engineering problems.
- Be successful in designing a variety of engineering systems, products or experiments.

- Be successful in careers and/or graduate study in engineering or other areas such as business, medicine and law.
- Have the ability to assume leadership and entrepreneurial positions.
- Successfully function and effectively communicate both individually and in multidisciplinary teams.
- Understand the importance of lifelong learning, ethics and professional accountability.

The Electrical Engineering Department undergraduate student outcomes as related to the above educational objectives are as follows:

All graduates of the electrical engineering program are expected to have the following:

- The ability to apply knowledge of mathematics, science and engineering.
- The ability to design and conduct experiments, as well as to analyze and interpret data.
- The ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- The ability to function on multidisciplinary teams.
- The ability to identify, formulate and solve engineering problems.
- An understanding of professional and ethical responsibility.
- The ability to communicate effectively.
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
- The recognition of the need for and the ability to engage in lifelong learning.
- A knowledge of contemporary issues.
- The ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

The Electrical Engineering Department is engaged in an ongoing assessment process that evaluates the success in meeting the educational objectives and outcomes and enhances the development of the program.

The undergraduate program in electrical engineering is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The Electrical Engineering Department emphasizes the following major areas of research interest:

- **Biomedical Engineering.** Overview of biomedical engineering, biomedical devices and instrumentation, biomedical signal capture, processing, and modeling.
- **Communications and Information Technology.** Detection and estimation theory, digital communications, computer networks, spread spectrum, cellular communications, coding, encryption, compression, and wireless and optical communications.
- **Control Systems.** Linear and nonlinear systems control, robotics, and computer and robot vision.
- **Digital Signal Processing.** Digital filter design, system identification, spectral estimation, adaptive filters, neural networks and DSP implementations.
- **Image Processing and Computer Vision.** Digital image processing, computer vision and pattern recognition.

- **Lasers, Optoelectronics, Electromagnetic Theory and Microwave Electronics.** Classical optics, fiber optics, laser recording, integrated optics, dielectric waveguides, antennas, transmission lines, laser diodes and signal processors, and superconductive microwave and optoelectronic devices.
- **Solid State Circuits, Computer-Aided Circuit Design and VLSI Design.** Electronic circuits, computer-aided design, very-large-scale integration design and memory interfaces.
- **Electronic Materials and Solid State Devices.** Fabrication and characterization of devices and materials, device physics, noise in solid state devices, infrared detectors, AlGaAs and GaAs devices and materials, superconductivity, superconductive devices and electronics, thin films, hybrid superconductor-semiconductor devices, ultrafast electronics, and applications of a scanning tunneling microscope.
- **Telecommunications.** Overview of modern telecommunications components and systems, data communications, digital telephony, and digital switching.
- **Power Engineering.** Power system operation and planning, renewable energy integration, smart grid, transportation electrification, and resilient energy networks.

Department Facilities

The department has access to the Lyle School of Engineering academic computing resources, consisting of shared-use computer servers and desktop client systems connected to a network backbone. All of the servers in the Lyle School of Engineering are running some variant of UNIX or Microsoft Windows. There is one primary file server that exports files using FNS or CIFS protocols. Each user, whether faculty, staff or student, has a "home" directory on the central file server. This directory is exported to other servers or desktop computers, regardless of operating systems, as needed. There are more than 40 servers whose purposes include the following: file service, UNIX mail, Exchange mail, firewall, UNIX authentication, NT authentication, printer management, lab image download, classroom-specific software, X windows service, news, domain name service, computational resources and general use. This primary file server allows a user's files to be used as a resource in both the UNIX and Microsoft PC environments. Almost all computing equipment within the Lyle School of Engineering is connected to the engineering network at 100 megabits and higher. The network backbone is running at a gigabit per second over fiber. Most servers and all engineering buildings are connected to this gigabit backbone network. The backbone within the Engineering School is connected to both the Internet 2 and the campus network that is then connected to the Internet at large. In addition to servers and shared computational resources, the Lyle School of Engineering maintains a number of individual computing laboratories associated with the departments. Specific department laboratory facilities for instruction and research include the following:

Antenna Laboratory. This laboratory consists of two facilities for fabrication and testing. Most of the antennas fabricated at the SMU antenna lab are microstrip antennas. Small and less complex antennas are made with milling machines, and a photolithic/chemical etching method is used to make more complex and large antennas. Fabricated antennas are characterized with a Hewlett-Packard 5810B network analyzer. Workstations are available for antenna design and theoretical computation. Radiation characteristics are measured at the Dallas-SMU Antenna Characterization Lab located in Richardson, Texas.

Biomedical Engineering Laboratory. This laboratory contains instrumentation for carrying out research in electrophysiology, psychophysics and medical ultrasound. Four Grass physiographs permit the measurement of electroencephalograms as well as visual and auditory evoked brain potentials. The lab also contains a state-of-the-art dual Purkinje eye tracker and image stabilizer made by Fourward Technologies Inc., a Vision Research Graphics 21-inch Digital Multisync Monitor for displaying visual stimuli, and a Cambridge Research Systems visual stimulus generator capable of generating a variety of stimuli for use in psychophysical and electrophysiological experiments. Ultrasound data can also measure with a Physical Acoustics apparatus consisting of a water tank, radio frequency pulser/receiver and radio frequency data acquisition system. Several PCs are also available for instrumentation control and data acquisition.

Multimedia Systems Laboratory. This facility includes an acoustic chamber with adjoining recording studio to allow high-quality sound recordings to be made. The chamber is sound-isolating with double- or triple-wall sheet rock on all four sides, as well as an isolating ceiling barrier above the drop ceiling. The walls of the chamber have been constructed to be nonparallel to avoid flutter echo and dominant frequency modes. Acoustic paneling on the walls of the chamber are removable and allow the acoustic reverberation time to be adjusted to simulate different room acoustics. The control room next to the acoustic chamber includes a large, 4-foot-by-8-foot acoustic window and an inert acoustic door facing the acoustic chamber. Up to 16 channels of audio can be carried in or out of the chamber to the control room. Experiments conducted in the Multimedia Systems Laboratory include blind source separation, deconvolution and dereverberation. Several of the undergraduate courses in electrical engineering use sound and music to motivate system-level design and signal processing applications. The Multimedia Systems Laboratory can be used in these activities to develop data sets for use in classroom experiments and laboratory projects for students to complete.

Wireless Systems Laboratory. This laboratory contains an array of infrastructure for experimentation across a number of wireless frequency bands, platforms and environments for research and instruction in lab-based courses on wireless communications and networking. The infrastructure includes 1) state-of-the-art test equipment for repeatability, control and observability of wireless channels, including complex channel emulators, fixed and mobile spectrum analyzers, wide-band oscilloscopes, and signal generators; 2) a wide range of reprogrammable wireless testbeds that operate from 400 MHz to 6 GHz for IEEE 802.11, cellular, and Bluetooth network and protocol development; and 3) diverse mobile phones and tablets that enable participatory sensing, context-aware applications and large-scale deployment in the field. The in-lab infrastructure is also enhanced by multiple outdoor antennas deployed on campus buildings and buses for understanding real wireless channels.

Semiconductor Processing Cleanroom. The 2,800 square-foot cleanroom, consisting of a 2,400 square-foot, class 10,000 room and a class 1,000 lithography area of 400 square feet, is located in the Jerry R. Junkins Engineering Building. A partial list of equipment in this laboratory includes acid and solvent hoods, photoresist spinners, two contact mask aligners, a thermal evaporator, a plasma asher, a plasma etcher, a turbo-pumped methane hydrogen reactive ion etcher, a four-target sputtering system, a plasma-enhanced chemical vapor deposition reactor, a diffusion-pumped four pocket e-beam evaporator, an ellipsometer, and profilometers. Other equipment includes a boron-trichloride reactive ion etcher, a chemical-assisted ion-beam etcher and a four-tube diffusion furnace. The cleanroom is capable of processing silicon, compound semiconductors and piezo materials for microelectronic, photonic and nanotechnology devices.

Submicron Grating Laboratory. This laboratory is dedicated to holographic grating fabrication and has the capability of sub 10th-micron lines and spaces. Equipment includes a floating air table, an argon ion laser (ultraviolet lines) and an Atomic Force Microscope. This laboratory is used to make photonic devices with periodic features, such as distributed feedback, distributed Bragg reflector, grating-outcoupled and photonic crystal semiconductor lasers.

Photonic Devices Laboratory. This laboratory is dedicated to characterizing the optical and electrical properties of photonic devices. Equipment includes an optical spectrum analyzer, an optical multimeter, visible and infrared cameras, an automated laser characterization system for edge-emitting lasers, a manual probe test system for surface-emitting lasers, a manual probe test system for edge-emitting laser die and bars, and a near- and far-field measurement system.

Photonics Simulation Laboratory. This laboratory has specific computer programs that have been developed and continue to be developed for modeling and designing semiconductor lasers and optical waveguides, couplers and switches. These programs include WAVEGUIDE (calculates near-field, far-field, and effective indices of dielectric waveguides and semiconductor lasers with up to 500 layers, and each layer can contain gain or loss), GAIN (calculates the gain as a function of energy, carrier density and current density for strained and unstrained quantum wells for a variety of material systems), GRATING (uses the Floquet Bloch approach and the boundary element method to calculate reflection, transmission and outcoupling of dielectric waveguides and laser structures with any number of layers), and FIBER (calculates the fields, effective index, group velocity and dispersion for fibers with a circularly symmetric index of refraction profiles). Additional software is under development to model the modulation characteristics of photonic devices.

Photonic Architectures Laboratory. This laboratory is a fully equipped opto-mechanical and electrical prototyping facility, supporting the activities of faculty and graduate students in experimental and analytical tasks. The lab is ideally suited for the packaging, integration and testing of devices, modules and prototypes of optical systems. It has three large vibration isolated tables, a variety of visible and infrared lasers, single element 1-D and 2-D detector arrays, and a large complement of optical and optomechanical components and mounting devices. In addition, the laboratory has extensive data acquisition and analysis equipment, including an IEEE 1394 Fire-Wire-capable image capture and processing workstation, specifically designed to evaluate the electrical and optical characteristics of smart pixel devices and FSOI fiber-optic modules. Support electronics hardware includes various test instrumentation, such as arbitrary waveform generators and a variety of CAD tools for optical and electronic design, including optical ray trace and finite difference time domain software.

Curriculum in Electrical Engineering

The undergraduate curriculum in electrical engineering provides the student with basic principles through required courses, and specialization through a guided choice of elective courses.

Areas of Specialization

Due to the extensive latitude in course selection and to the wide variety of courses available within the Department of Electrical Engineering and within the University as a whole, it is possible for the electrical engineering student to concentrate his or her studies in a specific professional area such as biomedical, computer engineering, engineering leadership, or smart wireless and embedded systems.

Each student may select one specialization or may personalize his or her degree by a particular choice of advanced major electives. Students should choose a specialization as soon as possible; however, for many students, this process continues from term to term as the individual becomes better acquainted with the discipline of electrical engineering and with the choices available.

Bachelor of Science in Electrical Engineering

The electrical engineering curriculum is administered by the Department of Electrical Engineering.

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hours within the electrical engineering curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	28
MATH 1337, 1338, 2339, 2343	
One of MATH 3308 (or CSE 2353), 3315 (or CSE 3365), 3337, 3353	
CHEM 1303	
PHYS 1303, 1304; 1105 *or* 1106	
One elective from PHYS 3305, 3344, 3374; CHEM 1304	
Core Electrical Engineering	21
EE 1350, 2322/2122, 2350, 2370/2170, 2381/2181, 3360	
Junior Electrical Engineering Courses	20
EE 3322/3122, 3381/3181, 3311, 3330, 3352, 3372	
Senior Design Sequence	6
EE 4311, 4312	
General Sequence or Specialization	27
General Sequence:	
CSE 1341, 1342	
One of EMIS 3308, 3309; CEE 3302; CSE 4360	
One of ME 2310, 2320, 2331, 2342; CSE 2341, 2353; *or* any 5000-level EE course approved by adviser	
One of EE 5356, 5357, 5381, 5385, 5387	
One of EE 5310, 5312, 5314, 5321, 5330, 5332, 5333	
One of EE 5352, 5360, 5362, 5370, 5371, 5372, 5373, 5374, 5375, 5376, 5377, 5378, 5379	
6 hours from any EE 5000-level course listed above	

Requirements for the Major (continued)	*Credit Hours*
Engineering Leadership Specialization:	
CSE 1341, 1342	
Three of EMIS 3308, 3309; CEE 3302; CSE 4360	
One of EE 5356, 5357, 5381, 5385, 5387	
One of EE 5310, 5312, 5314, 5321, 5330, 5332, 5333	
One of EE 5352, 5360, 5362, 5370, 5371, 5372, 5373, 5374, 5375, 5376, 5377, 5378, 5379	
3 hours from any EE 5000-level course listed above	
Computer Engineering Specialization:	
CSE 1341, 1342, 2341, 2353, 3353	
EE 5381, 5385	
One of EE 5357, 5387 or CSE 5343	
3 hours from EE 5000-level courses chosen with adviser's approval	
Smart Wireless and Embedded Systems Specialization:	
CSE 1341, 1342, 2341, 2353	
Two of EE 5330, 5333, 5357, 5378, 5379, 5381, 5387	
EE 5377, 5385 (or CSE 5385)	
3 hours from EE 5000-level courses chosen with adviser's approval	
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Note: EE 8000-level courses are primarily for graduate students but may be taken by highly qualified undergraduates with the approval of the adviser and the instructor. Special topics courses also are available.

Each student is expected to complete and file a plan of study with his or her academic adviser. The plan should state specific choices to meet the foregoing requirements and develop an area of specialization when specialization is desired.

Bachelor of Science in Electrical Engineering and Bachelor of Science With a Major in Mathematics

The Electrical Engineering Department and the Mathematics Department offer an integrated curriculum that enables a student to obtain both a B.S.E.E. degree and a B.S. degree with a major in mathematics.

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	34
MATH 1337, 1338, 2339, 2343, 3315, 3337, 3353	
One of MATH 5315, 5325, 5331, 5332, 5334	
CHEM 1303	
PHYS 1303, 1304; 1105 *or* 1106	
Computer Science	6
CSE 1341, 1342	
Core Electrical Engineering	21
EE 1350, 2322/2122, 2350, 2370/2170, 2381/2181, 3360	

Requirements for the Major (continued)	*Credit Hours*
Junior Electrical Engineering Courses	20
EE 3311, 3322/3122, 3330, 3352, 3372, 3381/3181	
Advanced Electives	15
One of EE 5352, 5360, 5362, 5370, 5371, 5372, 5373, 5374, 5375, 5376, 5377, 5378, 5379	
One of EE 5356, 5357, 5381, 5385, 5387	
One of EE 5310, 5312, 5314, 5321, 5330, 5332, 5333	
6 hours from any EE 5000-level course listed above	
Senior Design Sequence	6
EE 4311, 4312	
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Bachelor of Science in Electrical Engineering and Bachelor of Science With a Major in Physics

The Electrical Engineering Department and the Physics Department offer an integrated curriculum that enables a student to obtain both a B.S.E.E. degree and a B.S. degree with a major in physics.

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	48
MATH 1337, 1338, 2339, 2343, 3353	
CHEM 1303	
PHYS 1303/1105, 1304, 3305, 3344, 3374, 4211, 4321, 5337, 5382, 5383	
Computer Science	3
CSE 1341 *or* 1342	
Core Electrical Engineering	24
EE 1350, 2322/2122, 2350, 2370/2170, 2381/2181, 3360, 3372	
Junior Electrical Engineering Courses	17
EE 3311, 3322/3122, 3381/3181	
EE 3330 (*or* PHYS 4392), 3352	
Advanced Electrical Engineering Electives	9
Three of EE 5310, 5312, 5314, 5321, 5330, 5332, 5333, 5356, 5357, 5360, 5370–74, 5376–78, 5381, 5385, 5387	
Senior Design Sequence	6
EE 4311, 4312	
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Bachelor of Science in Electrical Engineering (Biomedical Specialization)

The Department of Electrical Engineering offers a B.S.E.E. degree with a specialization in biomedical engineering. This program enables students to satisfy requirements for admission to medical school.

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hours within this curriculum are distributed as follows:

Requirements for the Specialization	*Credit Hours*
Mathematics and Science	53
MATH 1337, 1338, 2339, 2343 3-hour elective MATH course at the 3000 level or above BIOL 1401, 1402, 3304, 3350 CHEM 1303/1113, 1304/1114, 3371/3117, 3372/3118 PHYS 1303/1105, 1304/1106	
Computer Science	3
CSE 1341 *or* 1342	
Core Electrical Engineering	28
EE 1350, 2322/2122, 2350, 2370/2170, 2381/2181, 3360, 3372, 3381/3181	
Junior Electrical Engineering	9–10
Three from EE 3311, 3322/3122, 3330, 3352	
Advanced Electrical Engineering Elective	3
Any EE 5000-level course approved by adviser	
Biomedical Engineering	6
EE 5340, 5345	
Senior Design Sequence	6
EE 4311, 4312	
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Minor in Electrical Engineering

For information on a minor in electrical engineering, the student should consult the department. A total of 18 credit hours in electrical engineering courses are required: **EE 2322, 3322, 2350, 2370** and six credit hours of elective electrical engineering courses at the 3000 level or above.

Electrical Engineering Courses (EE)

The third digit in a course number designator represents the subject area of the course. The following designators are used:

XX1X Electronic Materials

XX2X Electronic Devices

XX3X Quantum Electronics and Electromagnetic Theory

XX4X Biomedical Science

XX5X Network Theory and Circuits

XX6X Systems

XX7X Information Science and Communication Theory

XX8X Computers and Digital Systems

XX9X Individual Instruction, Research, Seminar and Special Project

EE 1301 (3). MODERN ELECTRONIC TECHNOLOGY. A lecture and laboratory course examining a number of topics of general interest, including the fundamentals of electricity, household electricity and electrical safety, an overview of microelectronics, concepts of frequency and spectrum, the phonograph and the compact disc, bar codes, and communication by radio and TV. Designed for nontechnical students who want to be more knowledgeable. Not open to EE majors.

EE 1350 (3). INTRODUCTION TO ELECTRICAL ENGINEERING. Introduces contemporary electrical and electronic devices, concepts, and systems. Includes principles of engineering design; electrical components and systems such as generators, motors, relays, transistors, and integrated circuits; physical laws; signals and systems for audio and images; signal conversion and manipulation; digital logic; binary representation and coding; radio transmission; and electrical power.

EE 2122 (1). EE LABORATORY: ELECTRONIC CIRCUITS I. Experimental study of basic MOS and bipolar transistors in analog and digital applications. Logic gates and linear and nonlinear applications of operational amplifiers. *Prerequisite:* C- or better in EE 2350. *Corequisite:* EE 2322.

EE 2170 (1). EE LABORATORY: DESIGN AND ANALYSIS OF SIGNALS AND SYSTEMS. Introduces various techniques for analyzing real signals and designing various linear time-invariant systems. Incorporates software-based simulations and actual circuit implementations, and uses Web authoring tools for the production of multimedia lab reports. *Prerequisite:* CSE 1341. *Corequisite:* EE 2370.

EE 2181 (1). LABORATORY: DIGITAL COMPUTER LOGIC. Analysis and synthesis of combinational and sequential digital circuits. Basic digital computer logic circuits are designed, simulated using Verilog HDL, and implemented using DigiDesigner kit and integrated circuits. *Corequisite:* EE 2381.

EE 2190 (1). SOPHOMORE PROJECT.

EE 2290 (2). SOPHOMORE PROJECT.

EE 2322 (3). ELECTRONIC CIRCUITS I. Introduces nonlinear devices used in electronic circuits. Covers the DC and AC analysis of circuits employing diodes, bipolar junction transistors, and MOSFETs. Topics include device I–V characteristics, biasing, transfer characteristic, gain, power dissipation, and the design of amplifier circuits and logic circuits. Also, introduces SPICE simulation for DC and transient simulations. *Prerequisite:* C- or better in EE 2350. *Corequisite:* EE 2122.

EE 2350 (3). CIRCUIT ANALYSIS I. Analysis of resistive electrical circuits, basic theorems governing electrical circuits, power consideration, analysis of circuits with energy storage elements, and transient and sinusoidal steady-state analysis of circuits with inductors and capacitors. *Corequisites:* MATH 2343, PHYS 1304.

EE 2370 (3). DESIGN AND ANALYSIS OF SIGNALS AND SYSTEMS. Introduces standard mathematical tools for analyzing and designing various continuous-time signals and systems. Studies frequency domain design and analysis techniques, the Fourier and Laplace transforms, and applications such as modulation and demodulation in communications and processing of audio signals. *Prerequisites:* MATH 2343, C- or better in EE 2350. *Corequisite:* EE 2170.

EE 2381 (3). DIGITAL COMPUTER LOGIC. Covers digital computers and information, combinational logic circuits, combinational logic design, sequential circuits (e.g., finite-state machines), registers and counters, and memory and programmed logic design. Studies design and simulation of digital computer logic circuits. *Corequisite:* EE 2181.

EE 2390 (3). SOPHOMORE PROJECT.

EE 2490 (4). SOPHOMORE PROJECT.

EE 3122 (1). EE LABORATORY: ELECTRONIC CIRCUITS II. Experiments in analog electronic circuit design. *Prerequisites:* C- or better in EE 2122, 2322. *Corequisite:* EE 3322.

EE 3181 (1). EE LABORATORY: MICROCONTROLLERS AND EMBEDDED SYSTEMS. Fundamentals of microprocessor design, assembly language programming, and embedded system implementation. Students study a widely used family of microprocessors for microcontroller-based system design, assembly-level programming, and hardware interfacing. *Prerequisites:* C- or better in EE 2181, 2381. *Corequisite:* EE 3381.

EE 3190 (1). JUNIOR PROJECT.

EE 3290 (2). JUNIOR PROJECT.

EE 3311 (3). SOLID-STATE DEVICES. A laboratory-oriented elective course that introduces the working principles of semiconductor devices by fabricating and testing silicon MOSFET transistors and III–V based semiconductor lasers in the SMU cleanroom. Lectures explain the basic operation of diodes, bipolar transistors, field effect transistors, light-emitting diodes, semiconductor lasers, and other photonic devices. Additional lectures discuss the basics of device processing, which include photolithography, oxidation, diffusion, ion-implantation, metalization, and etching. Laboratory reports describing the fabrication and testing of devices account for a major portion of the course grade. *Prerequisites:* CHEM 1303, C- or better in EE 2350.

EE 3322 (3). ELECTRONIC CIRCUITS II. Introduction to MOSFET analog electronic circuits. Provides a background for understanding modern electronic circuits such as digital-to-analog and analog-to-digital converters, active filters, switched-capacitor circuits, and phase-locked loops. Topics include MOSFET SPICE models, basic MOSFET, single-stage amplifiers, current-mirrors, differential amplifier stages, source-follower buffer stages, high-gain common-source stages, operational amplifier, frequency response, and negative feedback. *Prerequisites:* C- or better in EE 2122, 2322, and 2350. *Corequisite:* EE 3122.

EE 3330 (3). ELECTROMAGNETIC FIELDS AND WAVES. Vector analysis applied to static electric and magnetic fields, development of Maxwell's equations, elementary boundary-value problems, and determination of capacity and inductance. Introduction to time-varying fields, plane waves, and transmission lines. *Prerequisites:* EE 2350, MATH 2339.

EE 3352 (3). FUNDAMENTALS OF ELECTRIC POWER ENGINEERING. Introduction to electric power generation and distribution. Topics include energy resources such as fossil, hydraulic, wind, solar, and nuclear energies. Also, three-phase power generators and transformers, and electric machines such as induction motors, synchronous generators, DC and stepper motors, and power converters. *Prerequisite:* EE 2350 or permission of instructor.

EE 3360 (3). STATISTICAL METHODS IN ELECTRICAL ENGINEERING. An introduction to probability, elementary statistics, and random processes. Topics include fundamental concepts of probability, random variables, probability distributions, sampling, estimation, elementary hypothesis testing, basic random processes, stationarity, correlation functions, power-spectral-density functions, and the effect of linear systems on such processes. *Prerequisites:* C- or better in EE 2170, 2370.

EE 3372 (3). INTRODUCTION TO SIGNAL PROCESSING. Gives juniors a thorough understanding of the techniques needed for the analysis of discrete-time systems. Topics include Fourier methods and Z transform techniques, discrete Fourier transform, fast Fourier transform and applications, and digital filters. *Prerequisites:* C- or better in EE 2170, 2370.

EE 3381 (3). MICROCONTROLLERS AND EMBEDDED SYSTEMS. An introduction to microcontrollers and embedded systems. Students study a widely used family of microprocessors as an introduction to architecture, software, and interfacing concepts. Topics include number systems and arithmetic operations for computers, assembly and C language programming, microprocessor organization and operation, memory and I/O port interfacing, and microprocessor-based controller design. Students write, assemble, and execute embedded programs designed for various applications. *Prerequisites:* C- or better in EE 2381. *Corequisite:* EE 3181.

EE 3390 (3). JUNIOR PROJECT.

EE 3490 (4). JUNIOR PROJECT.

EE 4090 (0). SENIOR PROJECT.

EE 4096 (0). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

EE 4196 (1). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

EE 4296 (2). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

EE 4311 (3). SENIOR DESIGN I. Areas covered are tailored to the student's area of specialization. The student chooses a specific senior design project in electrical engineering from the available projects proposed by the faculty. Depending upon the specifics of the project, each student designs, constructs, and tests a solution and then submits a formal report to the faculty in charge of the project. *Prerequisites:* EE 2322, 3381 and EE senior standing.

EE 4312 (3). SENIOR DESIGN II. Areas covered are tailored to the student's area of specialization. The design project selected may be a continuation of the project undertaken in EE 4311, a new project selected from the list of available projects offered by the faculty, or a project proposed by the student and approved by the faculty. Depending upon the specifics of the project, a team designs, constructs, and tests a solution and then submits a formal report to the faculty in charge of the project. *Prerequisite:* EE 4311.

EE 4396 (3). SENIOR THESIS. *Prerequisite:* Admission to the departmental distinction program.

EE 4490 (4). SENIOR PROJECT.

EE 5050 (0). UNDERGRADUATE INDUSTRIAL INTERNSHIP. Represents a term of industrial work experience for noncooperative education students. Designates a student as full time for the term but carries no academic credit. Students register for the course in the same manner as for other SMU courses except that no tuition is charged. The course grade is determined by the grading of a written report by the student's adviser at the end of the term.

EE 5176 (1). NETWORK SIMULATION LABORATORY. An introductory, hands-on course in simulations of computer networks intended to be taken simultaneously with EE 5376 or other networks courses. Lab exercises use OPNET and other simulation software to visualize network protocols and performance. Students run a number of simulation exercises, which are designed to complement classroom instruction, to set up various network models, specify protocols, and collect statistics on network performance. General familiarity with PCs is recommended. *Corequisites:* EE 5376 and senior standing.

EE 5190 (1). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5290 (2). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5310 (3). INTRODUCTION TO SEMICONDUCTORS. Studies the basic principles in physics and chemistry of semiconductors that have direct applications on device operation and fabrication. Topics include basic semiconductor properties, elements of quantum mechanics, energy band theory, equilibrium carrier statistics, carrier transport, and generation-recombination processes. Applies these physical principles to semiconductor devices. Devices studied include metal-semiconductor junctions, p n junctions, LEDs, semiconductor lasers, bipolar junction transistor, field-effect transistors, and integrated circuits. Emphasizes obtaining the governing equations of device operation based on physical properties. *Prerequisite:* EE 3311.

EE 5312 (3). COMPOUND SEMICONDUCTOR DEVICES AND PROCESSING. This laboratory-oriented elective course for upper-level undergraduates and graduate students provides in-depth coverage of processing of InP- and GaAs-based devices in addition to silicon integrated circuit processing. Students without fabrication experience fabricate and characterize MOSFETs and semiconductor lasers. Students with some previous fabrication experience (such as EE 3311) fabricate and test an advanced device mutually agreed upon by the student(s) and instructor. Examples of such devices include high electron mobility transistors, heterojunction bipolar transistors, phase shifters, distributed Bragg reflector lasers, grating-assisted directional couplers, and semiconductor lasers from developing materials such as GaInNAs. The governing equations of photolithography, oxidation, diffusion, ion-implantation, metallization, and etching are derived from fundamental concepts. Silicon process modeling uses the CAD tool SUPREM. Optical components modeling uses the SMU-developed software WAVEGUIDE, GAIN, and GRATING. Includes peer review before final submission of a laboratory report describing the projects. *Prerequisite:* EE 3311 or equivalent.

EE 5313 (3). SOLAR CELLS AND APPLICATIONS. This laboratory-oriented course explores the sun's energy as a source of electrical power and the working principles of silicon and III–V solar cells. Covers characteristics of the sun, semiconductor properties, p n junctions, solar cell fabrication, and photovoltaic system design. Students fabricate and test silicon solar cells in the SMU cleanroom. Lectures and class discussions explain the basic operation of p-n junction diodes and solar cells along with the basics of device processing, including photolithography, oxidation, diffusion, ion implantation, metallization, and etching. *Prerequisite:* EE 3311 or permission of instructor.

EE 5314 (3). INTRODUCTION TO MICROELECTROMECHANICAL SYSTEMS. Develops the basics for MEMS, including microactuators, microsensors, and micromotors; principles of operation; micromachining techniques (surface and bulk micromachining), IC-derived microfabrication techniques; and thin lm technologies as they apply to MEMS. *Prerequisite:* EE 3311.

EE 5321 (3). SEMICONDUCTOR DEVICES AND CIRCUITS. A study of the basics of CMOS integrated analog circuits design. Topics include MOSFET transistor characteristics, DC biasing, small-signal models, different amplifiers, current mirrors, single- and multi-stage electronic amplifiers, frequency response of electronic amplifiers, amplifiers with negative feedback, and stability of amplifiers. Each student completes one or more design projects by the end of the course. *Prerequisites:* EE 3122, 3322.

EE 5330 (3). ELECTROMAGNETICS: GUIDED WAVES. Application of Maxwell's equations to guided waves. Transmission lines, plane wave propagation and reflection, hollow waveguides, dielectric waveguides, fiber optics, and cavity and dielectric resonators. *Prerequisite:* EE 3330.

EE 5332 (3). ELECTROMAGNETICS: RADIATION AND ANTENNAS. Covers polarization, reflection, refraction, and diffraction of EM waves; dipole, loop, slot and reflector antennas; array analysis and synthesis; self and mutual impedance; and radiation resistance. *Prerequisite:* EE 3330.

EE 5333 (3). ANTENNAS AND RADIO WAVE PROPAGATION FOR PERSONAL COMMUNICATION. Covers three important aspects of telecommunications: fixed site antennas, radio wave propagation, and small antennas proximate to the body. Topics include electromagnetics fundamentals; general definitions of antenna characteristics; electromagnetic theorems for antenna applications; various antennas for cellular communications, including loop, dipole, and patch antennas; wave propagation characteristics as in earth satellite communications, radio test sites, urban and suburban paths, and multipath propagation; and radio communication systems. *Prerequisite:* EE 3330.

EE 5336 (3). INTRODUCTION TO INTEGRATED PHOTONICS. Covers the issues of integrated photonics, fundamental principles of electromagnetic theory, waveguides, simulation of waveguide modes, and photonic structures, with a focus on optical waveguides and numerical simulation techniques because advances in optical communications will be based on nanostructure waveguides coupled with new materials. Topics include Maxwell's equations; slab, step index, and rectangular and graded index wave guides. Also, dispersion, attenuations, nonlinear effects, numerical methods, coupled mode theory, and extensive use of mathematical packages such as MATLAB and Mathematica. *Prerequisites:* C- or better in EE 3311, 3330 or permission of instructor.

EE 5340 (3). BIOMEDICAL INSTRUMENTATION. Application of engineering principles to solving problems encountered in biomedical research. Topics include transducer principles, electrophysiology, and cardiopulmonary measurement systems. *Prerequisites:* C- or better in EE 2122, 2322 and junior standing.

EE 5345 (3). MEDICAL SIGNAL ANALYSIS. Looks at the analysis of discrete-time medical signals and images. Topics include the design of discrete-time filters, medical imaging and tomography, signal and image compression, and spectrum estimation. The course project explores the application of these techniques to actual medical data. *Prerequisite:* EE 3372.

EE 5351 (3). POWER SYSTEM OPERATION AND ELECTRICITY MARKETS. An overview of power generation systems, economic operation of power systems, and electricity market operation. Introduces mathematical optimization methods used to solve practical problems in power system operation addressing economic and technical aspects of power generation and transmission. Topics include power generation characteristics; economic dispatch; unit commitment and proposed solution methodologies; the effect of transmission systems on unit commitment and economic dispatch of power systems; restructuring in power systems; power pools and bilateral contracts; pricing in electricity markets; day-ahead, real-time, and ancillary service markets; financial transmission rights; competition between market participants; congestion management; and demand response.

EE 5352 (3). POWER SYSTEMS ANALYSIS. Provides an overview of the power systems, including complex power calculation; theory of balanced three-phase circuits; per-unit system;

transmission line characteristics for short, medium, and long lines; power flow analysis; three-phase balance fault; unbalanced fault and sequence impendences; and transient stability analysis in power systems. *Prerequisites:* Basic knowledge of electric power systems, fundamentals of electric power engineering (EE 3352) or equivalent.

EE 5356 (3). VLSI DESIGN AND LABORATORY. Explores the design aspects involved in the realization of CMOS integrated circuits from device up to the register subsystem level. Addresses major design methodologies, with emphasis placed on structured, full-custom design. Also, the MOS device, CMOS inverter static characteristics, CMOS inverter dynamic characteristics, CMOS transistor fabrication technology, combination logic circuit, alternative static logic circuit, sequential logic circuit, dynamic logic circuit, propagation delay and interconnect, power dissipation and design for low power, memory device (DRAM, SRAM, ROM), electrostatic discharge protection, packaging, testing, and VLSI design flow. Students use state-of-the-art CAD tools to verify designs and develop efficient circuit layouts. *Prerequisites:* C- or better in EE 2181, 2322, 2381.

EE 5357 (3). CAE TOOLS FOR STRUCTURED DIGITAL DESIGN. Concentrates on the use of CAE tools for the design and simulation of complex digital systems. Discusses and uses Verilog hardware description language for behavioral and structural hardware modeling. Emphasizes structured modeling and design. Design case studies include a pipelined processor, cache memory, UART, and a floppy disk controller. *Prerequisites:* C- or better in EE 2381 and junior standing, or permission of instructor.

EE 5360 (3). ANALOG AND DIGITAL CONTROL SYSTEMS. Feedback control of linear continuous and digital systems in the time and frequency domain. Topics include plant representation, frequency response, stability, root locus, linear state variable feedback, and design of compensators. *Prerequisite:* EE 3372.

EE 5370 (3). COMMUNICATION AND INFORMATION SYSTEMS. An introduction to communication in modulation systems in discrete and continuous time, information content of signals, and the transition of signals in the presence of noise. Also, amplitude, frequency, phase and pulse modulation, and time and frequency division multiplexing. *Prerequisite:* EE 3360.

EE 5371 (3). ANALOG AND DIGITAL FILTER DESIGN. Covers approximation and analog design of Butterworth, Chebyshev, and Bessel filters; basic frequency transformations for designing low-pass, band-pass, band-reject, and high-pass filters; concept of IIR digital filters using impulse-invariant and bilinear transformations; design of FIR digital filters using frequency sampling and window methods; canonical realization of IIR and FIR digital filters; wave digital filters; and an introduction to two-dimensional filters. *Prerequisite:* EE 3372.

EE 5372 (3). TOPICS IN DIGITAL SIGNAL PROCESSING. Provides an extended coverage of processing of discrete-time signals. Reviews discrete-time signals and the analysis of systems in both the time and frequency domains. Topics include multirate signal processing, digital filter structures, filter design, and power spectral estimation. *Prerequisite:* EE 3372.

EE 5373 (3). DSP PROGRAMMING LABORATORY. Utilizes a hands-on approach that focuses on the essentials of programming digital signal processors (programmable semiconductor devices used extensively in digital cellular phones, high-density disk drives, and high-speed modems) while minimizing signal processing theory. Focuses on programming the Texas Instruments TMS320C50, a fixed-point processor. Emphasizes assembly language programming, and Topics include implementation of FIR and IIR filters, the FFT, and a real-time spectrum analyzer. *Recommended:* Basic knowledge of discrete-time signals and digital logic systems. *Prerequisite:* EE 3372.

EE 5374 (3). DIGITAL IMAGE PROCESSING. Introduces the basic concepts and techniques of digital image processing. Topics include characterization and representation of images, image enhancement, image restoration, image analysis, image coding, and reconstruction. *Prerequisite:* EE 5372.

EE 5375 (3). RANDOM PROCESSES IN ENGINEERING. An introduction to probability and stochastic processes as used in communication and control. Topics include probability theory, random variables, expected values and moments, multivariate Gaussian distributions, stochastic processes, autocorrelation and power spectral densities, and an introduction to estimation and queuing theory. *Prerequisite:* EE 3360.

EE 5376 (3). INTRODUCTION TO COMPUTER NETWORKS. Surveys basic topics in communication networks, with an emphasis on layered protocols and their design. Topics include OSI protocol reference model, data link protocols, local area networks, routing, congestion control, network management, security, and transport layer protocols. Network technologies include telephony, cellular, Ethernet, Internet protocol, TCP, and ATM. Assignments may include lab exercises involving computer simulations. *Corequisites:* EE 5176 and senior standing.

EE 5377 (3). EMBEDDED WIRELESS DESIGN LABORATORY. A wide variety of real-world experiences in wireless communications and networking using FPGAs equipped with embedded microprocessors. Covers basic wireless concepts of scheduled and random access as well as modulation and power control via labs that enable implementation of cellular and 802.11-based wireless protocols such as TDMA, Aloha, CSMA, and CSMA/CA. Also, broader topics such as embedded programming, interrupt-driven operation, and FPGA-based design. In a course project, student teams design novel wireless protocols and carry out experiments to measure the performance. *Prerequisite:* C- or better in EE 3360 or equivalent, or permission of instructor.

EE 5378 (3). MOBILE PHONE EMBEDDED DESIGN. Students learn to develop embedded software for the most widely used smartphone platforms, with emphasis on wireless and sensing applications. Topics include user interface design such as multitouch and basic HCI design tenets, storing and fetching data with local networked systems and databases, localization via GPS and wireless signal triangulation, sensing environmental and user characteristics, networking with various wireless protocols, graphics rendering, multimedia streaming, and designing for performance (e.g., controlling memory leaks, object allocation, and multithreading). Draws from various fields, including wireless communications and networking, embedded programming, and computer architecture.

EE 5379 (3). OPTIMIZATION IN WIRELESS NETWORKS. Covers a wide variety of optimization problems in the design and operation of wireless networks. Introduces basic linear programming and integer linear programming concepts and explains these concepts using examples from wired and wireless networks. Also, the basic structure and design of various wireless networks, including cellular networks (such as GSM) and wireless LANs (e.g., those based on 802.11g/n). *Prerequisite:* EE 2170 or equivalent, or permission of instructor.

EE 5381 (3). DIGITAL COMPUTER DESIGN. Emphasizes design of digital systems and register transfer. Design conventions, addressing modes, interrupts, input-output, channel organization, high-speed arithmetic, and hardwired and microprogrammed control. Also, central processor organization design and memory organization. Each student completes one or more laboratory projects. *Prerequisites:* C- or better in EE 2181, 2381 and junior standing.

EE 5385 (3). MICROCONTROLLER ARCHITECTURE AND INTERFACING. Emphasizes the design of embedded systems using microcontrollers. Briefly reviews microcontroller architecture. Includes hierarchical memory systems and interfacing of memory and peripherals, industry standard bus interfaces and other applicable standards, and topics in real-time operating systems and system-level design considerations. The corequisite laboratory requires students to develop software using assembler and high-level languages. *Prerequisite:* CSE 3381 or EE 3181, 3381.

EE 5387 (3). DIGITAL SYSTEMS DESIGN. Modern topics in digital systems design, including the use of HDLs for circuit specification and automated synthesis tools for realization. Programmable logic devices are emphasized and used throughout the course. Includes heavy laboratory assignment content and a design project. *Prerequisite:* C- or better in EE 2381 or in CSE 3381.

EE 5390 (3). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5391 (3). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5392 (3). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5393 (3). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5395 (3). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

EE 5490 (4). SPECIAL TOPICS. This special topics course must have a section number associated with a faculty member. The department offers special topics courses with a range of credit hours; the last digit in the course number represents courses with different topics.

Telecommunication Courses (EETS)

EETS 5301 (3). INTRODUCTION TO TELECOMMUNICATIONS. Overview of public and private telecommunications systems, traffic engineering, switching, transmission, and signaling. Also, channel capacity, media characteristics, Fourier analysis and harmonics, modulation, electromagnetic wave propagation and antennas, modems and interfaces, digital transmission systems, T1 carriers, digital microwave, satellites, fiber optics and SONET, and integrated services digital networks.

EETS 5302 (3). TELECOMMUNICATIONS MANAGEMENT AND REGULATION. Managerial sequel to EETS 5301 that provides a historical review of the most significant regulation and management issues affecting the telecommunications industry over the past 100 years. Students explore the regulatory environment the industry operates in today through the study of current events, articles, and recent state and federal legislation. *Prerequisite:* EETS 5301 (formerly EE 5301) or experience in the telecommunications industry.

EETS 5303 (3). FIBER OPTIC TELECOMMUNICATIONS. Introduction to the practical concepts involved in optical fiber communications systems. Covers basic optical principles, dielectric slab-waveguides, fiber waveguides, integrated optics devices, and the major components of a fiber communications link, including optical sources, detectors, and fibers.

EETS 5304 (3). NETWORK PROTOCOLS. Introduction to the protocol architecture of the Internet, following a bottom-up approach to the protocol layers. Provides an understanding of the internetworking concepts in preparation for advanced networking courses. Covers networking technologies (e.g., local area networks, packet switching, and ATM), Internet protocol and TCP/UDP in-depth, and an overview of important application protocols (e.g., HTTP, client/server computing, SMTP, FTP, and SNMP). *Prerequisite:* EETS 5301 or equivalent.

ENGINEERING MANAGEMENT, INFORMATION AND SYSTEMS

Professor Sila Çetinkaya, **Chair**

Professors: Sila Çetinkaya, Jeff Tian, Halit Üster. **Associate Professors:** Richard S. Barr, Eli V. Olinick. **Professor of Practice:** Jerrell T. Stracener. **Assistant Professor:** Michael Hahsler. **Senior Lecturers:** Leslie-Ann Asmus, Thomas F. Siems. **Lecturers:** Gretchen H. Coleman, Rachel P. Goodman. **Adjunct Faculty:** Karl J. Arunski, Charles W. Beall, Robert L. Bell, William D. Bell, George W. Chollar, Randall Clendening, Howard S. Cowin, Christopher M. Davis, John R. Graham, III, Michael E. Hopper, Robert H. Jones, John I. Lipp, James K. McCloud, William H. Muto, William P. Nanry, Robert S. Oshana, Oscar K. Pickels, James B. Rodenkirch, Christopher A. Rynas, Mark E. Sampson, Nandlal M. Singh, Stephen C. Skinner, Gheorghe M. Spiride, Russell A. Vacante, John W. Via, III, Timothy D. Woods, John R. Yarrow, Hossam A. Zaki.

General Information

The EMIS Department brings together the school's technical management and operations areas to offer a Bachelor of Science with a major in management science. This program focuses on computer models for decision-making and the application of engineering principles and techniques to enhance organizational performance. Faculty specializations include optimization, advanced analytics, telecommunications network design and management, supply-chain systems, systems engineering, logistics, quality control, reliability engineering, data science, information engineering, benchmarking, operations planning and management, network optimization, and mathematical programming.

The same systems-oriented, mathematical-model-based approach that is the cornerstone of engineering also has powerful application within organizations and their operations. This is the field of management science – also termed "the science of better" – the discipline of applying advanced analytical methods to help make better decisions.

Additional Majors and the 4+1 Program

Because of the flexibility of the curriculum, the majority of management science majors choose to receive a second major or one or more minors from a wide range of other disciplines. Examples include a Bachelor of Science, a major in management science or a second bachelor's degree in economics, mathematics, business, computer science, history, psychology, Spanish or French.

Other management science majors continue their studies to obtain a Master of Science in Engineering Management, systems engineering, information engineering or operations research. The 4+1 Program allows students to accelerate progress toward completion of a graduate degree.

More information on these and other options available to management science majors is available at www.smu.edu/Lyle/Departments/EMIS. EMIS faculty and advisers are also available to answer questions about the program.

Computing Facilities

Students in the EMIS Department have access to a wide range of computing facilities and networking equipment. The department manages three PC-based computing labs, including the Enterprise Systems Design Laboratory created for students in the senior design course. General-use UNIX and Linux machines (including eight-processor 64-bit Xeon workstations) provide advanced computing, analytical software and Web hosting to all engineering students. Windows- and Linux-based PCs and workstations are the primary desktop equipment. All computing facilities are networked via high-speed Ethernet, with Gigabit Ethernet connections to Internet 1, Internet 2 and the National Lambda Rail research network. Open computing labs and wireless services provide additional facilities access points for students.

Curriculum in Management Science

Management science deals with the development of mathematically based models for planning, managing, operating and decision-making. In the EMIS curriculum, these methods are also applied to the design and management of efficient systems for producing goods and delivering services.

A management scientist at a major airline would be concerned with building mathematical models to decide the best flight schedules, plane routes, and assignments of pilots and crews to specific flights and of flights to specific gates, as well as the best number of planes to own and operate, cities to fly to, cities to use as major hubs, layout for an airport terminal, overbooking policy and location to refuel aircraft. Optimal and good usable solutions for such issues can be uncovered through analysis with computer-based mathematical models. The management scientist develops an understanding of a practical decision problem, then designs and constructs a model that incorporates data from the MIS department and produces a high-quality solution.

Because of its generality, management science has broad applications in all engineering disciplines and in the fields of computer science, economics, finance, marketing, medicine, logistics, production, information engineering and statistics. Management science methods are used extensively in industry and government, and SMU's EMIS program prepares the technically oriented student to excel in today's competitive business environment. ABET, www.abet.org, does not provide accreditation for the discipline of management science.

Bachelor of Science With a Major in Management Science

Curriculum Notes. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hours within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics	12
MATH 1337, 1338, 3315 or 3316, 3353	
Science / Social Science	15
ECO 1311, 1312	
3 hours in natural science from group 1	
3 hours in natural science or technology from groups 1 and 2	
3 hours from groups 1, 2, and 3	
Group 1:	
BIOL 1401, 1402	
CEE 1331	
CHEM 1303/1113, 1304/1114	
GEOL 1301, 1305, 1307, 1308, 1313, 1315, 2320	
PHYS 1303/1105, 1304/1106, 1307/1105, 1308/1106, 1320	

Requirements for the Major (continued)	Credit Hours
Science / Social Science (continued)	
Group 2:	
ANTH 2315, 2363	
CEE 1301, 1378	
CSE 1331	
EE 1301, 1382	
ME 1301, 1202/1102, 1303	
PHYS 1403, 1404	
Group 3: Other courses in ANTH, ECO, PSYC, or SOCI	
Major Concentration	45
EMIS 1360, 2360, 3308 (or MNO 3370), 3309, 3340, 3360, 3361, 4395, 5362	
CEE 3302	
CSE 1341, 1342, 4360	
6 hours from EMIS courses at the 5000 level or above	
Business	6
ACCT 2301	
MKTG 3340	
Electives	15
Adviser must approve electives.	
	93

Note: All management science majors must earn a grade of at least *C-* in all courses taken in fulfillment of the requirements for the major; however, a grade of *C* or better is required in all subset classes. All courses must be taken for a grade (not pass/fail), with the exception of those courses for which the student has received test credit.

Minor in Management Science

For information on a minor in management science, the student should consult the department. The minor in management science operates concurrently with the B.S. degree. Students seeking a minor in management science must meet the same admission and subset requirements as students seeking a B.S. degree as described in the Admission to Advanced Standing section of this catalog, and they will be enrolled in the same sections of courses as B.S. management science majors. A total of 15 credit hours (in addition to the required subset courses) are required for the minor in management science: **EMIS 1360, 2360, 3340, 3360** and **MATH 3353.**

The Courses (EMIS)

EMIS 1305 (3). COMPUTING TECHNOLOGY: HISTORICAL AND ETHICAL PERSPECTIVES. Introduces historical and ethical implications of computer architecture, software, hardware, telecommunications, and artificial intelligence. Develops business software skills and Internet concepts for research and communication applications. Credit is not allowed for a computer science, computer engineering, or management science major or minor.

EMIS 1307 (3). INFORMATION TECHNOLOGY FOR BUSINESS. Focuses on the use of information technology in business; explains computer systems and component parts, terms used by technologists, and use of business software packages. No credit for EMIS majors or minors.

EMIS 1360 (3). INTRODUCTION TO MANAGEMENT SCIENCE. Management science is the application of mathematical modeling and scientific principles to solve problems and improve life in society. Students learn to develop plans, manage operations, and solve problems encountered in business and government. *Prerequisite:* Knowledge of college-level algebra. *Corequi-*

sites: MATH 1337, CSE 1341. Students are limited to a maximum of two enrollments in the course; medical withdrawals will be reviewed on a case by case basis.

EMIS 2360 (3). ENGINEERING ECONOMY. Evaluation of engineering alternatives by equivalent uniform annual cost, present worth, and rate-of-return analysis. Use of a computerized financial planning system. Credit not allowed for both EMIS 2360 and EMIS 8361. *Prerequisites:* C- or better in MATH 1337 and knowledge of introductory probability and statistics. *Corequisites:* MATH 1338 and CSE 1342 (must enroll in lab).

EMIS 2375 (3). CULTURAL AND ETHICAL IMPLICATIONS OF TECHNOLOGY. Explores the pervasive use of technology in today's society, the impact of technology on daily life, and the tie between technology and ethical responsibility. Students learn how their lives are being shaped by technology and how they in turn help shape technology.

EMIS 3150 (1). ETHICS IN COMPUTING. Computer professionals have a special responsibility to ensure ethical behavior in the design, development, and use of computers and computer networks. This course focuses on the education of the undergraduate through the study of ethical concepts and the social, legal, and ethical implications involved in computing. Issues to be studied include computer crimes, software theft, hacking and viruses, intellectual property, unreliable computers, technology issues in the workplace, and professional codes of ethics. *Prerequisite:* Junior standing.

EMIS 3308 (3). ENGINEERING MANAGEMENT. Examines planning, financial analysis, organizational structures, management of the corporation (including its products, services, and people), transfer of ideas to the marketplace, and leadership skills. Credit is not allowed for both EMIS 3308 and the same course offered by another department; credit is not allowed for both EMIS 3308 and EMIS 7351. *Prerequisite:* Junior standing. Lyle undergraduate majors only.

EMIS 3309 (3). INFORMATION ENGINEERING AND GLOBAL PERSPECTIVES. Examines global and information aspects of technology- and information-based companies. Credit is not allowed for the same course offered by another department. Credit is not allowed for both EMIS 3309 and EMIS 7357. *Prerequisite:* Junior standing. Lyle undergraduate majors only.

EMIS 3340 (3). STATISTICAL METHODS FOR ENGINEERING AND APPLIED SCIENTISTS. Basic concepts of probability and statistics useful in the solution of engineering and applied science problems. Topics include probability, probability distributions, data analysis, sampling distributions, estimations, and simple tests of hypothesis. Credit is not allowed for both EMIS 3340/STAT/CSE 4340 and EMIS 5370. *Prerequisite:* C- or better in MATH 1338 or equivalent.

EMIS 3360 (3). OPERATIONS RESEARCH. A survey of models and methods of operations research. Covers deterministic and stochastic models in a variety of areas. Credit is not allowed for both EMIS 3360 and 8360. Must enroll in lab. *Prerequisite:* C- or better in EMIS 1360. Management science majors, management science minors, or math operations research specialization majors only.

EMIS 3361 (3). STOCHASTIC MODELS IN OPERATIONS RESEARCH. Covers the formulation, solution, and application of models for decision-making under uncertainty. Probabilistic and statistical methodologies (e.g., decision analysis, queuing theory, stochastic process, Markov chains, and simulation models) address problems in the design, management, and usage of efficient systems for producing goods and delivering services. Students use specialized software and spreadsheet add-ins for model-building and problem-solving. Weekly 1-hour, 20-minute laboratory. *Prerequisite:* C- or better in EMIS 3340. *Corequisite:* MATH 3353. Management science majors only.

EMIS 4390 (3). UNDERGRADUATE PROJECT. An opportunity for the advanced undergraduate student to undertake independent investigation, design, or development. Written permission of the supervising faculty member is required before registration.

EMIS 4395 (3). SENIOR DESIGN. Consists of a large project involving the design of a management system, model building, data collection and analysis, and evaluation of alternatives. *Prerequisites:* C- or better in EMIS 5362 and senior standing.

EMIS 5050 (0). UNDERGRADUATE INTERNSHIP.

EMIS 5190 (1). SPECIAL TOPICS. Individual or group study of selected topics in management science. *Prerequisite:* Permission of instructor.

EMIS 5290 (2). SPECIAL TOPICS. Individual or group study of selected topics in management science. *Prerequisite:* Permission of instructor.

EMIS 5300 (3). SYSTEMS ANALYSIS METHODS. Introduction to modeling and analysis concepts, methods and techniques used in systems engineering, design of products and associated production, and logistics systems and analysis of operational system performance. Specific topics include probabilistic and statistical methods, Monte Carlo simulation, optimization techniques, applications of utility and game theory, and decision analysis.

EMIS 5301 (3). SYSTEMS ENGINEERING PROCESS. Examines the discipline, theory, economics, and methodology of systems engineering. Reviews the historical evolution of the practice of systems engineering and the principles that underpin modern systems methods. Emphasizes the economic benefits of investment in systems engineering and the risks of failure to adhere to sound principles. Develops an overview perspective distinct from the traditional design- and analytical-specific disciplines.

EMIS 5303 (3). INTEGRATED RISK MANAGEMENT. Introduction to risk management based upon integrated trade studies of program performance, cost, and schedule requirements. Topics include risk planning, risk identification and assessment, risk handling and abatement techniques, risk impact analysis, management of risk handling and abatement, and subcontractor risk management. Examines integrated risk management methods, procedures, and tools.

EMIS 5305 (3). SYSTEMS RELIABILITY, SUPPORTABILITY, AND AVAILABILITY ANALYSIS. Introduction to systems reliability, maintainability, supportability, and availability modeling and analysis, with an application to systems requirements definition and systems design and development. Covers both deterministic and stochastic models. Emphasizes RMS/A analyses to establish a baseline for systems performance and to provide a quantitative basis for systems trade-offs. *Prerequisite:* EMIS 5300.

EMIS 5307 (3). SYSTEMS INTEGRATION AND TEST. Examines the process of successively synthesizing and validating larger and larger segments of a partitioned system within a controlled and instrumented framework. System integration and test is the structured process of building a complete system from its individual elements and is the final step in the development of a fully functional system. Stresses the significance of structuring and controlling integration and test activities. Presents formal methodologies for describing and measuring test coverage, as well as sufficiency and logical closure for test completeness. Discusses interactions with system modeling techniques and risk management techniques. Based upon principles of specific engineering disciplines and best practices, which form a comprehensive basis for organizing, analyzing, and conducting integration and test activities.

EMIS 5310 (3). SYSTEMS ENGINEERING DESIGN. Introduces system design of complex hardware and software systems. Includes design concept, design characterization, design elements, reviews, verification and validation, threads and incremental design, unknowns, performance, management of design, design metrics, and teams. Centers on the development of real-world examples.

EMIS 5315 (3). SYSTEMS ARCHITECTURE DEVELOPMENT. A design-based methodological approach to system architecture development using emerging and current enterprise architecture frameworks. Covers structured analysis, object-oriented analysis and design approaches, enterprise architecture frameworks (e.g., Zachman framework, FEAF, DoDAF, and ANSI/IEE-1471) executable architecture model approaches as tools for system-level performance evaluation and trade-off analyses, case studies in enterprise architecture development, and the integration of architecture design processes into the larger engineering-of-systems environment. *Prerequisite:* EMIS 5301.

EMIS 5320 (3). SYSTEMS ENGINEERING LEADERSHIP. Augments the management principles embedded in the systems engineering process with process design and leadership principles and practices. Places emphasis on leadership principles by introducing the underlying behavioral science components, theories, and models. Demonstrates how the elements of systems engineering, project management, process design, and leadership integrate into an effective leadership system. *Prerequisite:* EMIS 5301.

EMIS 5330 (3). SYSTEMS RELIABILITY ENGINEERING. In-depth coverage of tasks, processes, methods, and techniques for achieving and maintaining the required level of system reliability considering operational performance, customer satisfaction, and affordability. Includes establishing system reliability requirements, reliability program planning, system reliability modeling and analysis, system reliability design guidelines and analysis, system reliability test and evaluation, and maintaining inherent system reliability during production and operation.

EMIS 5332 (3). DATA MINING FOR ANALYTICS. Analytics is based on collecting, managing, exploring, and acting on large amounts of data, and it has become a source of competitive advantage for many organizations. This course introduces data mining techniques (classification, association analysis, and cluster analysis) used in analytics. Reinforces all material covered through hands-on experience using state-of-the art tools to design and execute data mining processes. *Prerequisite:* Background in descriptive statistics and probability.

EMIS 5335 (3). HUMAN SYSTEMS INTEGRATION. Advances the understanding and application of cognitive science principles, analysis-of-alternatives methods, and engineering best practices for addressing the role of humans within the design of high-technology systems. Presents and discusses HSI-specific processes such as task-centered design; human factors engineering; manpower, personnel, and training; process analysis; and usability testing and assessment. *Prerequisite:* EMIS 5301.

EMIS 5340 (3). LOGISTICS SYSTEMS ENGINEERING. Utilizes system engineering principles and analyses to introduce concepts, methods, and techniques for engineering and development of logistics systems associated with product production and manufacturing; product order and service fulfillment; and product, service, and customer support. Topics include logistics systems requirements, logistics systems design and engineering concurrently with product and service development, transportation and distribution, supply and material support, and supply Web design and management. Also, product, service, and customer support.

EMIS 5347 (3). CRITICAL INFRASTRUCTURE PROTECTION AND SECURITY SYSTEMS ENGINEERING. Presents SE concepts as applied to the protection of the United States' critical infrastructure. A top-level systems viewpoint provides a greater understanding of this system of systems. Topics include the definition and advantages of SE practices and fundamentals; system objectives that include the viewpoint of the customer, users, and other stakeholders; the elements of the critical infrastructure and their interdependencies; the impact transportation system disruptions; and system risk analysis. *Prerequisites:* EMIS 5301, 5303.

EMIS 5352 (3). INFORMATION SYSTEM ARCHITECTURE. The architecture of an IS defines that system in terms of components and interactions among those components. Addresses IS hardware and communications elements for information engineers, including computer networking and distributed computing. Also, the principles, foundation technologies, standards, trends, and current practices in developing an appropriate architecture for Web-based and non-Internet information systems.

EMIS 5353 (3). INFORMATION SYSTEM DESIGN STRATEGIES. Surveys the fundamentals of software engineering and database management systems for information engineers. Covers the principles, foundation technologies, standards, trends, and current practices in data-centric software engineering and systems design, including object-oriented approaches and relational DBMS. Focuses on system design, development, and implementation aspects and not the implementation in code.

EMIS 5355 (3). ENGINEERING OPERATIONS. The management of a technical organization's operations can contribute to the strategic goals and objectives of the enterprise. By analyzing and managing operations as systems, strategic choices are shown to drive design and operating decisions. The course covers the tools and techniques for solving problems to achieve the overall goals and strategies of manufacturing and services organizations.

EMIS 5359 (3). INFORMATION ENGINEERING SEMINAR. Topics in management of information in specific industries or application areas. May be repeated for credit when the topics vary. *Prerequisite:* EMIS 5360.

EMIS 5360 (3). MANAGEMENT OF INFORMATION TECHNOLOGIES. Defines the management activities of the overall computer resources within an organization or government entity. Consists of current topics in strategic planning of computer resources, budgeting and fiscal controls, design and development of information systems, personnel management, project management, rapid prototyping, and system life cycles.

EMIS 5361 (3). COMPUTER SIMULATION TECHNIQUES. Introduction to the design and analysis of discrete probabilistic systems using simulation. Emphasizes model construction and a simulation language. *Prerequisites:* Programming ability and knowledge of introductory probability or statistics.

EMIS 5362 (3). PRODUCTION SYSTEMS ENGINEERING. Applies the principles of engineering, or "design under constraint," to modern production systems. Topics include production systems analysis and design considerations, system design and optimization models and methods, pull- and push-based production systems, quality engineering, and process improvement. Also, techniques for engineering and managing systems with specific architectures: batch-oriented, continuous-flow, projects, and just-in-time. *Prerequisite:* C- or better in EMIS 3360. Management science or math operations research specialization majors only.

EMIS 5364 (3). STATISTICAL QUALITY CONTROL. A comprehensive introduction to the statistical quality control methods that underlie the modern quality revolution. Uses statistics and simple probability to develop control charts to monitor and improve the quality of an ongoing process, and for acceptance-sampling plans (including MIL-STD). Defines control charts for attributes, variables, and CUSUM procedures and applies them to everyday problems in manufacturing and service businesses. *Prerequisite:* EMIS 3340 (STAT/CSE 4340), EMIS 5370, or STAT 5373.

EMIS 5365 (3). PROGRAM AND PROJECT MANAGEMENT. Development of principles and practical strategies for managing projects and programs of related projects for achieving broad goals. Topics include planning, organizing, scheduling, resource allocation, strategies, risk management, quality, communications, tools, and leadership for projects and programs.

EMIS 5366 (3). MARKETING ENGINEERING. Marketing engineering moves beyond traditional conceptual approaches to embrace the use of analytics, data, information technology, and decision models to help organizations effectively reach customers and make marketing decisions. Designed for technical individuals, the course applies engineering problem-solving approaches and computer tools to solve marketing problems from today's competitive work environment. *Prerequisites:* EMIS 3360 or equivalent, and EMIS 3340 (STAT/CSE 4340) or EMIS 5370.

EMIS 5369 (3). RELIABILITY ENGINEERING. Introduction to reliability engineering concepts, principles, techniques, and methods required for design and development of affordable products and services that meet customer expectations. Topics include reliability concepts and definitions, figures of merit, mathematical models, design analysis and trade studies, reliability testing and types of tests, test planning and analysis of test results, and statistical analysis of reliability data. *Prerequisite:* C- or better in EMIS 4340 or 5370.

EMIS 5377 (3). STATISTICAL DESIGN AND ANALYSIS OF EXPERIMENTS. Introduces statistical principles in the design and analysis of industrial experiments. Covers completely randomized, randomized complete and incomplete block, Latin square, and Plackett-Burman screening designs; complete and fractional factorial experiments; descriptive and inferential statistics; analysis of variance models; and mean comparisons. *Prerequisites or corequisites:* C- or better in EMIS 4340 and senior standing with a science or engineering major, or permission of instructor.

EMIS 5380 (3). MANAGING INFORMATION TECHNOLOGY CONTROLS. Surveys current practices in IT governance and controls, with approaches for balancing business needs with technology controls for high-risk processes. Topics include introduction to technology controls, the process of IT governance, systems and infrastructure life cycle management, IT delivery and support, and records management.

EMIS 5382 (3). INFORMATION TECHNOLOGY SECURITY AND RISK MANAGEMENT. For nontechnical managers and executives with decision-making responsibility in information security governance and risk management. Topics include information security organizations and policies, governance, program development and management, information risk management, legal and regulatory compliance, and business continuity planning.

EMIS 5390 (3). SPECIAL TOPICS. Individual or group study of selected topics in management science. *Prerequisite:* Permission of instructor.

MECHANICAL ENGINEERING

Professor Ali Beskok, **Chair**

Professors: Ali Beskok, Xin-Lin Gao, Yildirim Hürmüzlü, Radovan B. Kovacevic, Paul S. Krueger, José L. Lage, M. Volkan Otugen, Peter E. Raad, Wei Tong. **Associate Professors:** Charles M. Lovas, Edmond Richer, David A. Willis. **Assistant Professors:** Tindaro Ioppolo, Jeong Ho You. **Senior Lecturers:** Elena V. Borzova, Dona T. Mularkey. **Clinical Associate Professor:** Adam L. Cohen. **Adjunct Faculty:** Bogdan V. Antohe, Eric B. Cluff, Theodore A. Dumas, M. Wade Meaders, David J. Nowacki, Allen D. Tilley, Andrew K. Weaver, James R. Webb.

General Information

Mechanical engineering is a diverse, dynamic and exciting field. Mechanical engineers have wide-ranging technical backgrounds and a high potential for employment with mobility and professional growth. They apply creative knowledge to solve critical problems in many areas, including bioengineering (e.g., drug delivery and artificial organs), construction, design and manufacturing, electronics, energy (e.g., production, distribution and conservation), maintenance (individual machinery and complex installations), materials processing, medicine (diagnosis and therapy), national security and defense, packaging, pollution mitigation and control, robotics and automation, sensors, small-scale devices, and all aspects of transportation, (e.g., space travel and exploration).

The Mechanical Engineering Department at SMU has a long tradition of offering a superb engineering education within an environment fostering creativity and innovation. Small classes not only provide for strong mentoring but also help achieve academic excellence through cooperation and teamwork. Leading by example, through encouragement and dedication, the faculty is committed to the success of every student. In addition to offering introductory and advanced courses in their areas of specialization, faculty members teach courses that address the critical issues of technology and society.

The program prepares students by providing a solid background in fundamentals of science and engineering without compromising the practical aspects of mechanical engineering. Essential entrepreneurial know-how, interpersonal skills and the importance of lifelong learning complement the educational experience of students. The department stimulates professional and social leadership by providing, among others, opportunities for students to participate in the SMU Student Section of the American Society of Mechanical Engineers and in the SMU Tau-Sigma Chapter of Pi-Tau-Sigma, the National Honorary Mechanical Engineering Fraternity.

The curriculum consists of three major areas: thermofluids; dynamics and controls; and solid mechanics, materials and manufacturing. Practical mechanical engineering design is interlaced throughout the curriculum. In the senior year, student teams are guided through a complete design project, from concept to construction to testing, with support from industries, foundations and volunteer professionals. State-of-the-art software, computers and laboratory equipment support the high-quality education provided to students. Undergraduate students are encouraged to participate in research projects conducted by faculty and to consider extending their studies to include graduate work in mechanical engineering at SMU or elsewhere.

In combination with a solid liberal arts foundation, the program prepares students for graduate studies not only in engineering but also in other professional fields such as business, medicine and law. SMU mechanical engineering graduates have found success in graduate school and in employment, and regularly attain graduate degrees in engineering, medicine, business and law. Graduates are employed as engineers or consulting engineers for major engineering, pharmaceutical, environmental, financial, banking and real estate companies.

The undergraduate program in mechanical engineering is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

The program's mission is to educate mechanical engineers who are innovative, entrepreneurial and equipped to become global leaders in research and technology. Specific educational objectives of the mechanical engineering undergraduate program are to produce graduates who meet the following:

1. The ability to be innovative problem solvers and critical thinkers addressing technical and societal issues.
2. The ability to embrace professional development and lifelong learning relevant to their careers.
3. The ability to have entrepreneurial and leadership roles in industry, government and academia.

The Mechanical Engineering Undergraduate Program Outcomes and their relationships to the discipline-specific criteria are as follows:

a) The ability to apply knowledge of mathematics, science and engineering.
b) The ability to design and conduct experiments, as well as analyze and interpret data.
c) The ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
d) The ability to function on multidisciplinary teams.
e) The ability to identify, formulate and solve engineering problems.
f) An understanding of professional and ethical responsibility.
g) The ability to communicate effectively.
h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context.
i) The recognition of the need for and the ability to engage in lifelong learning
j) A knowledge of contemporary issues.
k) The ability to use the techniques, skills and modern engineering tools necessary for engineering practice.

An outstanding cooperative education program is also available for students. For further information on the SMU Co-op Program, students should see Cooperative Education at the beginning of the Lyle School of Engineering section.

The department offers the following undergraduate degrees. In addition, a minor in mechanical engineering is available to interested students.

Bachelor of Science in Mechanical Engineering
Bachelor of Science in Mechanical Engineering and Bachelor of Science with a major in math (dual degrees)
Bachelor of Science in Mechanical Engineering and Bachelor of Science with a major in physics (dual degrees)
Bachelor of Science in Mechanical Engineering (with a minor in business administration)

Bachelor of Science in Mechanical Engineering
(with a premedical/biomedical specialization)

Bachelor of Science in Mechanical Engineering
(with an engineering management and entrepreneurship specialization)

Departmental Facilities

In support of the teaching and research endeavors of the department, several research laboratories are available.

Laboratory for Porous Materials Applications. This laboratory is concerned with modeling; numerical simulation; and experimental testing of mass, energy and momentum transport in heterogeneous and porous media.

Nanoscale Electro-Thermal Sciences Laboratory. This facility focuses on non-invasive characterization of the thermal properties of thin-film materials.

Laser Micromachining Laboratory. This lab conducts fundamental studies of thermal processes during short-pulse laser-material interactions and applied studies of laser-assisted microfabrication, including high-power laser ablation, laser micromachining, and laser-induced forward transfer. Current research applies these techniques to the fabrication of microfluidic devices and superhydrophobic surfaces.

Experimental Fluid Mechanics Laboratory. This facility focuses on pulsed jet micropropulsion and flow-through porous media.

Micro, Nano and Biomechanics of Materials Laboratory. This laboratory supports research primarily in the area of solid mechanics and materials engineering, with a focus on the combined experimental characterization as well as the computational analysis of mechanical properties, stress/strain, and microstructure of engineering and biological materials. Applications in advancing manufacturing and materials processing technologies, engineering design analyses, and biomedical sciences and engineering are also studied in this facility.

Systems, Measurement and Control Laboratory. This facility is equipped for instruction in the design and analysis of analog and digital instrumentation and control systems. Modern measurement and instrumentation equipment is used for experimental control engineering, system identification, harmonic analysis, simulation and real-time control applications. Equipment also exists or microprocessor interfacing for control and instrumentation.

Micro-Sensor Laboratory. This laboratory focuses on research in the development of micro-optical sensors for a wide range of aerospace and mechanical engineering applications, including temperature, pressure, force, acceleration and concentration. A major research component in this lab is concentrated on the study of the optical phenomenon called the “whispering gallery modes” and its exploitation for sensor development in the microsize level with a nanolevel measurement sensitivity.

Systems Laboratory. This facility is dedicated to analysis and modeling of bipedal gait dynamics, rigid body impact mechanics and the pneumatically operated haptic interface system.

Research Center for Advanced Manufacturing. The RCAM center supports research and development activities in areas of rapid prototyping and manufacturing (laser-based and welding-based deposition), laser materials processing (welding, forming, surface modification), welding (including electrical arc welding, variable polarity plasma arc welding, friction stir welding, and micro plasma arc welding), waterjet/abrasive waterjet materials processing, sensing and control of manufacturing processes, and numerical modeling of manufacturing processes.

Center for Laser Aided Manufacturing. This facility, which is housed in the Research Center for Advanced Manufacturing facility, collaborates with RCAM.

Energy Harvesting Materials Laboratory. Due to the limited reserves of fossil fuels like coals, oil and natural gas, finding an efficient way to produce renewable energy from natural resources is in great demand. In the Energy Harvesting Materials Laboratory, research focuses on the investigation and design of materials to generate electricity from solar light (solar cells), from mechanical vibration (piezoelectric power generators) and from temperature difference (thermoelectric systems). Research focuses on small-scale materials (nanomaterials) to improve energy conversion efficiency in those systems based on atomic-scale and continuum approaches.

Biomedical Instrumentation and Robotics Laboratory. This laboratory's research activities promote strong interdisciplinary collaboration between several branches of engineering and biomedical sciences. The research interests are centered on two areas:

- Medical robotics, especially novel robotic applications in minimally invasive, natural orifice, and image-guided and haptic-assisted surgery.
- In vivo measurement of mechanical properties of biological tissue.

These areas of concentration touch upon fundamentals in analytical dynamics, nonlinear control of mechanical systems, computer-aided design and virtual prototyping, applied mathematics, data acquisition, signal processing, and high-performance actuators.

Microsystems Research Laboratory. The research carried out in this laboratory focuses in the area of optical actuators and sensors, micro-optofluidics, energy conversion, and smart materials.

Multiscale Modeling and Simulations Laboratory. This research group performs modeling and simulations of materials and structures.

BioMicrofluidics Laboratory. In this laboratory, students design, build and test lab-on-a-chip devices for biomedical, environmental monitoring, and food and water safety applications and perform numerical simulations of mass momentum and energy transport in micro- and nano-scales, using continuum-based and atomistic methods.

Laboratory for Additive Manufacturing, Robotics and Automation. This laboratory is engaged in research sponsored by the National Science Foundation's National Robotics Initiative. It is dedicated to the development of advanced, multimaterial 3-D printing technology as applied to the manufacturing of soft robotic components. Other future research areas include robotic technologies for minimally invasive medical procedures and automated construction systems.

Instructional Laboratories

In support of the teaching and research endeavors of the department, several instructional laboratories are available. They include the following:

Information Technology Computer Laboratory. The laboratory features 25 computer workstations, printers, scanners and an overhead projector with an Internet connection used to support mechanical engineering and non-Lyle School of Engineering undergraduates in meeting the SMU-wide IT requirement for all students.

Computational/Design Laboratory. Dedicated computational facilities that include personal computers and high-resolution color X-terminals, all connected through a high-speed network that allows communication with the school's and University's computers, as well as with off-campus systems via NSFNet. Available Lyle School of Engineering computational facilities include several high-speed, multiprocessor workstations and servers. Educational software includes Parametric Technologies Pro-Engineer CAD system, MATLAB, ANSYS structural analysis package, MacroFlow and Fluent CFD packages.

Graphics Laboratory. Used primarily for first-year graphics, this facility is available for students working on design projects. A special design projects library is located adjacent to the drafting room.

Mechanics of Materials (Structures) Laboratory. This laboratory is equipped for instruction and research on the behavior of materials under various loading conditions such as fatigue, impact, hardness, creep, tension, compression and flexure.

Systems, Measurement and Control Laboratory. This facility is equipped for instruction in the design and analysis of analog and digital instrumentation and control systems. Modern measurement and instrumentation equipment is used for experimental control engineering, system identification, harmonic analysis, simulation and real-time control applications. Equipment also is used for microprocessor interfacing for control and instrumentation.

Thermal and Fluids Laboratory. Equipment in this laboratory is used for instruction in experimental heat transfer, thermodynamics and fluid mechanics. Modern equipment is available for conducting experiments on energy conservation; aerodynamics; internal combustion engines; heating, ventilation and air conditioning systems; convective cooling of electronics; heat exchangers; and interferometric visualization. State-of-the-art systems support automatic control and data acquisition. A partial list of the equipment in this lab includes a refrigeration training unit, heat transfer test unit with water boiler, airflow bench, kinematic viscosity bath, forced convection heat transfer experiment bench, low-pressure board, dead weight tester, vortex tube, free and forced heat transfer unit, hydraulic trainer and pneumatic trainer.

Shared Laboratory Space

Laboratories shared with the Civil and Environmental Engineering Department include the following:

Hydraulics/Hydrology, Thermal and Fluids Laboratory
CAD Computer Laboratory
Structural and Mechanics of Materials Laboratory
Project construction area

Curriculum in Mechanical Engineering

Mechanical engineering offers the broadest curriculum in engineering to reflect the wide range of mechanical engineering job opportunities in government and industry. The mechanical engineer is concerned with creation, research, design, analysis, production and marketing of devices for providing and using energy and materials. The major concentration areas of the program include the following:

Solid and Structural Mechanics. Concerned with the behavior of solid bodies under the action of applied forces. The solid body may be a simple mechanical link-age, an aerodynamic control surface, an airplane or space vehicle, or a component of a nuclear reactor. The applied forces may have a variety of origins, such as mechanical, aerodynamic, gravitational, electromotive and magnetic. Solid mechanics provides one element of the complete design process and interacts with all other subjects in the synthesis of a design.

Fluid Mechanics. Deals with the behavior of fluid under the action of forces applied to it. The subject proceeds from a study of basic fundamentals to a variety of applications, such as flow-through compressors, turbines and pumps, around an airplane or missile. Fluid mechanics interacts with solid mechanics in the practice of mechanical engineering because the fluid flow is generally bounded by solid surfaces. Fluid mechanics is also an element in the synthesis of a design.

Thermal Sciences. Concerned with the thermal behavior of all materials – solid, liquid and gaseous. The subject is divided into three important branches, namely, thermodynamics, energy conversion and heat transfer. Thermodynamics is the study of the interaction between a material and its environment when heat and/or work are involved. Energy conversion is a study of the transformation of one form of energy to another, such as the conversion of solar energy to electrical energy in a solar cell. Heat transfer is a study of the processes by which thermal energy is transferred from one body of material to another. Since energy is required to drive any apparatus and since some of the energy is thermal energy, the thermal sciences interact with all other areas of study as an integral part of the design process.

Materials Science and Engineering. Pertains to the properties of all materials – solid, liquid and gaseous. It deals with mechanical, fluid, thermal, electrical and other properties. Properties of interest include modulus of elasticity, compressibility, viscosity, thermal conductivity, electrical conductivity and many others. The study of materials proceeds from the characteristics of individual atoms of a material, through the cooperative behavior of small groups of atoms, up to the behavior and properties of the bulk material. Because all mechanical equipment is composed of materials, works in a material environment and is controlled by other material devices, it is clear that the materials sciences lie at the heart of the design synthesis process.

Control Systems. Provides necessary background for engineers in the dynamics of systems. In the study of controls, both the transient and steady-state behaviors of the system are of interest. The transient behavior is particularly important in the starting and stopping of propulsion systems and in maneuvering flight, whereas the steady-state behavior describes the normal operating state. Some familiar examples of control systems include the flight controls of an airplane or space vehicle and the thermostat on a heating or cooling system.

Design Synthesis. The process by which practical engineering solutions are created to satisfy a need of society in an efficient, economical and practical way. This synthesis process is the culmination of the study of mechanical engineering and deals with all elements of science, mathematics and engineering.

Areas of Specialization

Mechanical engineering is a diverse field, and advanced major electives may be selected from a variety of advanced courses in mechanical engineering. In addition, specializations are offered in premedical/biomedical and engineering management and entrepreneurship, which includes required courses in engineering management, information engineering and global perspectives, technical entrepreneurship, and technical communications.

A student may also personalize his or her degree with the addition of a minor in business administration within the Bachelor of Science in Mechanical Engineering. In addition to satisfying the required core mathematics, science and engineering courses, students must satisfy the minor in business administration requirements (listed in the Cox School of Business section of this catalog); three hours of ME courses at the 3000 level or higher approved by the student's adviser are also required. Admission requirements to the Cox School must also be satisfied and may include additional coursework.

Bachelor of Science in Mechanical Engineering

In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hour requirements within the mechanical engineering curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	31
MATH 1337, 1338, 2339, 2343, 3353	
STAT 4340 *or* equivalent	
CHEM 1303	
PHYS 1303/1105, 1304	
One from the following:	
BIOL 1401, 1402	
CHEM 1304	
GEOL 1301, 1305, 1307, 1308, 1313	
PHYS 3305, 3340, 4321	
Math course, 3000 level or higher, approved by adviser	
Engineering	56
ME 1302, 2310, 2320, 2331/2131, 2340/2140, 2342/2142, 2350, 2372, 3332/3132, 3340, 3370, 4360/4160, 4380, 4381, 4370	
EE 2350	
CEE 3302	
Tracks (choose one)	18
Distributed Track	
One from thermofluids required courses below	
One from dynamics and controls required courses below	
One from solid mechanics, materials, and manufacturing required courses below	
Three additional ME courses from any track's required or elective courses	
Thermofluids Track	
Required: ME 4338, 5371	
Electives: Two from ME 3360, 5332, 5333, 5383	
One from dynamics and controls required or elective courses	
One from solid mechanics, materials, and manufacturing required or elective courses	

Requirements for the Major (continued)	*Credit Hours*
Tracks (continued)	
Dynamics and Controls Track	
Required: ME 5320, 5322	
Electives: Two from ME 3360, 5302, 5326	
One from thermofluids required or elective courses	
One from solid mechanics, materials, and manufacturing required or elective courses	
Solid Mechanics, Materials, and Manufacturing Track	
Required: ME 5374, 5338	
Electives: ME 5361, 5364	
One from thermofluids required or elective courses	
One from dynamics and controls required or elective courses	
	105

Any deviation from the mechanical engineering curriculum requires approval of a petition submitted by the student to the Mechanical Engineering Department faculty prior to the beginning of the term during which the student expects to complete the requirements for graduation.

Bachelor of Science in Mechanical Engineering With Engineering Management and Entrepreneurship Specialization

In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hour requirements within the mechanical engineering curriculum are distributed as follows:

Requirements for the Specialization	*Credit Hours*
Mathematics and Science	31
MATH 1337, 1338, 2339, 2343, 3353	
STAT 4340 *or* equivalent	
CHEM 1303	
PHYS 1303/1105, 1304	
One from the following:	
BIOL 1401, 1402	
CHEM 1304	
GEOL 1301, 1305, 1307, 1308, 1313	
PHYS 3305, 3340, 4321	
Math course, 3000 level or higher, approved by adviser	
Engineering	53
ME 1302, 2310, 2320, 2331/2131, 2340/2140, 2342/2142, 2350, 2372, 3332/3132, 3340, 3370, 4360/4160, 4370, 4380, 4381	
EE 2350	
Engineering Leadership	12
CEE 3302, CSE 4360, EMIS 3308, 3309	
Advanced Major Electives	9
ME courses, 3000 level or higher, from the thermofluids; dynamics and controls; and solid mechanics, materials, and manufacturing tracks in the B.S. in mechanical engineering degree plan above	
	105

Any deviation from the mechanical engineering curriculum requires approval of a petition submitted by the student to the Mechanical Engineering Department faculty prior to the beginning of the term during which the student expects to complete the requirements for graduation.

Bachelor of Science in Mechanical Engineering and Bachelor of Science With a Major in Mathematics

The Mechanical Engineering Department and the Mathematics Department offer a curriculum that enables a student to obtain both a B.S.M.E. degree and B.S. with a major in mathematics.

In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hour requirements within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	37
MATH 1337, 1338, 2339, 2343, 3315, 3337, 3353	
STAT 4340 *or* equivalent	
One advanced elective as defined in the description of the mathematics major	
CHEM 1303	
PHYS 1303/1105, 1304	
Engineering	56
ME 1302, 2310, 2320, 2331/2131, 2340/2140, 2342/2142, 2350, 2372, 3332/3132, 3340, 3370, 4360/4160, 4370, 4380, 4381	
CSE 1341	
EE 2350	
Advanced Major Electives	9
ME courses, 3000 level or higher, from the thermofluids; dynamics and controls; and solid mechanics, materials, and manufacturing tracks in the B.S. in mechanical engineering degree plan above	
Engineering Leadership	3
One from the following:	
CEE 3302	
CSE 4360	
EMIS 3308 *or* 3309	
	105

Any deviation from the mechanical engineering curriculum requires approval of a petition submitted by the student to the Mechanical Engineering Department faculty prior to the beginning of the term during which the student expects to complete the requirements for graduation.

Bachelor of Science in Mechanical Engineering and Bachelor of Science With a Major in Physics

The Mechanical Engineering Department and the Physics Department offer a curriculum that enables a student to obtain both a B.S.M.E. degree and a B.S. degree with a major in physics.

In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hour requirements within this curriculum are distributed as follows:

Requirements for the Major	*Credit Hours*
Mathematics and Science	58
MATH 1337, 1338, 2339, 2343, 3353 STAT 4340 *or* equivalent CHEM 1303 PHYS 1303/1105, 1304/1106, 3305, 3344, 3374, 4211, 4321, 4392, 5382, 5383 Two advanced physics electives	
Engineering	50
ME 1302, 2310, 2331/2131, 2340/2140, 2342/2142, 2350, 2372, 3332/3132, 3340, 3370, 4360/4160, 4370, 4380, 4381 EE 2350	
Advanced Major Elective	3
ME course, 3000 level or higher, from the thermofluids; dynamics and controls; and solid mechanics, materials, and manufacturing tracks in the B.S. in mechanical engineering degree plan above	
	111

Note: The B.S. in physics requires CSE 1341 or 1342.

Any deviation from the mechanical engineering and/or physics curricula requires approval of a petition submitted by the student to the appropriate faculty prior to the beginning of the term during which the student expects to complete the requirements for graduation.

Bachelor of Science in Mechanical Engineering (Premedical/Biomedical Specialization)

The Mechanical Engineering Department offers a B.S.M.E. degree with a premedical/biomedical specialization. This program enables students to satisfy the premedical or predental requirements for admission to medical or dental school, while at the same time satisfying the requirements for an accredited degree in mechanical engineering. In addition to the Universitywide requirements, which include the completion of a minimum of 120 academic credit hours for any degree, the credit hour requirements within this curriculum are distributed as follows:

Requirements for the Specialization	*Credit Hours*
Mathematics and Science	56
MATH 1337, 1338, 2339, 2343, 3353 STAT 4340 *or* equivalent BIOL 1401, 1402, 3304, 3350 CHEM 1303/1113, 1304/1114, 3371/3117, 3372/3118 PHYS 1303/1105, 1304/1106	
Engineering	52
ME 1302, 2310, 2320, 2331/2131, 2340/2140, 2342/2142, 2350, 2372, 3332/3132, 3340, 3370, 4360, 4370, 4380, 4381 EE 2350	

Requirements for the Major (continued)	*Credit Hours*
Advanced Major Elective	3
ME course, 3000 level or higher, from the thermofluids; dynamics and controls; and solid mechanics, materials, and manufacturing tracks in the B.S. in mechanical engineering degree plan above	
	111

Any deviation from the mechanical engineering curriculum requires approval of a petition submitted by the student to the Mechanical Engineering Department faculty prior to the beginning of the term during which the student expects to complete the requirements for graduation.

Minor in Mechanical Engineering

For approval of a minor in mechanical engineering, the student should consult the department. The five courses represent a minor that provides a broad introduction to mechanical engineering. Based on the student's interests and background, other sets of mechanical engineering courses may be substituted with the department's approval.

Requirements for the Minor	*Credit Hours*
Four from ME 2310, 2320, 2331, 2340, 2342	12
One from ME 3340, 3370	3
	15

The Courses (ME)

ME 1301 (3). MACHINES AND SOCIETY. Introduces engineering systems to nonengineering students. Defines engineering, what engineers do, and what mechanical engineers do. Topics include the historical perspective on engineering design, principles of design engineering, energy conversion processes, engineered products, what mechanical engineers produce, the basic principles of converting science to technology, and the development of technology for society and humanity. Also, the laboratory and workshop experience, including computer animation and simulation.

ME 1302 (3). INTRODUCTION TO MECHANICAL ENGINEERING. Introduction to mechanical engineering and the engineering profession. Topics include forces in structures and fluids, conservation laws and thermal systems, motion of machinery, engineering design, and basic concepts in intellectual property for mechanical engineers. Also, topics in mechanical engineering as appropriate for current events.

ME 1303 (3). ENERGY, TECHNOLOGY, AND THE ENVIRONMENT. An elementary introduction to the ways energy is produced and distributed, energy resources, electrical power, heating and cooling, solar energy applications, and other topics related to people and the environment.

ME 1304 (3). GREEN ENGINEERING: DESIGNING TOMORROW TODAY. Presents how design choices for materials, manufacturing processes, energy usage, and end-of-life disposal affect economic and natural environments. Also, case studies in design for the environment for various industries. In lab, students use computer modeling to create designs and then analyze and compare the designs' total life cycle impact through eco-audits of energy and carbon footprints. Students also use software to compare and select materials best suited for a particular design and its constraints.

ME 1305 (3). INFORMATION TECHNOLOGY AND SOCIETY. A comprehensive survey of information technologies and the growing interconnectivity between them as currently utilized throughout society. Students acquire portable IT skills in the use of word processing, spreadsheets, presentation tools, graphics applications, and the Internet that will prepare them for success in the workplace and beyond. Discusses issues surrounding IT, including history, ethics, legal questions, use in producing and maintaining a competitive advantage, effects on society, and associated costs and benefits.

ME 2131 (1). THERMODYNAMICS LABORATORY. One 3-hour laboratory session per week. Basic thermal-property and power-device measurements to complement lecture material of ME 2331. Offered parallel to ME 2331. *Prerequisites:* MATH 1337 and sophomore standing.

ME 2140 (1). MECHANICS OF MATERIALS LABORATORY. Experiments in mechanics of deformable bodies, to complement ME 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, and the effect of stress concentrators. *Prerequisite or corequisite:* ME/CEE 2340.

ME 2142 (1). FLUID MECHANICS LABORATORY. One 3-hour laboratory session per week. Experiments in fluid friction, pumps, boundary layers, and other flow devices to complement lecture material of ME 2342. *Prerequisite or corequisite:* ME/CEE 2342.

ME 2310 (3). STATICS. Equilibrium of force systems, computations of reactions and internal forces, and determinations of centroids and moments of inertia. Also, introduction to vector mechanics. *Prerequisite:* MATH 1337.

ME 2320 (3). DYNAMICS. Introduction to kinematics and dynamics of particles and rigid bodies. Also, Newton's laws, kinetic and potential energy, linear and angular momentum, work, impulse, and inertia properties. *Prerequisite:* ME/CEE 2310 or equivalent.

ME 2331 (3). 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. *Prerequisites:* CHEM 1303, ME/CEE 2310, and MATH 2339.

ME 2340 (3). 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:* ME/CEE 2310. *Corequisite:* ME/CEE 2140.

ME 2342 (3). FLUID MECHANICS. Fluid statics, fluid control volume, and applications; irrotational flow; Bernoulli's and Euler's equations; similitude and dimensional analysis; differential analysis of fluid flow; incompressible viscous flow; and boundary layer theory. *Prerequisites:* ME/CEE 2310, MATH 2339, PHYS 1303. *Corequisite:* MATH 2343. ME/CEE 2320 is recommended but not required.

ME 2350 (3). ELEMENTS OF MECHANICAL ENGINEERING MEASUREMENTS. Introduces basic engineering experimentation and measurements, including techniques for measurement and experimentation; data acquisition; signal processing; and analysis, interpretation, and reporting of results. *Prerequisite:* ME 2310. *Prerequisite or corequisite:* ME 2320.

ME 2372 (3). INTRODUCTION TO CAD. Introduces mechanical computer-aided design. Surveys technical topics related to CAD and computer-aided manufacturing, with emphasis on the hands-on use of interactive computer graphics in modeling, drafting, assembly, and analysis using a state-of-the-art CAD system.

ME 3132 (1). HEAT TRANSFER LABORATORY. One 3-hour laboratory session per week. Experiments in conduction, convection, and radiation to complement lecture material of ME 3332. *Prerequisite or corequisite:* ME 3332.

ME 3332 (3). HEAT AND MASS TRANSFER. Fundamental principles of heat transmission by conduction, convection, and radiation; mass transfer; and application of these principles to the solution of engineering problems. *Prerequisites:* ME/CEE 2331, 2342.

ME 3340 (3). ENGINEERING MATERIALS. A study of the fundamental factors influencing the structure and properties of structural materials, including metals, polymers, and ceramic. Covers phase diagrams, heat treatment, metallography, mechanical behavior, atomic bonding, and corrosion. *Prerequisites:* CHEM 1303 (or equivalent), ME/CEE 2310.

ME 3341 (3). INTERMEDIATE THERMAL SCIENCES. Application of the laws of thermodynamics, availability, irreversibility, real gases and mixtures, generalized thermodynamics relations and charts, and chemical equilibrium. *Prerequisite:* ME/CEE 2331.

ME 3350 (3). STRUCTURAL ANALYSIS. Emphasis on the classical methods of analysis of statically determinate and indeterminate structural systems. Also, computation of reactions, shears, moments, and deflections of beams, trusses, and frames. Students use computers as an analytical tool. *Prerequisites:* ME/CEE 2140, 2340.

ME 3360 (3). FLUID POWER SYSTEMS. Principles of operations, design criteria, and performance characteristics of fluid power systems' components such as pumps, motors, valves, and cylinders. Also, goals-oriented circuit design and analysis, industrial standards, and circuit representation and maintenance. Includes practical and/or demo lectures, a design project based on specialized software, industry speakers, and site visits. *Prerequisites:* ME 2342, 2320.

ME 3370 (3). MANUFACTURING PROCESSES. Comprehensive, balanced, and up-to-date coverage of the relevant fundamentals and real-world applications of manufacturing processes (e.g., casting, forming, machining, high-power laser beam materials processing, electrical discharge machining, abrasive water-jet machining). Also, rapid prototyping and manufacturing. A set of laboratories introduces students to the basics of manufacturing processes and reinforces lecture material. *Prerequisite:* ME 3340.

ME 3390 (3). GERMAN TECHNOCULTURE. Fundamentals of German contemporary culture within the context of technology and study abroad experience. Emphasis is placed on reading and communication (writing and oral) skills. Field trips are an integral part of the course.

ME 4090 (0). SENIOR PROJECT.

ME 4160 (1). CONTROL LABORATORY. Experiments in control engineering, digital and analog simulation of feedback control systems, actuator saturation, and design and implementation of simple control systems on various laboratory equipment. *Corequisite:* ME 4360.

ME 4338 (3). THERMAL SYSTEMS DESIGN. Prepares, presents, and critiques thermal systems designs. Solves associated problems of simulation, optimization, and economics. Includes solving problems and design with a thermal network analyzer. *Prerequisite:* ME 3332.

ME 4350 (3). 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:* ME/CEE 3350.

ME 4351 (3). ETHICAL DECISION-MAKING IN APPLIED SCIENCE AND ENGINEERING AND TECHNOLOGY. The ethical issues, hard choices, and human failures in notorious, historical cases such as the Space Shuttle Challenger, Grand Teton Dam, and Union Carbide Bhopal disasters. Principles, methods, and bases for ethical decision-making and action. Application of classical ethical philosophy to hypothetical, modern problems and dilemmas in the business of control and implementation of technology.

ME 4360 (3). DESIGN AND CONTROL OF MECHANICAL SYSTEMS. Covers block modeling of mechanical systems, mathematical models of linear systems, and solution of differential equations by use of Laplace transforms. Also, feedback control systems, time domain analysis, stability, frequency response, and root locus plots. Includes Bode diagrams, performance criteria, system compensation, and design of control systems for mechanical systems. *Prerequisite:* ME 5322 or equivalent.

ME 4370 (3). ELEMENTS OF MECHANICAL DESIGN. Application of the principles of mechanics and physical properties of materials to the proportioning of machine elements, including consideration of fatigue, functioning, productivity, and economic factors. Also, computer applications. *Prerequisites:* ME/CEE 2340, ME 3370.

ME 4380 (3). MECHANICAL ENGINEERING DESIGN I. A study of design methodology and development of professional project-oriented skills, including communication, team management, creative problem-solving, interpersonal management, and leadership skills. Uses team-project activities to apply project-oriented skills to solution of design problems. Investigates nontechnical considerations in design, including patents, ethics, aesthetics, safety, and economics. *Prerequisite or corequisite:* ME 3370.

ME 4381 (3). MECHANICAL ENGINEERING DESIGN II. Student design teams have full responsibility for conducting a full-term design project for an industrial client. Periodic design reports and design reviews are presented to and critiqued by the industrial client, the faculty, and the design team. *Prerequisite:* ME 4380. *Prerequisite or corequisite:* ME 4370.

ME 5050 (0). UNDERGRADUATE INTERNSHIP.

ME 5190 (1). UNDERGRADUATE SEMINAR: ETHICS IN ENGINEERING AND TECHNOLOGY. Covers ethical issues, hard choices, and human failures in life. Discusses practical, ethical issues with examples from everyday life. Presents ethical issues encountered in copyright law and intellectual property, along with issues involved in telephone communications and email. Discusses principles, methods, and bases for ethical decision-making and action.

ME 5290 (2). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, and development. The project and the supervising faculty must be approved by the chair of the department in which the student expects to receive the degree.

ME 5302 (3). LINEAR SYSTEM ANALYSIS. Introduces topics within the domain of modern control theory, with emphasis on the application of the developed concepts in designing linear systems and casting their responses in prescribed forms. Includes state representation of linear systems, controllability, observability, minimal representation, linear state variable feedback, observers, and quadratic regulator theory.

ME 5303 (3). ORGANIZATIONAL LEADERSHIP. This course in personnel and organizational leadership covers the scientific structure of organizations and methods used to improve the productivity and quality of life of people working in the organization. Introduces industrial organizational psychology as applied to the manufacturing organization, with a focus on understanding individual behavior and experiences in industrial and organizational settings. Also introduces industrial psychology as it addresses the human resource functions of analyzing jobs and appraising, selecting, placing, and training people. Addresses the psychology of work, including employee attitudes, behavior, emotions, health, motivation, and well-being, as well as the social aspects of the workplace.

ME 5314 (3). INTRODUCTION TO MICROELECTROMECHANICAL SYSTEMS AND DEVICES. Develops the basics for MEMS and devices, including microactuators, microsensors, and micromotors; principles of operation; micromachining techniques (surface and bulk micromachining); IC-derived microfabrication techniques; and thin lm technologies as they apply to MEMS.

ME 5319 (3). ADVANCED MECHANICAL BEHAVIOR OF MATERIALS. A senior-graduate course that relates mechanical behavior on a macroscopic and microscopic level to design. Topics include macroscopic elasticity and plasticity, viscoelasticity, yielding, yield surfaces, work hardening, geometric dislocation theory, creep, and temperature- and environment-dependent mechanical properties. *Prerequisites:* ME/CEE 2340, ME 3340.

ME 5320 (3). INTERMEDIATE DYNAMICS. Emphasizes methods of formulation and solution of the kinematical, dynamical, and motion constraint equations for three-dimensional, lumped-parameter, dynamical systems. Detailed discussions on differentiation of vectors, kinematics, inertia properties, momentum and energy principles, generalized forces, holonomic and non-holonomic constraints, constrained generalized coordinates, and Newton-Euler and Lagrange formulations of the equations of motion. The symbolic software Mathematica is used to reduce the time and effort required to derive the kinematical and dynamical equations. Practical examples of detailed motion analysis of mechanisms using CAD software to augment the theoretical formulations. *Prerequisites:* ME/CEE 2320 and MATH 2339, 2343.

ME 5321 (3). FAILURE ANALYSIS AND PREVENTION. A senior or graduate course in the evaluation of the failure of structural materials and components. Topics include site examination, macroscopic examination, optical microscopy, transmission electron and SEM interpretation, examination and interpretation of failure surfaces, failure modes, and causes of failure. *Prerequisite:* ME 3340.

ME 5322 (3). VIBRATIONS. Review of fundamentals of vibrations with application of simple machine and structural members. Topics include harmonic motion, free and forced vibration, resonance, damping, isolation, and transmissibility. Single, multiple, and infinite degree-of-freedom systems are also examined. *Prerequisites:* ME/CEE 2320, MATH 3353, and MATH 2343 or equivalent.

ME 5323 (3). INTRODUCTION TO FRACTURE MECHANICS. Linear elastic fracture mechanics and application of theory to design and evaluation of critical components: elastic stress intensity calculations, plane strain fracture toughness, plane stress and transitional behavior, crack opening displacements, fracture resistance, fatigue crack propagation, transition temperature approach to fracture control, microstructure of fracture, and fracture control programs. *Prerequisite:* ME/CEE 2340.

ME 5324 (3). FATIGUE THEORY AND DESIGN. A senior or graduate course that includes continuum, statistical, and fracture mechanics treatments of fatigue, stress concentrators, planning and analysis of probit, SNP and response tests, mechanisms of fatigue design, fail-safe versus safe-life design, and crack propagation. Emphasizes engineering design aspects of fatigue rather than theoretical mechanisms. *Prerequisite:* ME 3340.

ME 5326 (3). VEHICLE DYNAMICS. Covers modeling of wheeled vehicles to predict performance, handling, and ride. Explores the effects of vehicle center of mass, tire characteristic traction and slip, engine characteristics, and gear ratios of performance. Includes suspension design and steady-state handling models of four-wheeled vehicles and car trailer systems to determine oversteer and understeer characteristics, critical speeds, and stability. Also, multi-degree-of-freedom ride models (including tire and suspension compliance) and computer animation and simulations. *Prerequisite:* ME/CEE 2320 or permission of instructor.

ME 5329 (3). FLUID POWER SYSTEMS. Develops the fundamentals of a fluid power system design by introducing the basic building blocks such as pumps, motors, hydraulic cylinders, accumulators, multiposition directional valves, and other related components. Studies properties of the common hydraulic fluids to ascertain their influence on the behavior of typical fluid power system. Includes mathematical models of the individual components to aid in the simulation of a hydraulic system for a desired function. Also, introduces commercially available software for system simulation. The 1-hour lab allows students to gain hands-on experience with hydraulic systems.

ME 5330 (3). HEAT TRANSFER. Application of the principles of conduction, convection, and radiation heat transfer. Topics include steady and unsteady state, special configurations, numerical and analytical solutions, and design. *Prerequisite:* ME 3332 or equivalent.

ME 5331 (3). ADVANCED THERMODYNAMICS. Laws of thermodynamics, availability, irreversibility, real gases and mixtures, thermodynamic relations and generalized charts, combustion, chemical and phase equilibrium, and computational combustion. *Prerequisites:* ME/CEE 2331, 2342.

ME 5332 (3). HEAT TRANSFER IN BIOMEDICAL SCIENCES. Fundamentals of heat transfer in medicine and biology, biothermal properties, thermal regulation processes, and biomedical heat transfer processes with applications in tissue laser radiation, freezing and thawing of biological materials, cryosurgery, and others. *Prerequisites:* ME/CEE 2342 and ME 3332, or consent of instructor.

ME 5333 (3). TRANSPORT PHENOMENA IN POROUS MEDIA. Covers fractals and their role in characterizing complex structures and the fundamental concepts of momentum, heat, and mass transport through heterogeneous (e.g., composite, porous) materials, with emphasis on the mathematical modeling of heat and mass transfer in heterogeneous and fully saturated systems. Presents relevant industrial and natural applications throughout the course. *Prerequisites:* ME/CEE 2342 and ME 3332, or consent of instructor.

ME 5334 (3). FUNDAMENTALS OF ELECTRONIC PACKAGING. Introduces microsystems packaging and covers the role of packaging in microelectronics, the role of packaging in microsystems, electrical package design, design for reliability, thermal management, single- and multichip packaging, IC assembly, passive devices, optoelectronics, RF packaging, MEMS, sealing and encapsulation, system-level PWBs, PWB assembly, packaging materials and processes, and microsystem design for reliability.

ME 5335 (3). CONVECTIVE COOLING OF ELECTRONICS. Reviews the fundamental concepts of convection heat transfer and applications of these principals to the convective cooling of electronic components and systems, with emphasis on the design of natural and forced convection heat sinks with air and liquid cooling, fan and pump selection procedures (e.g., piezoelectric fans and micropumps), acoustic fan noise and noise measurement techniques, augmentation of convection heat transfer in the form of plate-fin and pin-fin extended surfaces, spray cooling, jet impingement cooling, microchannel cooling, heat pipes, and capillary pumped loops. Covers pool boiling and flow boiling as applied to the thermal management of electronics, and the design of electronic chassis with flow through coldwalls and edge-cooled PWBs. Uses several industry-related applications as examples. *Prerequisite:* ME 3332.

ME 5336 (3). INTERMEDIATE FLUID DYNAMICS. Reviews fundamental concepts of undergraduate fluid mechanics and introduces advanced fluid dynamics, including irrotational flow, tensor notation, and the Navier-Stokes equations. *Prerequisite:* ME/CEE 2342 or equivalent.

ME 5337 (3). INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS. Concepts of stability, convergence, accuracy, and consistency; applications to linear and nonlinear model partial differential equations; curvilinear grid generation; and advanced topics in grid generation. Also, the Beam-Warming factored implicit technique; MacCormack techniques; and solution methods for the Reynolds equation of lubrication, the boundary layer equations, and the Navier-Stokes equations. *Prerequisites:* ME 2342 or equivalent, MATH 2343 or equivalent, or permission of instructor.

ME 5338 (3). NONTRADITIONAL MANUFACTURING PROCESSES. Explores difficult-to-machine materials and the increased geometrical complexity of components that have resulted in the development of nontraditional manufacturing processes based on the application of electrical, chemical, ultrasonic, magnetic, and photonic sources of energy. Introduces fundamentals of materials processing by laser beam, electron beam, ion beam, abrasive waterjet, ultrasonic machining, electro-discharge machining, chemical and electrochemical machining, and hybrid machining (laser beam, plasma arc, and waterjet assisted machining). Emphasizes the additive manufacturing processes as one of the fastest developing disciplines in materials processing. Covers theoretical problems and practical considerations related to the nontraditional manufacturing processes. *Prerequisites:* ME 3340, 3370; a basic understanding of manufacturing processes, mechanical and physical properties of materials, and physics.

ME 5340 (3). INTRODUCTION TO SOLID MECHANICS. Three-dimensional stress and strain, failure theories, introduction to two-dimensional elasticity, torsion of prismatic members, beams on elastic foundation, introduction to plates and shells, and energy methods. *Prerequisites:* ME/CEE 2340, MATH 2343.

ME 5341 (3). STRUCTURAL PROPERTIES OF SOLIDS. Develops an understanding of the structural aspect of solids and their relationship to properties and applications. Topics include structural defects, bonding and crystal structure, solid-state reactions and phase transformations, degradation, and deformation. *Prerequisite:* ME 3340 or permission of instructor.

ME 5342 (3). INTRODUCTION TO THERMAL MANAGEMENT OF ELECTRONICS. Emphasizes the thermal design of electronic packages and systems. Topics include the basics of conduction, convection (natural and forced), and radiation heat transfer. Also, pool boiling and flow boiling, extended surfaces as applied to the design of heat exchangers and cold plates, and thermal interface resistance as applied to the design of electronic packages. Introduces modern cooling technologies such as single-phase cooling and two-phase cooling, heat pipes, and thermoelectric coolers. *Prerequisite:* ME 3332.

ME 5343 (3). ELECTRONIC PACKAGING MATERIALS: PROCESSES, PROPERTIES, AND TESTING. Focuses on an overview of materials used in electronic packaging. Examines solderability, microscopic processes, and alloy selection. Also, composites and applying conducting polymer matrix composites, metal films, and vacuum processes. Covers the importance of encapsulation, temperature humidity bias testing, and temperature cycle testing, as well as the measurement of properties of material in electronic packaging, thermal properties, physical properties, manufacturing properties, and materials selection. *Prerequisite:* ME 3340.

ME 5344 (3). CONDUCTIVE COOLING OF ELECTRONICS. Reviews the fundamental concepts of conduction heat transfer and applications of these principals to the conductive cooling of electronic components and systems, with emphasis on contact conductance, interface thermal resistance, heat spreaders, thermal interface materials, phase change materials, thermoelectric devices, Stirling cycle refrigerators, and the cooling of special electronic components such as multichip modules, power modules, high-density power supplies, and printed wiring boards. Features the thermal management by conduction of GaAs and GaN monolithic microwave integrated circuits). Employs steady-state and transient analyses, including transient junction-to-case thermal resistance measurements. *Prerequisite:* ME 3332.

ME 5346 (3). APPLICATION OF COMPUTATIONAL TECHNIQUES TO THE MECHANICAL AND THERMAL DESIGN OF ELECTRONIC SYSTEMS. Develops the student's capability to characterize the mechanical and thermal performance of electronic devices and systems through the use of computational techniques. Commercial codes are used to create a thermal model of a fan-cooled, rectangular geometry, electronics chassis using direct air-cooling. Features additional computer codes for thermal modeling of heat transfer and fluid flow systems, and utilizes codes for the design of cold plates and heat exchangers. Students are exposed to concepts of structural modeling of components mounted on printed wiring boards in a vibration environment, and they analyze a number of industry-related problems, including first-level packages, printed wiring boards, and system-level electronics. At the end of the class, a student is expected to formulate and model a complex industry-based problem. *Prerequisites:* ME/CEE 2320, 2340 and ME 3332, 3340.

ME 5348 (3). THERMAL, FLUID, AND MECHANICAL MEASUREMENTS IN ELECTRONICS. Includes the following thermal and fluid measurement topics: the need for experimentation in electronic design; the use of similitude in electronics cooling, velocity, temperature, and pressure measurements; thermal conductivity and thermal diffusivity measurements; heat flux measurements; design of wind tunnels; flow visualization techniques; and characterization of electronic components. Also, experimental procedures used for vibration and shock testing of electronic equipment. Describes the instrumentation and test procedures used for complex environmental testing to commercial and military specifications. Covers the basic principles of acoustics and the measurement techniques used to evaluate noise levels generated by electronic systems. *Prerequisites:* ME/CEE 2140, 2142, 2340, 2342, 3132, 3332.

ME 5355 (3). INTEGRATED DESIGN AND MANUFACTURING. Industrial performance is strongly correlated to success in integrating design and manufacturing. Examines the interrelationships between the total product realization cycle, product generation, and manufacturing, with the objective of improving industrial performance.

ME 5356 (3). HUMAN FACTORS IN DESIGN AND MANUFACTURING. Deals with human factors or ergonomics relating to designing for human use. Covers the empirical and analytic aspects of design and manufacturing as affected by the need to accommodate human use and abilities. Topics include visual displays of static and dynamic information, text, graphics, symbols, and codes. Also, auditory, tactual, and olfactory displays, as well as speech and nonverbal communications, physical work and materials handling, motor skills, and hand tool devices and controls. Explores workplace design, anthropometry, component arrangement in space, lighting, sound, climate, and motion. *Recommended:* Knowledge of simple statistical analysis. *Prerequisite:* Senior or graduate standing, or permission of instructor.

ME 5357 (3). OPTIMIZED MECHANICAL DESIGN. Covers principles and methods for optimal design of machine elements (e.g., springs, shafts, gears, weldments of joints), mechanical systems (e.g., transmissions, cam systems, inertia loads and balancing), and computer applications. *Prerequisite:* ME 4370 or equivalent.

ME 5358 (3). DESIGN OF ELECTRONIC PACKAGING. A focus on thermal and mechanical design of electronic packaging. Fundamentals of heat transfer and fluid flow are applied to electronic packages and systems, including selection of fans, heat sinks, and other hardware important to good design. Mechanical designs of equipment that operates in more severe shock and vibration environments are developed using classical methods, with consideration given to selecting appropriate hardware. *Prerequisites:* ME/CEE 2320; MATH 2343, 3337.

ME 5359 (3). ANALYSIS AND DESIGN OF OPTOELECTRONIC PACKAGING. Provides an overview of optical fiber interconnections in telephone networks, packaging for high-density optical back planes, and selection of fiber technologies. Also, semiconductor laser and optical amplifier packaging, optical characteristics and requirements, electrical properties, mechanical properties, waveguide technologies, optical alignment and packaging approaches, passive device fabrication and packaging, array device packaging, hybrid technology for optoelectronic packaging, and flip-chip assembly for smart pixel arrays.

ME 5360 (3). ELECTRONIC PRODUCT DESIGN AND RELIABILITY. Investigates the failures, failure modes, and failure mechanisms in electronic systems. Covers failure detection, electrical simulation, and environmental stress tests. Also, failure analysis, including the use of X rays, thermal imaging and infrared microscopy, acoustical imaging, scanning laser acoustic microscopy, infrared spectroscopy, differential scanning calorimeter, thermomechanical analyzer, and other testing procedures. Discusses solder joint reliability of ball grid array assemblies, plastic ball grid array assemblies, flip chip assemblies, and chip scale package assemblies, as well as fine pitch, surface mount technology assemblies. Explores temperature as a reliability factor, an overview of high-temperature electronics, the use of silicon devices at high temperatures, and the selection of passive devices for use at high temperatures. *Prerequisite:* ME 3340 or graduate student standing.

ME 5361 (3). MATRIX STRUCTURE ANALYSIS. A systematic approach to the formulation of force and displacement method of analysis, the representation of structures as assemblages of elements, and computer solution of structural systems. *Prerequisite:* ME/CEE 3350 or permission of instructor.

ME 5362 (3). ENGINEERING ANALYSIS WITH NUMERICAL METHODS. Application of numerical and approximate methods in solving a variety of engineering problems. Examples include equilibrium, buckling, vibration, fluid mechanics, thermal science, and surveying problems. *Prerequisite:* Senior standing.

ME 5363 (3). ELECTRONIC MANUFACTURING TECHNOLOGY. Covers the complete field of electronics manufacturing. Topics include an introduction to the electronics industry; electronic components; the theory and methods of manufacture of solid-state devices; packaging techniques such as wire bonding, flip chip, and TAB; printed wiring board; soldering and solderability; leaded and surface-mounted components; electromagnetic interference; electrostatic discharge prevention; testability; and electronic stress screening. In each area, current technology as well as leading-edge tools are discussed.

ME 5364 (3). INTRODUCTION TO STRUCTURAL DYNAMICS. Covers dynamic responses of structures and behavior of structural components to dynamic loads and foundation excitations, single- and multidegree-of-freedom systems response and applications to analysis of framed structures, and an introduction to systems with distributed mass and flexibility. *Prerequisite:* MATH 2343.

ME 5368 (3). PROJECT AND RISK MANAGEMENT. Focuses on specific concepts, techniques, and tools for managing projects successfully, including network planning techniques, resource allocation, models for multiproject scheduling, methods of controlling costs, determining schedules, and performance parameters. Covers the basics of risk management, including hard analysis, risk analysis, risk control, and risk financing. Focuses on integrating risk assessment with managerial decision-making. Emphasizes examples and case studies.

ME 5371 (3). INTRODUCTION TO GAS DYNAMICS AND ANALYSIS OF PROPULSION SYSTEMS. Introduction to the mechanics and thermodynamics of high-speed compressible flows with application to the design of propulsion systems. Focus is on one-dimensional and quasi one-dimensional compressible flow, normal shocks, oblique shocks, and two-dimensional flow method of characteristics. Also includes analysis of air-breathing propulsion systems and design of air-breathing propulsion systems components such as inlets and nozzles. *Prerequisites:* ME 2342, 2331.

ME 5372 (3). INTRODUCTION TO CAD. Introduces mechanical computer-aided design. Surveys technical topics related to CAD and computer-aided manufacturing, with emphasis on the hands-on use of interactive computer graphics in modeling, drafting, assembly, and analysis using a state-of-the-art CAD system. *Prerequisite:* Junior standing or consent of instructor.

ME 5374 (3). ADVANCED CAD/CAE. Focuses on advanced modeling techniques, structural analysis and optimization, kinematical and dynamical analysis, mechanism design and virtual prototyping, and thermal analysis and flow simulation. Emphasis on hands-on use of state-of-the-art CAD/CAE systems. *Prerequisite:* ME 2372 or consent of instructor.

ME 5376 (3). ROBOTICS: INTRODUCTION TO COMPUTER-AIDED MANUFACTURING. Introduction to industrial robotics and numerically controlled machines, economics of CAM, applications of robotics in industry, robot safety, addition of senses and intelligence, and research in CAM flexible manufacturing cells and systems. Hands-on laboratory work with industrial robots and NC machines. Independent study and report on a specific robot application. *Prerequisites:* CSE 1341, PHYS 1403, and MATH 2343 or equivalent.

ME 5377 (3). ADVANCED STEEL DESIGN. The behavior and design of steel structures, including general methods of plastic analysis, plastic moment distribution, steel frames, unbraced and braced frames, and composite construction. *Prerequisite:* ME/CEE 4350.

ME 5383 (3). HEATING, VENTILATING, AND AIR CONDITIONING. Covers the selection and design of basic refrigeration, air conditioning, and heating systems. Includes load calculations, psychometrics, cooling coils, cooling towers, cryogenics, solar energy applications, and special topics. *Prerequisites:* ME/CEE 2331, ME 3332.

ME 5386 (3). CONVECTION HEAT TRANSFER. Advanced topics in forced convection heat transfer using analytical methods and boundary-layer analysis. Also, laminar and turbulent flow inside smooth tubes and over external surfaces, convection processes in high-speed flows. *Prerequisite:* ME 3332 or equivalent.

ME 5390 (3). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, and development. The project and the supervising faculty must be approved by the chair of the department in which the student expects to receive the degree.

ME 5391 (3). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

ME 5392 (3). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

ME 5393 (3). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

ME 5394 (3). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

ME 5395 (3). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

ME 5490 (4). UNDERGRADUATE SEMINAR. An opportunity for the advanced undergraduate student to undertake independent investigation, design, and development. The project and the supervising faculty must be approved by the chair of the department in which the student expects to receive the degree.

ME 5491 (4). SPECIAL PROJECTS. Intensive study of a particular subject or design project not available in regular course offerings and under the supervision of a faculty member approved by the department chair.

MULTIDISCIPLINARY STUDIES

General Information

The multidisciplinary studies designation accommodates academic programs and courses that do not typically fit within the departments of the Lyle School of Engineering. Included in this area are courses designed for the Engineering Cooperative Education Program, engineering special topics and first-year students exploring engineering degree programs.

Engineering Courses (ENGR)

ENGR 1099 (0). ENGINEERING INTERNSHIP. Represents a term of industrial work activity in connection with the Engineering Cooperative Program. Internship courses are taken in numerical sequence. Students register for this course in the same manner as for other SMU courses except that no tuition is charged. Each course grade is determined by the student's written report and from the scoring of the employer's evaluation form.

ENGR 1101 (1). ENGINEERING AND BEYOND. Explores the five engineering departments at SMU and how the areas work together. Includes case studies, departmental presentations, industry panels, and industry tours.

ENGR 1199 (1). ENGINEERING INTERNSHIP. Represents a term of practicum experience in the student's field of study. For students taking more than one internship course, internship courses are taken in numerical sequence. Tuition is charged for the course. The course grade is based on the student's written report due within 2 weeks of the final day of employment.

ENGR 2099 (0). ENGINEERING INTERNSHIP. Represents a term of industrial work activity in connection with the Engineering Cooperative Program. Internship courses are taken in numerical sequence. Students register for this course in the same manner as for other SMU courses except that no tuition is charged. Each course grade is determined by the student's written report and from the scoring of the employer's evaluation form.

ENGR 2199 (1). ENGINEERING INTERNSHIP. Represents a term of practicum experience in the student's field of study. For students taking more than one internship course, internship courses are taken in numerical sequence. Tuition is charged for the course. The course grade is based on the student's written report due within 2 weeks of the final day of employment.

ENGR 2315 (3). ENGINEERING AND DESIGN FOR THE DEVELOPING WORLD. Engineering design in the developed world takes for granted the availability of several key resources such as construction material, water, and electricity. This course examines engineering design in the absence of these resources, with a focus on the development of shelter and sanitation in an efficient manner. Emphasis on understanding the total energy cycle of a structure and multiple alternative energy solutions. Additional topics include developing solutions for extreme low-cost, high-population densities and ecological sustainability. Students work in interdisciplinary teams to design and build energy-efficient homes and sustainable sanitation options and to investigate alternative energy systems. *Prerequisite:* PHYS 1303. *Corequisites:* ENGR 2320 and sophomore or above standing.

ENGR 3099 (0). ENGINEERING INTERNSHIP. Represents a term of industrial work activity in connection with the Engineering Cooperative Program. Internship courses are taken in numerical sequence. Students register for this course in the same manner as for other SMU courses except that no tuition is charged. Each course grade is determined by the student's written report and from the scoring of the employer's evaluation form.

ENGR 3199 (1). ENGINEERING INTERNSHIP. Represents a term of practicum experience in the student's field of study. For students taking more than one internship course, internship courses are taken in numerical sequence. Tuition is charged for the course. The course grade is based on the student's written report due within 2 weeks of the final day of employment.

ENGR 4099 (0). ENGINEERING INTERNSHIP. Represents a term of industrial work activity in connection with the Engineering Cooperative Program. Internship courses are taken in numerical sequence. Students register for this course in the same manner as for other SMU courses except that no tuition is charged. Each course grade is determined by the student's written report and from the scoring of the employer's evaluation form.

ENGR 4199 (1). ENGINEERING INTERNSHIP. Represents a term of practicum experience in the student's field of study. For students taking more than one internship course, internship courses are taken in numerical sequence. Tuition is charged for the course. The course grade is based on the student's written report due within 2 weeks of the final day of employment.

ENGR 5090 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5091 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5092 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5093 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5094 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5095 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5096 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5097 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5098 (0). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5099 (0). ENGINEERING INTERNSHIP. Represents a term of industrial work activity in connection with the Engineering Cooperative Program. Internship courses are taken in numerical sequence. Students register for this course in the same manner as for other SMU courses except that no tuition is charged. Each course grade is determined by the student's written report and from the scoring of the employer's evaluation form.

ENGR 5190 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5191 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5192 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5193 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5194 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5195 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5196 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5197 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5198 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5199 (1). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5290 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5291 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5292 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5293 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5294 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5295 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5296 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5297 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5298 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5299 (2). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5390 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5391 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5392 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5393 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5394 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5395 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5396 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5397 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5398 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

ENGR 5399 (3). SPECIAL TOPICS. Individual or group study of selected topics in engineering. *Prerequisite:* Permission of instructor.

Ways of Knowing Courses (KNW)

KNW 2300 (3). INTRODUCTION TO ENGINEERING DESIGN. Introduces engineering design methodologies and basic teaming skills. Students participate on a team in a term-long, multidisciplinary design experience in which each student provides basic engineering capabilities in mechanical, software, electronic, civil, and/or environmental systems. Each team designs a robot that achieves stated design objectives while operating autonomously, with as little human interaction as possible. Teams submit group design memos documenting the evolution of the design. Each team makes a preliminary design presentation and report and a final design presentation and report. A competition is held at the end of the term. *Prerequisites or corequisites:* MATH 1337 and one of CEE 1302, CSE 1341, EE 1322, EE 1382, EMIS 1360, or ME 1302.

ARMY RESERVE OFFICERS' TRAINING CORPS

General Information

While Army ROTC courses are not offered on the SMU campus, students can participate in the Army ROTC program at the University of Texas at Arlington by enrolling as they enroll for other SMU courses. Further program information and application procedures may be obtained by contacting the UTA Department of Military Science at 817-272-3281. Students who participate in the UTA Army ROTC program are responsible for their own travel and other physical arrangements.

Army ROTC offers students the opportunity to graduate as officers and serve in the U.S. Army, the Army National Guard or the U.S. Army Reserve. Army ROTC scholarships are awarded on a competitive basis. Each scholarship pays for tuition and required educational fees, and provides a specified amount for textbooks, supplies and equipment. Each scholarship also includes a subsistence allowance of up to $1,000 for every year the scholarship is in effect.

Students can enroll in the Army ROTC on-campus program as they enroll for other SMU courses. Army ROTC courses are listed under ROTC in the my.SMU schedule of classes, and permission to enroll must be obtained from Betsy Willis at bwillis@lyle.smu.edu or 214-768-1732.

The Courses (ROTC)

ROTC 1141 (1). FOUNDATIONS OF LEADERSHIP. Fundamental concepts of leadership in a profession, with classroom and outdoor laboratory environments. Studies time management skills, basic drill, ceremony, physical fitness, repelling, leadership reaction, first aid, presentations, and marksmanship. *Corequisite:* ROTC 1180. Includes mandatory participation in independent physical fitness training, plus optional participation in a weekend field training exercise.

ROTC 1142 (1). INTRODUCTION TO LEADERSHIP. Application of principles of leadership through participation in physically and mentally challenging exercises with upper-division ROTC students, with a focus on communication skills, organizational ethics, and time management techniques. *Corequisite:* ROTC 1180. Includes mandatory participation in individual physical fitness training, plus optional participation in a weekend field training exercise.

ROTC 1143 (1). ARMY ROTC: INTRODUCTION TO LEADERSHIP I. Introduces basic military skills, including principles of emergency first aid, evacuation of casualties, map and compass reading, terrain association, cross-country navigation, principles of physical fitness training, and military inspections. *Corequisite:* ROTC 1180.

ROTC 1180 (1). LEADERSHIP LABORATORY. A practical laboratory of applied leadership and skills. Students plan, organize, and conduct training that is oriented toward leadership development. Topics include marksmanship and small-unit tactics. Multitiered programs focus on individual skill levels. Uniform and equipment provided. May be repeated for credit.

ROTC 2248 (2). EVOLUTION OF CONTEMPORARY MILITARY STRATEGY. A review of contemporary military conflicts. Selected battles from World War II, Korea, Vietnam, and the Yom Kippur War are examined for impact upon current U.S. military doctrine, strategy, and weapons systems. *Corequisite:* All military science students must enroll or participate in ROTC 1180 unless exception is given by the PMS.

ROTC 2251 (2). INDIVIDUAL AND TEAM DEVELOPMENT. Application of ethics-based leadership skills and fundamentals of the ROTC's Leadership Development Program. Develops skills in oral presentations, concise writing, event planning, coordination of group efforts, advanced first aid, land navigation, and military tactics. *Corequisite:* ROTC 1180. Includes mandatory participation in individual physical fitness training, plus optional participation in a weekend field training exercise.

ROTC 2252 (2). INDIVIDUAL AND TEAM MILITARY TACTICS. Introduces individual and team aspects of military tactics in small-unit operations. Includes use of radio communications, safety assessments, movement techniques, team safety and security, and pre-execution checks.

Corequisite: ROTC 1180. Includes mandatory participation in individual physical fitness training, plus optional participation in a weekend field training exercise.

ROTC 2291 (2). CONFERENCE COURSE. Supplements the military science curricula through concentrated, independent study in a narrower field of military skill or subject matter. May be repeated for credit. Does not count for PE credit. *Prerequisite:* Permission of the PMS.

ROTC 2343 (3). LEADERSHIP TRAINING CAMP. A rigorous 5-week summer camp conducted at an Army post. Stresses leadership, initiative, and self-discipline. No military obligation incurred. Course completion qualifies the student for entry into the advanced course. Three different cycles offered during the summer, but spaces are limited by the Army. Candidates can apply for a space any time during the school year prior to the summer. Open only to students who have not taken all four of ROTC 1141, 1142, 2251, and 2252 and who pass an ROTC physical examination. P/F grade only.

ROTC 3341 (3). LEADERSHIP I. Development of ability to evaluate situations, plan and organize training, learn military tactics, review case studies in leadership management, and develop teaching and briefing skills. *Prerequisite:* Permission of PMS. *Corequisite:* ROTC 1180.

ROTC 3342 (3). LEADERSHIP II. Practical application of squad and platoon leadership in tactical situations, operation of small-unit communications systems, and development of the leaders' abilities to express themselves, analyze military problems, and prepare and deliver logical solutions. Demanding physical fitness training and performance-oriented instruction in preparation for summer field training. *Prerequisite:* Permission of PMS. *Corequisite:* ROTC 1180.

ROTC 3443 (4). NATIONAL ADVANCED LEADERSHIP CAMP. A 5-week, off-campus field training course stressing the practical application of leadership management, with emphasis on tactical and technical military field skills. Open only to students who have successfully completed ROTC 3341 and 3342. P/F grade only.

ROTC 3495 (4). NURSING ADVANCED SUMMER TRAINING. A 7-week, off-campus internship at a major U.S. Army hospital for ROTC nursing students. This nursing practicum provides hands-on experience that integrates clinical, interpersonal, and leadership knowledge and skills. Practical experience and familiarization with Army nursing in a variety of clinical tasks in the areas of medical-surgical nursing, pediatrics, obstetrics, and, in some cases, intensive care in ICUs in some cases. May be used for partial credit for NURS 3647 or 3347 with prior arrangement and approval of the dean of nursing. *Prerequisites:* Completion of the junior year of a baccalaureate nursing program and permission of the PMS.

ROTC 4341 (3). ADVANCED LEADERSHIP I. Stresses leadership qualities necessary for command and staff functions and operations. Students plan and conduct meetings, briefings, conferences, physical training programs. Introduces the Army's logistical system and personnel management system. Also, preparation of after-action reports. *Prerequisite:* Permission of PMS. *Corequisite:* ROTC 1180.

ROTC 4342 (3). ADVANCED LEADERSHIP II. Examines the ethical standards, professional roles, responsibilities, and uniqueness of the profession of officership. Includes case study analysis of military law and practical exercises on establishing an ethical command climate. Students complete a term-long senior leadership project that requires them to plan, organize, and demonstrate their leadership skills. Following course completion, students are commissioned as second lieutenants in the Army. Provides a basic working knowledge of the military justice system, with emphasis on company-level actions and requirements, including law of land warfare. *Prerequisite:* Permission of PMS. *Corequisite:* ROTC 1180.

ROTC 4391 (3). CONFERENCE COURSE. Independent study on current topics in military science. Performance is assessed by oral examination, written test, or research paper, as arranged. May be repeated for credit. *Prerequisite:* Permission of PMS.