DREXEL UNIVERSITY
College of
Engineering

CATALOG
2013-2014

DREXEL INSTITUTE
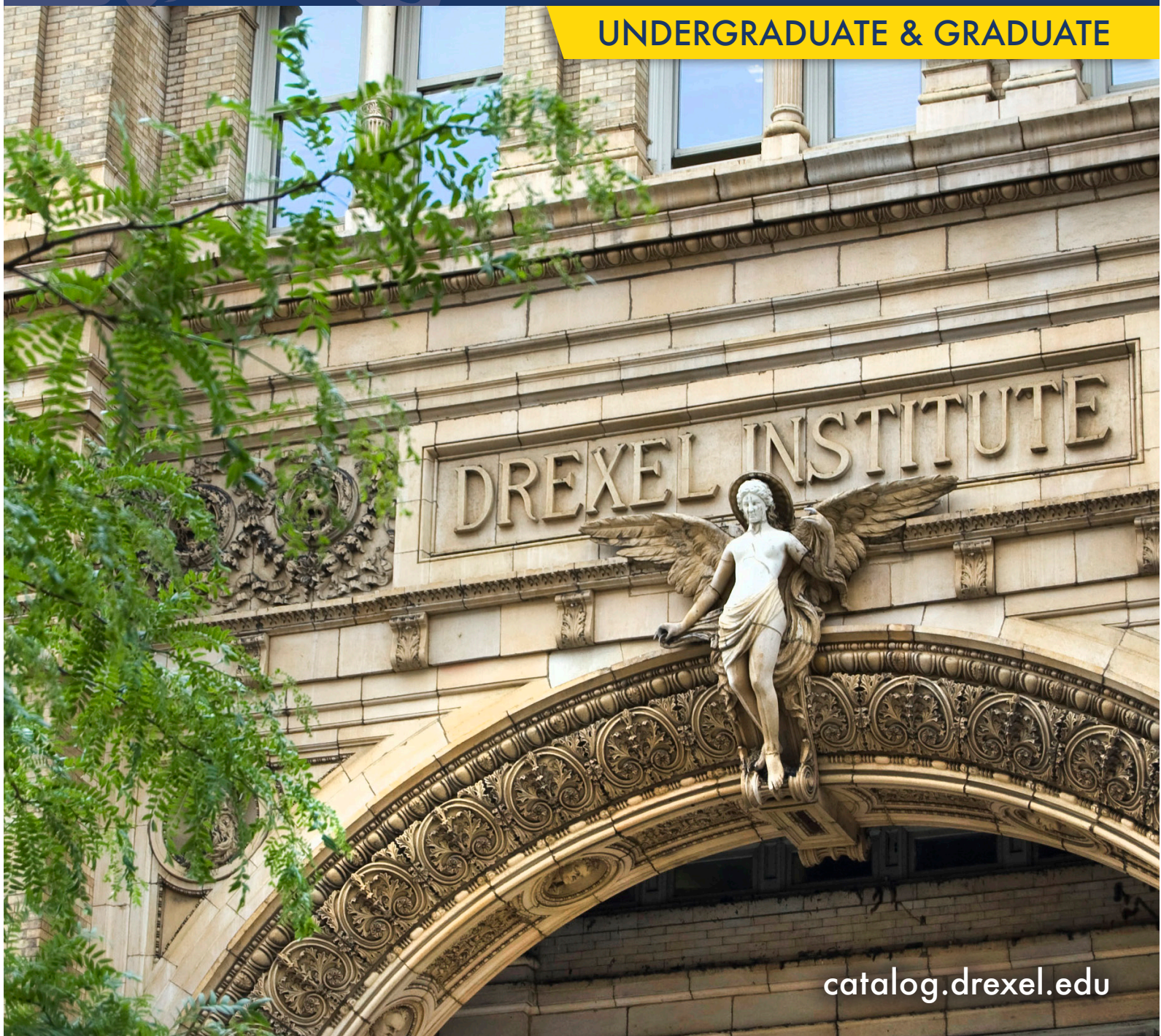
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College of Engineering: Undergraduate Studies

The College of Engineering curriculum is designed to provide students a thorough understanding of scientific, mathematical, and engineering fundamentals--as well as the ability to apply these areas of knowledge creatively to a wide variety of engineering problems.

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About the College

Drexel University's College of Engineering has emphasized its strengths in engineering, science and technology to train students to become the leaders of the future. In little over a century, Drexel University has transformed itself into a large, comprehensive institution committed to excellence in education, research and service to the engineering society and to the broader community. Although much has changed, the original mission of the University still rings true today.

As Drexel moves into the 21st century, the College of Engineering will continue to offer students a diverse academic learning and research environment, while continuing to build on its national reputation for excellence in engineering and research.

Objectives of the Undergraduate Engineering Program

The profession of engineering is concerned with turning the natural elements and energies to the service of mankind. The objectives of the undergraduate program in the College of Engineering (http://www.drexel.edu/coe) are:

- *To offer an education that will give graduates the flexibility to adjust to future changes in technology*
- *To develop a sense of professionalism*
- *To provide a framework for concentrated study in a professional area*

To implement those objectives the curricula of the College of Engineering are designed to provide a firm grounding in basic science and liberal arts, along with broad-based engineering sciences and professional engineering subjects.

Co-operative Education

In five-year co-operative programs, engineering majors spend a total of 12 terms in school and six terms on co-op assignment. Freshmen attend classes for three terms. During their sophomore, pre-junior, and junior years, students generally attend class for two terms and are assigned a co-operative employment position for two terms each year.

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

About the Curriculum

Degree Requirements

The degree of Bachelor of Science in the engineering specialities requires a minimum of 192 credits of academic work and six terms of co-op or engineering experience for the five-year program. For the four-year program, only two terms of co-op are required. Transfer students must complete a minimum of two terms of co-op or engineering experience in order to earn a co-operative engineering degree accredited by ABET. All full-time students in the college of engineering are required to complete the minimum terms of co-op.

Engineering student must maintain an overall grade point average of 2.0 in all required courses in their major.

The Bachelor of Science in Engineering (BSE) program is a customizable undergraduate engineering degree program offered in the College of Engineering. The program is designed for students who are seeking an interdisciplinary education rooted in engineering. The degree is structured so students achieve a strong foundation in science, math and engineering. Upper level engineering electives can be chosen to fit the student's individual interests and career objectives. The BS in Engineering program allows the student to create their own engineering curriculum path with the assistance of their BSE advisors. The program is also flexible enough so that students can complete up to two minors in areas which may include but are not limited to environmental studies, finance, entrepreneurship, music, legal studies or pre-med. To learn more about the Bachelor of Science in Engineering program, please visit the Program Overview webpage (http://www.drexel.edu/engineering/programs/undergrad/Engineering/BSE/ProgramOverview).

Curricular Organization

With the exception of Computer Science and Software Engineering majors, all students in the College of Engineering study the same subjects during the three terms in the first year. During the two terms of the sophomore year, students begin taking department specific coursework.

The first five terms are devoted to those subjects that form the foundation of the engineering curriculum. Courses in the core engineering curriculum are organized and taught to provide an integrated view of the basic sciences and an introduction to the art of engineering through group projects that deal with open-ended problems characteristic of the practice of engineering. Students also learn to use the modern tools of engineering both on the computer and in the laboratory.

The college considers it essential that students entering the Drexel Engineering Curriculum be placed in courses that take advantage of their abilities and prior training. Student preparation level is determined by a review committee that evaluates the student's high school record, standardized test scores, and placement tests administered during freshman orientation.

Students who demonstrate the preparation and skills to succeed in our integrated engineering calculus course immediately will be placed in starting in the fall term. Students who are not prepared for this sequence may participate in a special "pre-engineering" program before the fall term. These students may also have a modified fall schedule and may need summer school during the following summer.

In the second year, two professional subjects are introduced, and all the first-level professional courses are completed by the junior year. The senior year in all curricula contains at least one elective sequence so that students can study some aspect of engineering more deeply. In addition, all curricula provide a design experience in the senior year. Recognizing the importance of general education studies in the education of an engineer, all curricula require that courses be taken in this area. These requirements are described in more detail in the General Education Requirements (p. 4).

The Common Curriculum

University Requirements

UNIV E101	The Drexel Experience	2.0

Foundation Requirements

MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0

In addition, engineering students complete ten (10) General Education Requirements.

Electives

In addition to the electives in the General Education electives there are two types of elective sequences in the engineering curricula: technical electives and free electives. Technical electives are courses in engineering, science, or management that build on the required professional courses and lead to a specific technical specialization. Possible elective sequences should be discussed with and approved by advisors before the end of the junior year. Free electives are any courses for which students are eligible and that are not remedial in nature for engineering students.

Withdrawal from the College of Engineering

It is the policy of the College of Engineering that an engineering student who withdraws from the University cannot petition for readmission to the College of Engineering until at least one complete term has elapsed.

General Education Requirements

The General Education Program is designed to give engineering students an opportunity to take a set of courses that complement their technical studies and satisfy their intellectual and/or career interests. All engineering majors must take ten (10) courses. Three of the ten courses are designated as follows and must be completed by all majors:

ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0

The remaining seven (7) General Education course requirements are not designated and can be chosen from the disciplines listed below. Any course of three credits or more selected from the categories below meets this requirement, except as noted.

Course Subjects

This following list is a sampling of subject codes for courses that can be taken to fulfill General Education requirements; other courses may be accepted upon advisor approval.

Accounting (ACCT), Africana Studies (AFAS), Anthropology (ANTH), Arabic (ARBC), Architecture (ARCH), Art History (ARTH), Business Law (BLAW), General Business (BUSN), Chinese (CHIN), Communication (COM), Criminal Justice (CJ), Culinary Arts (CULA), Customer Operations (CUST), Dance (DANC), Economics (ECON), English (ENGL, except 101, 102, 103 & 105), Entertainment & Arts Management (EAM), Education (EDUC), Film Studies (FMST), Finance (FIN), French (FREN), German (GER), Greek, (GREC), History (HIST), Hotel & Restaurant Management (HRM), Humanities (HUM, except 106, 107, & 108), International Area

Studies (IAS), International Business (INTB), Italian (ITAL), Japanese (JAPN), Korean (KOR), Language (LANG), Leadership (LEAD), Management (MGMT), Marketing (MKTG), Music (MUSC), Operations Management (OPM), Operations Research (OPR), Organizational Behavior (ORGB), Philosophy (PHIL), Photography (PHTO), Production Operations Management (POM), Political Science (PSCI), Psychology (PSY, except 330, 337, 364 & 365), Russian (RUSS), Screenwriting & Playwriting (SCRP), Sociology (SOC, except 364 & 365), Spanish (SPAN), Sports Management (SMT), Business Statistics (STAT), Taxation (TAX), Theatre (THTR), Women's Studies (WMST), and Writing (WRIT).

Environmental Policy (ENVP) courses can be chosen by Architectural Engineering, Civil Engineering, and Environmental Engineering programs.

Architectural engineering students' general studies requirements are slightly different. The three-course ARCH 141–ARCH 143 (Architecture and Society) sequence, offered through the Antoinette Westphal College of Media Arts and Design, is required of all architectural engineering students.

Some engineering majors require a study in basic economic principles, the history of the engineering profession and its impact on modern society, and ethical standards required for the practice of the profession. Check curriculum guidelines for requirements. Any required economics, history or ethics courses will replace general education requirements on a course-for-course basis.

General Education electives must be non-technical. All Computer, Math, Engineering & Science related courses will NOT count as General Education electives.

Exceptions: This policy regarding General Education requirements applies to all College of Engineering programs with the exception of the BS in Computer Science and the BS in Software Engineering.

Special Programs
Accelerated Programs/ Bachelor's/Master's Dual Degree Program

The Accelerated Program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the program makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum. Students enrolled in this program may take advantage of the five-year Bachelor's/Master's Dual Degree Program described on the College of Engineering's Accelerated: BS /MS (http://drexel.edu/engineering/programs/special_opp) web page.

Lincoln University/Drexel 3-3 Plan

Drexel participates in a program with Lincoln University under which a student may attend Lincoln University for three years, taking liberal arts subjects and pre-engineering courses in mathematics, science, and related areas; transfer to Drexel; and receive a degree in engineering after three additional years at Drexel. This is similar to the conventional 3-2 program in which other colleges and universities participate; the extra year is necessitated by Drexel's co-operative education plan.

Pre-Professional Programs

The College of Engineering offers Master of Science programs in engineering management and software engineering, telecommunications engineering, and master's and PhD programs in chemical engineering, civil engineering, computer engineering, electrical engineering, environmental engineering, materials engineering, and mechanical engineering. An Advanced Certificate in Engineering is also offered. For additional information, consult the graduate catalog or contact the graduate division of the College of Engineering. Students wishing to prepare for admission to professional schools of law or medicine may obtain preprofessional counseling and assistance in making application from the Office of Preprofessional Programs, 215-895-2437.

Facilities
Core Engineering Facilities

The Freshman Engineering Design Laboratories encompass three laboratories. They include two newly renovated spaces: a double laboratory room in the Bossone Research Center, which accommodates two lab sections, and another laboratory room that accommodates a single lab section in the LeBow Engineering Center.

Freshman Design courses taken by all new freshmen are held exclusively in these newly renovated rooms, which were completed in the fall of 2011. A team of Drexel faculty and staff designed these rooms to promote open communication within and across groups of students. Each room is equipped with Media:Scape tables manufactured by SteelCase. Each table has two 32-inch monitors that are connected to a MacMini computer, which is housed in the furniture, contributing to the overall clean look and feel of the classroom. The classroom design fosters and supports teamwork.

The Freshman Engineering Design Laboratories are a great example of Drexel's commitment to undergraduate education, by providing up-to-date, high-quality technology to facilitate the kind of experiential learning that keeps Drexel at the cutting edge.

Department Facilities

Departments within the College of Engineering have laboratory equipment appropriate for required lab coursework within curriculum. Most engineering department webpages describe their specialized facilities in detail.

Architectural Engineering
About the Program

Bachelor of Science in Architectural Engineering (BSAE): 193.0 quarter credits

The architectural engineering major prepares graduates for professional work in the analysis, design, construction, and operation of residential, commercial, institutional, and industrial buildings. The program develops engineers familiar with all aspects of safe and economical construction. Students study the principles of structural support and external cladding, building environmental systems, and project management and develop depth in at least one area.

The program integrates building disciplines, including coordination with architects; construction managers; civil, mechanical, and electrical engineers; and others. Students use computer-aided design tools to

understand system interactions; perform analysis, design, scheduling, and cost analysis; and present their work.

The first two years of the curriculum cover fundamentals necessary for all engineers. The pre-junior and junior years emphasize building systems and the principles governing their performance. In addition to the core engineering and science, students learn architectural approaches through studio design. Seniors focus on either structural or building environmental systems design, as well as a full-year realistic design project. The academic program is complemented by exposure to professional practice in the co-op experience.

A special feature of the major is senior design. A group of students works with a faculty advisor to develop a significant design project selected by the group. All architectural engineering students participate in a design project.

Mission Statement

The civil and architectural engineering faculty are responsible for delivering an outstanding curriculum that equips our graduates with the broad technical knowledge, design proficiency, professionalism, and communications skills required for them to make substantial contributions to society and to enjoy rewarding careers.

Program Educational Objectives

Architectural engineering graduates will become professionals who analyze, design, construct, manage, or operate residential, commercial, institutional and industrial buildings and systems, or advance knowledge of the field.

Student Outcomes

The department's stidemt outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Concentration Options

Mechanical Concentration (HVAC)

Students who choose the mechanical concentration (HVAC) prepare for careers dealing with the building environment. As co-ops and graduates, they will be involved in the many design aspects of building environmental control, including:

- building load definitions
- equipment selection and design
- distribution system design
- control systems design
- energy analysis and system optimization
- building operation for safety, economy and maximum performance

Structural Concentration

Students who choose the structural concentration prepare for careers dealing with the building structure. As co-ops and graduates, they will be involved in the design of the many aspects of building structure including:

- building load definitions
- structural system design
- foundation system design

Digital Building Concentration*

Students who choose the digital building concentration prepare for careers dealing with the role of computer technology in building design, construction and operation. As co-ops and graduates, they will be involved in:

- development and use of Building Information Models (BIM) and databases
- configuration and operation of building sensor and actuator networks and monitoring systems
- developing and maintaining construction schedules, databases and monitoring systems

*Available for enrollment starting in academic year 2014-2015.

Additional Information

The Architectural Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For more information about this major, contact the program director:
James E. Mitchell
Associate Professor
Civil Arch & Environmental Engineering
james.mitchell@drexel.edu

Degree Requirements

General Education/Liberal Studies Requirements

ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
UNIV E101	The Drexel Experience	2.0

General Education requirements [*]		12.0
Foundation Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Major Requirements		
AE 220	Introduction to HVAC	3.5
AE 340	Architectural Illumination and Electrical Systems	3.0
AE 390	Architectural Engineering Design I	4.0
AE 391	Architectural Engineering Design II	4.0
AE 544	Building Envelope Systems	3.0
ARCH 141	Architecture and Society I	3.0
ARCH 142	Architecture and Society II	3.0
ARCH 143	Architecture and Society III	3.0
ARCH 191	Studio 1-1	3.0
ARCH 192	Studio 1-2	3.0
CAE 491 [WI]	Senior Design Project I	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CAE 493 [WI]	Senior Design Project III	3.0
CAEE 201	Introduction to Infrastructure Engineering	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 250	Construction Materials	4.0
CIVE 330	Hydraulics	4.0
CIVE 320	Introduction to Fluid Flow	3.0
MEM 202	Statics	3.0
MEM 230	Mechanics of Materials I	4.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
Concentration Courses		29.0

Students select one of the following concentrations for a total of 29.0 credits:

Mechanical Concentration		
AE 430	Control Systems for HVAC	
CIVE 370	Introduction to Structural Analysis	
CIVE 371	Introduction to Structural Design	
CIVE 372	Structural Laboratory	
MEM 345	Heat Transfer	
MEM 413	HVAC Loads	
MEM 414	HVAC Equipment	
Three professional electives		
Structural Concentration		
CIVE 300	Theory of Structures I	
CIVE 301	Theory of Structures II	
CIVE 310	Soil Mechanics I	
CIVE 400	Structural Design I	
CIVE 401	Structural Design II	
CIVE 402	Structural Design III	
CIVE 410	Foundation Engineering	
Two professional electives		
Digital Building Concentration		
AE 510	Intelligent Buildings	
CIVE 370	Introduction to Structural Analysis	
CIVE 371	Introduction to Structural Design	
CIVE 372	Structural Laboratory	
CMGT 361	Contracts And Specifications I	
CMGT 467	Techniques of Project Control	
INFO 210	Database Management Systems	
INFO 203	IT for Engineers	
Total Credits		193.0

[*] General Education Requirements. (p. 4)

Sample Plan of Study

BS Architectural Engineering, Mechanical Engineering

5 YR UG Co-op Concentration/Mechanical Engineering

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		

CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
PHYS 101	Fundamentals of Physics I	4.0
MATH 122	Calculus II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
CAEE 201	Introduction to Infrastructure Engineering	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ARCH 191	Studio 1-1	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MEM 202	Statics	3.0
	Term Credits	**18.0**
Term 6		
AE 340	Architectural Illumination and Electrical Systems	3.0
ARCH 141	Architecture and Society I	3.0
ARCH 192	Studio 1-2	3.0
CIVE 320	Introduction to Fluid Flow	3.0
MEM 230	Mechanics of Materials I	4.0
	Term Credits	**16.0**
Term 7		
AE 220	Introduction to HVAC	3.5
ARCH 142	Architecture and Society II	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 250	Construction Materials	4.0
CIVE 330	Hydraulics	4.0
	Term Credits	**18.5**
Term 8		
AE 390	Architectural Engineering Design I	4.0
ARCH 143	Architecture and Society III	3.0

CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 370	Introduction to Structural Analysis	3.0
MEM 345	Heat Transfer	4.0
	Term Credits	**17.0**
Term 9		
AE 391	Architectural Engineering Design II	4.0
CIVE 371	Introduction to Structural Design	3.0
CIVE 372	Structural Laboratory	1.0
Professional elective[*]		3.0
General Education elective[*]		3.0
	Term Credits	**14.0**
Term 10		
AE 544	Building Envelope Systems	3.0
CAE 491 [WI]	Senior Design Project I	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
MEM 413	HVAC Loads	3.0
General Education elective[*]		3.0
	Term Credits	**15.0**
Term 11		
CAE 492 [WI]	Senior Design Project II	3.0
MEM 414	HVAC Equipment	3.0
Professional elective[*]		3.0
General Education elective[*]		3.0
	Term Credits	**12.0**
Term 12		
AE 430	Control Systems for HVAC	3.0
CAE 493 [WI]	Senior Design Project III	3.0
Professional elective[*]		3.0
General Education elective[*]		3.0
	Term Credits	**12.0**

Total Credit: 193.0

[*] See degree requirements (p. 6).

BS Architectural Engineering, Structural 5 YR UG Co-op Concentration/Structural

Term 1		**Credits**
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5

CS 122	Computation Laboratory II	1.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
CAEE 201	Introduction to Infrastructure Engineering	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ARCH 191	Studio 1-1	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MEM 202	Statics	3.0
	Term Credits	**18.0**
Term 6		
AE 340	Architectural Illumination and Electrical Systems	3.0
ARCH 141	Architecture and Society I	3.0
ARCH 192	Studio 1-2	3.0
CIVE 320	Introduction to Fluid Flow	3.0
MEM 230	Mechanics of Materials I	4.0
	Term Credits	**16.0**
Term 7		
AE 220	Introduction to HVAC	3.5
ARCH 142	Architecture and Society II	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 250	Construction Materials	4.0
CIVE 330	Hydraulics	4.0
	Term Credits	**18.5**
Term 8		
AE 390	Architectural Engineering Design I	4.0
ARCH 143	Architecture and Society III	3.0

CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 300	Theory of Structures I	3.0
CIVE 310	Soil Mechanics I	4.0
	Term Credits	**17.0**
Term 9		
AE 391	Architectural Engineering Design II	4.0
CIVE 301	Theory of Structures II	4.0
Professional elective[*]		3.0
General Education elective[*]		3.0
	Term Credits	**14.0**
Term 10		
AE 544	Building Envelope Systems	3.0
CAE 491 [WI]	Senior Design Project I	3.0
CIVE 400	Structural Design I	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
General Education elective[*]		3.0
	Term Credits	**15.0**
Term 11		
CAE 492 [WI]	Senior Design Project II	3.0
CIVE 401	Structural Design II	3.0
CIVE 410	Foundation Engineering	3.0
General Education elective[*]		3.0
	Term Credits	**12.0**
Term 12		
CAE 493 [WI]	Senior Design Project III	3.0
CIVE 402	Structural Design III	3.0
Professional elective[*]		3.0
General Education elective[*]		3.0
	Term Credits	**12.0**

Total Credit: 193.0

[*]   See degree requirements (p. 6).

BS Architectural Engineering, Digital Building

5 YR UG Co-op Concentration/Digital Building

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0

ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
PHYS 101	Fundamentals of Physics I	4.0
MATH 122	Calculus II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
CAEE 201	Introduction to Infrastructure Engineering	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ARCH 191	Studio 1-1	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MEM 202	Statics	3.0
	Term Credits	**18.0**
Term 6		
AE 340	Architectural Illumination and Electrical Systems	3.0
ARCH 141	Architecture and Society I	3.0
ARCH 192	Studio 1-2	3.0
CIVE 320	Introduction to Fluid Flow	3.0
MEM 230	Mechanics of Materials I	4.0
	Term Credits	**16.0**
Term 7		
AE 220	Introduction to HVAC	3.5
ARCH 142	Architecture and Society II	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 250	Construction Materials	4.0
CIVE 330	Hydraulics	4.0
	Term Credits	**18.5**
Term 8		
AE 390	Architectural Engineering Design I	4.0
ARCH 143	Architecture and Society III	3.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0

CIVE 370	Introduction to Structural Analysis	3.0
MEM 345	Heat Transfer	4.0
	Term Credits	**17.0**
Term 9		
AE 391	Architectural Engineering Design II	4.0
CIVE 371	Introduction to Structural Design	3.0
CIVE 372	Structural Laboratory	1.0
INFO 210	Database Management Systems	3.0
General Education Elective[*]		3.0
	Term Credits	**14.0**
Term 10		
AE 544	Building Envelope Systems	3.0
CAE 491 [WI]	Senior Design Project I	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
INFO 203	IT for Engineers	3.0
General Education Elective[*]		3.0
	Term Credits	**15.0**
Term 11		
AE 510	Intelligent Buildings	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CMGT 467	Techniques of Project Control	4.0
General Education Elective[*]		3.0
	Term Credits	**13.0**
Term 12		
CAE 493 [WI]	Senior Design Project III	3.0
CMGT 361	Contracts And Specifications I	3.0
Professional Elective[*]		3.0
General Education Elective[*]		3.0
	Term Credits	**12.0**

Total Credit: 194.0

[**]   Students are asked to speak with their program advisor before registering for the INFO elective.

Co-op/Career Opportunities

The major in architectural engineering prepares students for professional work in residential, commercial, institutional, and industrial building systems, in cooperation with architects and other engineers.

Sample Co-Op Experiences

When students complete their co-op jobs, they are asked to write an overview of their experiences. These brief quotes are taken from some recent student reports:

Project technician, major university: "Studied and surveyed existing buildings and facilities for: their compliance with the Americans with Disabilities Act, heating and air conditioning equipment sizing, electrical loads, and their planning and usage of space. Designed improvements from the field surveys taken, and developed construction drawings. Worked closely with the workforce in implementing these changes."

CAD technician, private engineering firm: "Prepared computer generated construction plans for various water and sewer reconstruction

projects. . . .Was able to expand my knowledge of Auto CAD to include Advanced Design Modules."

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

The Accelerated Program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the program makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

A student completing the Bachelor of Science degree program in architectural engineering may complete additional courses (specified by the department) to earn the Bachelor of Science degree in civil engineering. (The reverse is difficult because of prerequisites in the sequence of architectural studio design courses, which begins in the sophomore year.)

Required Courses for Dual Degree in Civil Engineering

CIVE 430	Hydrology	3.0
CIVE 477 [WI]	Seminar	2.0
CIVE 478 [WI]	Seminar	1.0
ENVE 300	Introduction to Environmental Engineering	3.0
Technical Elective (200-level or above) *		3.0
Required Courses for Mechanical Concentration		
CIVE 310	Soil Mechanics I	4.0
CIVE 410	Foundation Engineering	3.0
Required Courses for Structural Concentration		
CIVE 375	Structural Material Behavior	3.0

* Check with the Department for Technical elective options.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science degree in the same period as the bachelor of science. Exceptional students can also pursue a master of science degree in the same period as the bachelor of science. For more information about this program, visit the Department's BS /MS Dual Degree Program (http://www.cae.drexel.edu/dual_degree.asp) page.

Minor in Architectural Engineering

The minor in architectural engineering, designed to broaden the professional capabilities of students, offers the building systems portion of the architectural engineering curriculum with enough attention to structural components for completeness. Pursuing a minor in architectural engineering can be of interest to mechanical engineering students who wish to learn the application of HVAC systems within the building context; to civil engineering students who require knowledge of large-scale infrastructure systems; and to chemical engineering students who wish to understand the energy and distribution aspects of process plant design.

The minor consists of a minimum of 24 credits total, with five required core courses. Students take a minimum of eight additional credits taken from a list of optional courses.

While this minor is primarily designed to provide technical knowledge and skills to other engineers, with the appropriate prerequisites students from other disciplines—such as architecture—can also complete this minor.

Prerequisites

The common engineering core curriculum prerequisites are required of all students in the College of Engineering. Students from other colleges will need the appropriate background prerequisite courses in physics, mathematics and thermodynamics.

Required Courses

CAEE 201	Introduction to Infrastructure Engineering	3.0
AE 220	Introduction to HVAC	3.5
AE 340	Architectural Illumination and Electrical Systems	3.0
or ARCH 263	Environmental Systems III	
AE 390	Architectural Engineering Design I	4.0
CIVE 370	Introduction to Structural Analysis	3.0
Select two of the following:		8.0
CIVE 250	Construction Materials	
CIVE 371	Introduction to Structural Design	
MEM 413	HVAC Loads	
MEM 310	Thermodynamic Analysis I	
ARCH 191	Studio 1-1	
or ARCH 101	Studio 1-A	
AE 391	Architectural Engineering Design II	
CIVE 240 [WI]	Engineering Economic Analysis	
Total Credits		24.5

Facilities

The Department is well equipped with state-of-the-art facilities:

- The department computer labs are in operation: a computer-assisted design (CAD) and computerized instructional lab; and a graduate-level lab (advanced undergraduates can become involved in graduate-level work).
- External labs are used for surveying, building diagnostics, and surface and ground-water measurements.

Chemical Engineering

Bachelor of Science in Chemical Engineering (BSCHE): 192.5 quarter credits

About the Program

The department of Chemical and Biological Engineering's chemical engineering curriculum is structured so that students progress through sequences in the fundamental physical sciences, humanities, engineering sciences, and engineering design.

Chemical engineers are concerned primarily with process engineering, the conversion of raw materials into valuable products. The products can include pharmaceuticals, specialized plastics, petrochemicals, materials for biomedical applications, and energy. The processes, which usually

start out at a small laboratory scale, must be developed for production at a large chemical plant scale. The large change in scale requires careful engineering to minimize environmental contamination and to insure public safety.

The Department of Chemical and Biological Engineering is responsible for equipping our graduates with the broad technical knowledge and teamwork skills required for them to make substantial contributions to society.

Sample Senior Design Projects

A special feature of the major is senior design. A student — or group of students — works with a faculty advisor to develop a significant design project. Some recent examples include:

- Design of a process to make petrochemical intermediates
- Plastics recycling design
- Process design for antibiotic products

Program Educational Objectives

The chemical engineering major has four goals for its students:

- Our graduates will succeed in careers requiring strong skills in engineering, science, communication, and teamwork.
- Our graduates will continue to upgrade their technological skills through life-long learning involving self- or group-study.
- Our graduates will conduct their work with an understanding of its global impact and ethical consequences.
- Our graduates will contribute to research and development at the forefront of chemical engineering and related fields.

To help students reach these goals, the curriculum is structured so that they progress through sequences in the fundamental physical sciences, humanities, engineering sciences, and design.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Additional Information

The Chemical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For more information about this program, visit Drexel University's Department of Chemical and Biological Engineering (http://www.chemeng.drexel.edu) web page.

Degree Requirements

General Education/Liberal Studies Requirements

HIST 285	Technology in Historical Perspective	3.0
ENGL 101	Expository Writing and Reading	3.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGL 103	Analytical Writing and Reading	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		15.0
Free Electives		3.0
Foundation Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Sophomore Engineering Elective Options		
Select one of the following:		3.0
BIO 214	Principles of Cell Biology	
CHEM 230	Quantitative Analysis	
ENVS 260	Environmental Science and Society I	
MATH 221	Discrete Mathematics	
PHYS 202	Fundamentals of Physics IV	
Professional Requirements		

CHE 201	Process Material Balances	3.0
CHE 202	Process Energy Balances	3.0
CHE 206	Basic Chemical Engineering Thermodynamics	3.0
CHE 301	Process Thermodynamics	3.0
CHE 302	Process Fluid Mechanics	4.0
CHE 303	Process Heat Transfer	3.0
CHE 304	Process Mass Transfer	4.0
CHE 305	Process Separations	4.0
CHE 307	Process Modeling I	4.0
CHE 308	Process Modeling II	4.0
CHE 332 [WI]	Chemical Engineering Laboratory	2.0
CHE 333 [WI]	Chemical Engineering Laboratory II	2.0
CHE 334 [WI]	Chemical Engineering Laboratory III	2.0
CHE 335	Statistics and Design of Experiments	3.0
CHE 420	Process Systems Engineering	3.0
CHE 424	Chemical Kinetics and Reactor Design	4.0
CHE 481	Process Design I	3.0
CHE 482 [WI]	Process Design II	3.0
CHE 483 [WI]	Process Design III	3.0
CHEC 352	Physical Chemistry and Applications II	4.0
CHEC 353	Physical Chemistry and Applications III	4.0
CHEM 241	Organic Chemistry I	4.0
CHEM 242	Organic Chemistry II	4.0
CHEM 356	Physical Chemistry Laboratory	2.0
Concentration Electives		14.0
Total Credits		192.5

*   General Education Requirements (p. 4).

Graduate-Level Electives

CHE 502	Mathematical Methods in Chemical Engineering	3.0
CHE 513	Chemical Engineering Thermodynamics	3.0
CHE 525	Transport Phenomena I	3.0
CHE 543	Kinetics & Catalysis I	3.0
CHE 554	Process Systems Engineering	3.0
CHE 562	Bioreactor Engineering	3.0
CHE 564	Unit Operations in Bioprocess Systems	3.0
CHE 614	Chemical Engineering Thermodynamics II	3.0

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Expository Writing and Reading	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Analytical Writing and Reading	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
CHE 201	Process Material Balances	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
CHE 202	Process Energy Balances	3.0
CHE 206	Basic Chemical Engineering Thermodynamics	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Sophomore Engineering Elective*		3.0
	Term Credits	**15.0**
Term 6		
CHE 301	Process Thermodynamics	3.0
CHE 307	Process Modeling I	4.0
CHEM 241	Organic Chemistry I	4.0
CHEM 356	Physical Chemistry Laboratory	2.0
HIST 285	Technology in Historical Perspective	3.0
	Term Credits	**16.0**
Term 7		
CHE 302	Process Fluid Mechanics	4.0
CHE 332 [WI]	Chemical Engineering Laboratory	2.0
CHE 335	Statistics and Design of Experiments	3.0
CHEM 242	Organic Chemistry II	4.0
PHIL 315	Engineering Ethics	3.0
	Term Credits	**16.0**
Term 8		
CHE 303	Process Heat Transfer	3.0
CHE 305	Process Separations	4.0
CHE 333 [WI]	Chemical Engineering Laboratory II	2.0

CHEC 352	Physical Chemistry and Applications II	4.0
General Education Elective[*]		3.0
	Term Credits	**16.0**
Term 9		
CHE 304	Process Mass Transfer	4.0
CHE 334 [WI]	Chemical Engineering Laboratory III	2.0
CHE 308	Process Modeling II	4.0
CHEC 353	Physical Chemistry and Applications III	4.0
General Education Elective[*]		3.0
	Term Credits	**17.0**
Term 10		
CHE 420	Process Systems Engineering	3.0
CHE 424	Chemical Kinetics and Reactor Design	4.0
CHE 481	Process Design I	3.0
General Education Elective[*]		3.0
	Term Credits	**13.0**
Term 11		
CHE 482 [WI]	Process Design II	3.0
Free Elective		3.0
CHE Concentration Electives		7.0
General Education Elective[*]		3.0
	Term Credits	**16.0**
Term 12		
CHE 483 [WI]	Process Design III	3.0
CHE Concentration Electives		7.0
General Education Elective[*]		3.0
	Term Credits	**13.0**

Total Credit: 192.5

[*]   See degree requirements (p. 12).

Co-op/Career Opportunities

Chemical engineers tend to work for large corporations with such job assignments as process engineering, design engineering, plant operation, research and development, sales, and management. They also work for federal and state government agencies on projects related to environmental problems, defense, energy, and health-related research.

Some major employers of Drexel's chemical engineering graduates are DuPont, Merck, BASF, ExxonMobil, Rohm & Haas, and Air Products. A number of graduates go on to pursue master's and/or doctoral degrees. Graduate schools that Drexel's chemical engineers have attended include the University of California at Berkeley and Massachusetts Institute of Technology, among others.

Co-Op Experiences

Drexel is located in downtown Philadelphia with easy access to major pharmaceutical, chemical, and petroleum companies. When students complete their co-op jobs, they are asked to write an overview of their experiences. These brief quotes are taken from some recent student reports:

Research assistant, chemicals manufacturer: "Conducted research in a developmental polyamide process. Aspects included scale-up from bench-scale to batch demonstration, installation and calibration of on-line composition sensors, off-line analytical techniques to assess product quality, and interfacing with plant sites to define and standardize a critical quality lab procedure. Documented results in technical memos and in a plant presentation . . .I had a lot of freedom and responsibility. It was great interacting with other researchers and technicians. Everyone was so helpful. "

Co-op engineer, chemicals manufacturer: "Created material safety data sheets, which involved chemical composition, hazard communication, occupational safety and health, emergency response, and regulatory issues for numerous products and wastes. Handled domestic and international regulatory reviews. Determined hazardous waste reporting requirements, handling and disposal procedures. Evaluated toxicological and ecological data for assessment of hazard ratings. Provided input on product safety technical reports. "

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated Program

The Accelerated Program of the College of Engineering provides opportunities for highly-talented and strongly-motivated students to progress toward their educational goals essentially at their own pace. Through advanced placement, credit by examination, flexibility of scheduling, and independent study, the program makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Bachelor's/Master's Dual Degree Program

Drexel offers a combined MS/BS degree program for our top engineering students who want to obtain both degrees in the same time period as most students obtain a Bachelor's degree. In chemical engineering, the course sequence for MS/BS students involves additional graduate courses and electives.

Facilities

From the start of their freshman year, students learn to use the equipment they are likely to need in their careers, such as oscilloscopes, signal generators, amplifiers, and power supplies. These skills make students more useful as co-op employees and give them a competitive advantage in their engineering careers. The new 15-station laboratories equipped with Hewlett-Packard computers, software, and test and measurement instruments now add to the value of a Drexel engineering degree.

Computer/Design Center

The Drexel Curriculum boasts two types of lab experience: Instrumentation and Computer Design. Instrumentation Labs introduce Engineering Majors to the sight, sound, and feel of equipment such as digital multimeters, power supplies, oscilloscopes, and waveform generators. The Computer Labs imbue these pre-engineers with knowledge of software which they will be vital in today's work environment. Visit the Computer/Design Center (http://www.tdec.drexel.edu/?page=edl/#CDC) for more information.

Civil Engineering

Bachelor of Science in Civil Engineering (BSCIV): 190.5 quarter credits

About the Program

The civil engineering major prepares students in the fundamental principles necessary to practice this profession in any of its branches, including construction management, water resources, structural, transportation, environmental, geotechnical, and public facilities engineering.

Civil engineers are active in the planning, design, construction, research and development, operation, maintenance, and rehabilitation of large engineering systems. A particular focus is the reconstruction of the nation's infrastructure through solutions that minimize the disruption of social and natural environments.

Civil engineering graduates are grounded in the fundamental principles necessary for the practice of this profession in any of its modern branches, including construction management, water resources engineering, structural engineering, geotechnical engineering, transportation engineering, and environmental engineering.

Seven of the required courses in the discipline include integral laboratories or field projects for both educational illustration and professional practice exposure.

Careful selection of the electives specified in the curriculum can lead to a wide variety of career objectives. For instance, students with an interest in water resources engineering may elect advanced courses in hydrology, ecology, and chemistry; select senior professional electives in the geotechnical and water resources areas; and choose appropriate topics for senior design and senior seminar. Seniors, with the approval of the department head, can elect certain graduate courses.

A special feature of the major is senior design. A group of students works with a faculty advisor to develop a significant design project selected by the group. All civil engineering students participate in a design project.

Mission Statement

The civil and architectural engineering faculty are responsible for delivering an outstanding curriculum that equips our graduates with the broad technical knowledge, design proficiency, professionalism, and communications skills required for them to make substantial contributions to society and to enjoy rewarding careers.

Program Educational Objectives

Civil engineering graduates will become professionals who analyze, design, construct, manage or operate physical infrastructure and systems, or advance knowledge of the field.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Additional Information

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For more information about this major, contact the Department of Civil, Architectural and Environmental Engineering (http://www.cae.drexel.edu).

Degree Requirements

General Education/Liberal Studies Requirements

ENGL 101	Expository Writing and Reading	3.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGL 103	Analytical Writing and Reading	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		21.0
Free Electives		6.0
Foundation Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0

ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
Major Requirements		
CAE 491 [WI]	Senior Design Project I	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CAE 493 [WI]	Senior Design Project III	3.0
CAEE 201	Introduction to Infrastructure Engineering	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 250	Construction Materials	4.0
CIVE 310	Soil Mechanics I	4.0
CIVE 320	Introduction to Fluid Flow	3.0
CIVE 330	Hydraulics	4.0
CIVE 375	Structural Material Behavior	3.0
CIVE 410	Foundation Engineering	3.0
CIVE 430	Hydrology	3.0
CIVE 477 [WI]	Seminar	2.0
CIVE 478 [WI]	Seminar	1.0
ENVE 300	Introduction to Environmental Engineering	3.0
MEM 202	Engineering Mechanics-Statics	3.0
MEM 230	Mechanics of Materials I	4.0
Senior Professional Electives [**]		18.0
Select one of the following:		3.0
CIVE 370	Introduction to Structural Analysis	
CIVE 300	Theory of Structures I	
Based on whether or not students are pursuing a structural or non-structural concentration, students select one of the following options:er:		4.0
CIVE 301	Theory of Structures II	
CIVE 371 & CIVE 372	Introduction to Structural Design and Structural Laboratory	
Total Credits		190.5

[*] General Education Requirements (p. 4).

[**] A sequence of three courses in a major area of study is required, with a total of six 3-credit professional electives.

Sample Plan of Study

BS Civil Engineering

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Expository Writing and Reading	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
Term Credits		**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
Term Credits		**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Analytical Writing and Reading	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
Term Credits		**19.0**
Term 4		
CAEE 201	Introduction to Infrastructure Engineering	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
Term Credits		**17.0**
Term 5		
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MEM 202	Engineering Mechanics-Statics	3.0
Term Credits		**15.0**
Term 6		
CIVE 320	Introduction to Fluid Flow	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
ENVE 300	Introduction to Environmental Engineering	3.0
MEM 230	Mechanics of Materials I	4.0
General Education Elective [*]		3.0
Term Credits		**16.0**
Term 7		
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 250	Construction Materials	4.0

CIVE 330	Hydraulics	4.0
General Education Elective[*]		3.0
	Term Credits	**18.0**
Term 8		
CIVE 310	Soil Mechanics I	4.0
CIVE 430	Hydrology	3.0
CIVE 370 or 300	Introduction to Structural Analysis Theory of Structures I	3.0
General Education Elective[*]		3.0
Free Elective		3.0
	Term Credits	**16.0**
Term 9		
CIVE 375	Structural Material Behavior	3.0
CIVE 410	Foundation Engineering	3.0
General Education Electives[*]		3.0
CIVE 301 (Non-structural concentration takes CIVE 371 & CIVE 372)	Theory of Structures II	4.0
	Term Credits	**13.0**
Term 10		
CAE 491 [WI]	Senior Design Project I	3.0
CIVE 477 [WI]	Seminar	2.0
Professional Electives[*]		6.0
General Education Elective[*]		3.0
	Term Credits	**14.0**
Term 11		
CAE 492 [WI]	Senior Design Project II	3.0
CIVE 478 [WI]	Seminar	1.0
Professional Electives[*]		6.0
General Education Elective[*]		3.0
	Term Credits	**13.0**
Term 12		
CAE 493 [WI]	Senior Design Project III	3.0
Free Elective		3.0
Professional Electives[*]		6.0
General Education Elective[*]		3.0
	Term Credits	**15.0**

Total Credit: 190.5

[*]   See degree requirements (p. 15).

Co-op/Career Opportunities

When students complete their co-op jobs, they are asked to write an overview of their experiences. These brief quotes are taken from some recent student reports:

Engineering construction inspector, state department of transportation: Supervised daily activities involved in the roadway construction of the [interstate] bypass. Recorded daily visual inspection reports for soil sub-base and materials placed on site.Aided senior roadway engineers in approving grade prior to asphalt placement. Used various instruments to check temperature and depths for asphalt placement.Took part in on-site discussions with contractor to clear up any daily construction problems that would hinder quality of construction. ”

Construction inspector,municipal department of public property: “Inspected work performed by private contractors on city public works construction and rehabilitation projects for adherence to contract plans and specifications. Projects included health centers, police and fire stations, libraries, city hall, transit concourses, and prisons. Responsible for daily inspection reports and overall coordination for each respective project. Also responsible for reviewing bills and writing contract modifications and amendments. . .the variety of work was excellent. ”

Environmental co-op, chemicals manufacturer: “Compiled data and wrote monthly regulatory reports, in charge of hazardous waste management and small projects as needed. . . . I had my own responsibilities that had an impact on the entire company. Employer was really interested in my opinion and gave me a chance to demonstrate my abilities, but also knew when to step in. Everybody was willing to answer any questions I may have had. ”

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated program

The Accelerated Program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the program makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

A student completing the Bachelor of Science degree program in architectural engineering may complete additional courses (specified by the department) to earn the Bachelor of Science degree in civil engineering. (The reverse is difficult because of prerequisites in the sequence of architectural studio design courses, which begins in the sophomore year.)

Civil Engineering students can also complete a dual degree with the Bachelor of Science in Environmental Engineering.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science degree in the same period as the bachelor of science.

For more information about this program, visit the Department's BS / MS Dual Degree Program (http://www.drexel.edu/academics/coe/cae/dual_degree.asp) page.

Facilities

The Department is well equipped with state-of-the-art facilities:

- The department computer labs are in operation: a computer-assisted design (CAD) and computerized instructional lab; and a graduate-level lab (advanced undergraduates can become involved in graduate-level work).
- External labs are used for surveying, building diagnostics, and surface and ground-water measurements.
- A $4.5-million instruction and research lab renovation was funded by the National Science Foundation, alumni, and corporations.

Computer Engineering

Bachelor of Science in Computer Engineering (BSCE): 192.0 quarter credits

About the Program

The major provides a broad focus on digital circuit design, computer hardware and organization, programming and computer software, algorithms, and networks.

Computer engineers design smaller, faster, and more reliable computers and digital systems; embed microprocessors in larger systems (e.g. anti-lock brake systems); work in theoretical issues in computing; use object-oriented programming languages; and design large-scale software systems and computer networks. Computer engineers may work in positions that apply computers in control systems, digital signal processing, telecommunications, and power systems, and may design very large-scale integration (VLSI) integrated circuits and systems.

The computer engineering degree program is designed to provide our students with breadth in engineering, the sciences, mathematics, and the humanities, as well as depth in both software and hardware disciplines appropriate for a computer engineer. It embodies the philosophy and style of the Drexel Engineering Curriculum, and will develop the student's design and analytical skills. In combination with the co-op experience, it opens to the student opportunities in engineering practice, advanced training in engineering or in other professions, and an entry to business and administration.

The computer engineering program's courses in ECE are supplemented with courses from the departments of Mathematics and Computer Science. Students gain the depth of knowledge of computer hardware and software essential for the computer engineer.

Mission Statement

The ECE Department at Drexel University serves the public and the university community by providing superior career-integrated education in electrical and computer engineering; by conducting research in these fields, to generate new knowledge and technologies; and by promoting among all its constituents professionalism, social responsibility, civic engagement and leadership.

Program Educational Objectives

The Electrical and Computer Engineering Program Educational Objectives are that its alumni in their early years after graduation:

1. Secure positions and continue as valued, creative, dependable, and proficient employees in a wide variety of fields and industries, in particular as electrical and computer engineers;

2. Succeed in graduate and professional studies, such as engineering, science, law, medicine and business;

3. Pursue professional development through lifelong learning opportunities for a successful and rewarding career;

4. Provide leadership in their profession, in their communities, and in the global society;

5. Contribute to their professional disciplines body of knowledge;

6. Function as responsible members of society with an awareness of the social and ethical ramifications of their work.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Additional Information

The Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Additional information about the major is available on the ECE Department website (http://www.ece.drexel.edu/Undergraduate_Programs2.html).

Timothy P. Kurzweg, PhD
Associate Professor

Associate Department Head for Undergraduate Studies

Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director – Undergraduate Advising
Department of Electrical and Computer Engineering
Bossone Research Center Suite 313
advising@ece.drexel.edu

To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30.

Degree Requirements

General Education/Liberal Studies Requirements

ENGL 101	Expository Writing and Reading	3.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGL 103	Analytical Writing and Reading	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		18.0

Foundation Requirements

MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ECE 200	Digital Logic Design	3.0
ECE 201	Foundations of Electric Circuits	3.0
ECE 203	Programming for Engineers	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0

Professional Requirements

CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ECE 391	Introduction to Engineering Design Methods	1.0
ECE 491 [WI]	Senior Design Project I	2.0
ECE 492 [WI]	Senior Design Project II	2.0
ECE 493	Senior Design Project III	4.0
ECEC 301	Advanced Programming for Engineers	3.0
ECEC 302	Digital Systems Projects	4.0
ECEC 304	Design with Microcontrollers	4.0
ECEC 353	Systems Programming	3.0
ECEC 355	Computer Organization & Architecture	4.0
ECEC 356	Embedded Systems	4.0
ECEC 357	Introduction to Computer Networks	4.0
ECEL 301 [WI]	Electrical Engineering Laboratory	2.0
ECEL 302	ECE Laboratory II	2.0
ECEL 303	ECE Laboratory III	2.0
ECEL 304	ECE Laboratory IV	2.0
ECES 302	Transform Methods and Filtering	4.0
MATH 221	Discrete Mathematics	3.0
ECE 361	Probability for Engineers	3.0
or ECE 362	Engineering Statistics	
or ENGR 361	Statistical Analysis of Engineering Systems	
Six Computer Engineering Courses		**18.0**
Free Electives		**11.5**
Total Credits		192.0

[*] General Education Requirements (p. 4).

Sample Plan of Study

5 YR Ug Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Expository Writing and Reading	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Analytical Writing and Reading	3.0
ENGR 103	Engineering Design Laboratory III	2.0

MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
ECE 200	Digital Logic Design	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ECE 201	Foundations of Electric Circuits	3.0
ECE 203	Programming for Engineers	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 221	Discrete Mathematics	3.0
	Term Credits	**15.0**
Term 6		
ECEC 301	Advanced Programming for Engineers	3.0
ECEC 302	Digital Systems Projects	4.0
ECEL 301 [WI]	Electrical Engineering Laboratory	2.0
ECES 302	Transform Methods and Filtering	4.0
General Education elective[*]		3.0
	Term Credits	**16.0**
Term 7		
ECEC 304	Design with Microcontrollers	4.0
ECEC 355	Computer Organization & Architecture	4.0
ECEL 302	ECE Laboratory II	2.0
PHIL 315	Engineering Ethics	3.0
Free elective		3.0
	Term Credits	**16.0**
Term 8		
CS 265	Advanced Programming Tools and Techniques	3.0
ECEC 357	Introduction to Computer Networks	4.0
ECEL 303	ECE Laboratory III	2.0
General Education elective[*]		3.0
	Term Credits	**12.0**
Term 9		
CS 260	Data Structures	3.0
ECE 391 (Also offered spring term.)	Introduction to Engineering Design Methods	1.0
ECEC 356	Embedded Systems	4.0
ECEC 353	Systems Programming	3.0
ECEL 304	ECE Laboratory IV	2.0
ECE 361, 362, or ENGR 361	Probability for Engineers Engineering Statistics Statistical Analysis of Engineering Systems	3.0
General Education elective[*]		3.0
	Term Credits	**19.0**

Term 10		
ECE 491 [WI]	Senior Design Project I	2.0
Two Computer Engineering electives		6.0
General Education elective[*]		3.0
Free Elective		3.0
	Term Credits	**14.0**
Term 11		
ECE 492 [WI]	Senior Design Project II	2.0
Two Computer Engineering electives		6.0
General Education elective[*]		3.0
Free elective		3.5
	Term Credits	**14.5**
Term 12		
ECE 493	Senior Design Project III	4.0
Two Computer Engineering electives		6.0
General Education elective[*]		2.0
Free elective		3.0
	Term Credits	**15.0**

Total Credit: 192.0

[*]   See degree requirements (p. 19).

Co-op/Career Opportunities

Computer engineers work for computer and microprocessor manufacturers; manufacturers of digital devices for telecommunications, peripherals, electronics, control, and robotics; software engineering; the computer network industry; and related fields.A degree in computer engineering can also serve as an excellent foundation to pursue graduate professional careers in medicine, law, business, and government.

Graduates are also pursuing advanced studies in electrical and computer engineering, aerospace engineering, and mechanical engineering at such schools as MIT, Stanford, Princeton, Georgia Institute of Technology, University of California at Berkeley, University of Pennsylvania, and University of Maryland.

Sample Co-Op Experiences

When students complete their co-op jobs, they are asked to write an overview of their experiences.These brief quotes are taken from some recent student reports:

Co-op engineer, electronics manufacturer: "My position consisted mostly of the technical aspect of prototype development. My employer would supply me with a schematic diagram of a new circuit. It was then my responsibility to build the circuit, in breadboard form, power up the circuit, and determine if the circuit was producing the desired outputs or functions. . . . Everyone took time out of their jobs to answer any questions I had, and I was always treated as a member of the team. . . . My supervisor showed a genuine interest in teaching me what I had yet to learn in school. His explanations were down-to-earth and easy to understand. "

Network support technician, commercial laboratory: "I was responsible for the construction, installation, and troubleshooting of network cabling and equipment. Additional responsibilities included: maintenance of the network database, training of additional network personnel, as well as

supervision and evaluation of additional large-scale network installations when performed by outside contractors. "

Quality assurance, producer and distributor of music CDs: "I evaluated compact disc test systems and calibration processes. Aided in the work toward ISO-9002 certification for the entire facility as well as for quality assurance through writing procedures and providing training. . . . Gained managerial and supervisory experience from close work with supervisor. . . . Excellent work environment."

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated Program

The accelerated program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. These options include opportunities for accelerated studies, dual degrees, and combined bachelor's/master's programs.

Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the "fast track" makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

With careful planning, students can complete two full degrees in the time usually required to complete one. The double major option works best in closely related areas. For detailed information the student should contact his or her advisor.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science degree in the same period as the bachelor of science.

For more information on these and other options, visit the Department of Electrical and Computer Engineering BS/MS (http://www.ece.drexel.edu/undergrad/bsms.html) page.

Minor in Computer Engineering

The computer engineering minor is designed to provide students from other computer-intensive majors—such as computer science or other engineering majors—with a foundation of knowledge in the hardware portion of computer systems. The minor consists of a minimum of seven ECE courses. There are four required courses and an additional 12.0 credits of elective courses.

Prerequisites

The minor assumes that students will have a background in mathematics, physics, and computer programming equivalent to that covered in the first two years of engineering.

Calculus prerequisites should include MATH 121, MATH 122 and MATH 200.

Physics requirements are PHYS 101, PHYS 102 and PHYS 201. Programming experience must include CS 121/CS 122/CS 123 or CS 171 at the minimum. CS 172, CS 260 and CS 265 are also recommended, and are required for some upper level ECEC courses. Courses taken to meet these requirements will not count toward the minor.

Required Courses

ECE 200	Digital Logic Design	3.0
ECEC 302	Digital Systems Projects	4.0
ECEC 355	Computer Organization & Architecture	4.0
ECEL 304	ECE Laboratory IV (prerequisite waived for minor)	2.0
Electives [*]		12.0
Total Credits		25.0

[*] Students should choose an additional 12 credits from 300- and/or 400-level Computer Engineering (ECEC) courses. All prerequisites must be satisfied.

Additional Information

Additional information about this minor is available on the ECE Department website (http://www.ece.drexel.edu/Undergraduate_Programs2.html).

Timothy P. Kurzweg, PhD
Associate Professor
Associate Department Head for Undergraduate Studies
Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director – Undergraduate Advising
Department of Electrical and Computer Engineering
Bossone Research Center Suite 313
advising@ece.drexel.edu
To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30

Facilities

Drexel University and the Electrical and Computer Engineering Department are nationally recognized for a strong history of developing innovative research. Research programs in the ECE Department prepare students for careers in research and development, and aim to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. The ECE Department is well equipped with state-of-the-art facilities in each of the following ECE Research laboratories:

Research Laboratories at the ECE Department

- Adaptive Signal Processing and Information Theory Research Group (http://www.ece.drexel.edu/aspitrg.html)
- Applied Communications and Information Networking Center (http://www.ece.drexel.edu/acinc.html)
- Applied Networking Research Laboratory (http://www.ece.drexel.edu/anrl.html)
- Biochemical Signal Processing Laboratory (http://www.ece.drexel.edu/bspl.html)
- Cleanroom Microfabrication Facility (http://www.ece.drexel.edu/cmf.html)
- Data Fusion Laboratory (http://www.ece.drexel.edu/dfl.html)
- Drexel Network Modeling Laboratory (http://www.ece.drexel.edu/dnml.html)
- Drexel Wireless Systems Laboratory (http://www.ece.drexel.edu/dwsl.html)
- Electric Power Engineering Center (http://www.ece.drexel.edu/epec.html)
- Electronic Design Automation (EDA) Facility (http://www.ece.drexel.edu/edaf.html)
- Microwave Photonics Center (http://www.ece.drexel.edu/mpc.html)
- Microwave-Photonics Device Laboratories (http://www.ece.drexel.edu/mpdl.html)
- Music and Entertainment Technology Laboratory (http://www.ece.drexel.edu/metl.html)
- NanoPhotonics Laboratory (http://www.ece.drexel.edu/npl.html)
- Opto-Electro-Mechanical Laboratory (http://www.ece.drexel.edu/oeml.html)
- Plasma and Magnetics Laboratory (http://www.ece.drexel.edu/pml.html)
- Power Electronics Research Laboratory (http://www.ece.drexel.edu/perl.html)
- Supervisory Control Laboratory (http://www.ece.drexel.edu/scl.html)
- Testbed for Power/Performance Management of Enterprise Computing Systems (http://www.ece.drexel.edu/tppm.html)

Computer Science

About the Program

Bachelor of Arts in Computer Science: (BACS): 186.5 quarter credits
Bachelor of Science in Computer Science (BSCS): 186.5 quarter credits

The Drexel major in computer science offer extensive exposure and hands-on practice in the core areas of the field, including programming paradigms and languages, algorithms, systems, networking, and software engineering. Students also select upper level tracks in areas such as artificial intelligence, security, graphics and vision, and in human-computer interaction. The program's flexibility allows students to easily minor in an area in which they would like to apply their computing knowledge, tracks and electives. This hands-on curriculum combined

with co-op provides real world experience that culminates in a full year software project.

The programs of study in computer science are designed with the flexibility to prepare students for careers in a rapidly changing profession and to allow strong preparation for graduate education in the field. In addition to the courses in the major, the Bachelor of Science program emphasizes foundation courses in the sciences and in applied mathematics, leading to careers involving applications in science and engineering. The Bachelor of Arts degree emphasizes foundation courses in the humanities and the social sciences, leading to careers involving applications in those areas.

Core courses in all programs include programming and data structures, programming language concepts, computer systems architecture, and a track of courses in software methodology and engineering. Students also choose two other tracks from the following: artificial intelligence, computer graphics, computer and network security, data structures and algorithms, game development and design, human-computer interaction, numeric and symbolic computation, operating systems and programming languages. Please contact the department for a current list of computer science elective and track courses.

Game Programming and Development Concentration

This concentration provides conceptual understanding of game design and practical experience in the design and the development of games. Students in the Game Programming and Development (GMPD) concentration program do not choose tracks. Two tracks, plus the additional two CS electives, are already built into the concentration.

Mission Statement

To educate students for computer science careers in industry and research with an emphasis on analysis of problems, understanding of fundamental concepts, and interest in lifelong learning. To integrate real-world experiences, e.g. , as obtained through the cooperative education program, into the academic curriculum.

Program Educational Objectives

The Bachelor of Science in Computer Science program prepares its graduates:

- to understand and be able to apply the underlying principles of computer science to a variety of problem domains;
- to develop good communication skills so that they can solve problems and communicate their solution;
- to develop strong analytical skills so that they can quickly assess how to solve problems;
- to be able to work in groups and appreciate the dynamic and collaborative nature of problem solving;
- to be equipped with a thorough understanding of the development process of software including design, implementation, documentation, and testing;
- to appreciate the role that computers play in society and to be able to direct the use of technology in a beneficial way and to solve new problems.

- to understand and be able to apply mathematics and science.

The Bachelor of Arts in Computer Science program prepares its graduates:

- to understand and be able to apply the underlying principles of Computer Science to a variety of problem domains;

- to develop good communication skills so that they can solve problems and communicate their solution;

- to develop strong analytical skills so that they can quickly assess how to solve problems;

- to be able to work in groups and appreciate the dynamic and collaborative nature of problem solving;

- to be equipped with a thorough understanding of the development process of software including design, implementation, documentation, and testing;

- to appreciate the role that computers play in society and to be able to direct the use of technology in a beneficial way and to solve new problems.

- to have a broad education in the liberal arts balanced with technical study in computer science.

Both BA an BS program alumni will:

- be valued employees in a wide variety of occupations in industry, government and academia, in particular as computer scientists and software engineers;

- succeed in graduate and professional studies, such as engineering, science, law, medicine and business;

- pursue life-long learning and professional development to remain current in an ever changing technological world;

- provide leadership in their profession, in their communities, and society;

- function as responsible members of society with an awareness of the social and ethical ramifications of their work.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate.

The Drexel Computer Science program prepares its graduates:

- to understand and be able to apply the underlying principles of Computer Science to a variety of problem domains;
- to develop good communication skills so that they can solve problems and communicate their solution;
- to develop strong analytical skills so that they can quickly assess how to solve problems;
- to be able to work in groups and appreciate the dynamic and collaborative nature of problem solving;
- to be equipped with a thorough understanding of the development process of software including design, implementation, documentation, and testing;

- to appreciate the role that computers play in society and to be able to direct the use of technology in a beneficial way and to solve new problems.

Program-Specific Outcomes:

The Bachelor of Science in Computer Science program prepares its graduates:

- to understand and be able to apply mathematics and science.

The Bachelor of Arts in Computer Science program prepares its graduates:

- to have a broad education in the liberal arts balanced with technical study in computer science.

Additional Information

The Computer Science BS and BA programs are accredited by the Computing Accreditation Commission (CAC) of ABET, http://www.abet.org.

For more information about this major, contact the Department of Computer Science (http://www.cs.drexel.edu).

Degree Requirements (BA)

The Bachelor of Arts (BA) program emphasizes foundation courses in the humanities and the social sciences, leading to careers involving applications in those areas.

General Education Requirements

COM 230	Techniques of Speaking	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 311	Computer Ethics	3.0
UNIV E101	The Drexel Experience	2.0
Humanities/Fine Arts electives		6.0
International Area Studies courses		6.0
Foreign Language courses		8.0
Social Studies electives		12.0
Diversity Studies electives		6.0
Science Requirements [*]		18.0
Students must take one full year of a laboratory science and take courses in more than one science field.		
BIO 122 & BIO 124 & BIO 126	Cells and Genetics and Evolution & Organismal Diversity and Physiology and Ecology	
CHEM 101 & CHEM 102 & CHEM 103	General Chemistry I and General Chemistry II and General Chemistry III	
PHYS 101 & PHYS 102 & PHYS 201	Fundamentals of Physics I and Fundamentals of Physics II and Fundamentals of Physics III	
Additional science electives (as needed to reach 18.0 credits total.)		
Mathematics Requirements		26.0

MATH 101	Introduction to Analysis I	
or MATH 121	Calculus I	
MATH 102	Introduction to Analysis II	
or MATH 122	Calculus II	
MATH 239	Mathematics for the Life Sciences	
or MATH 123	Calculus III	
MATH 221	Discrete Mathematics	
STAT 201	Introduction to Business Statistics	
or MATH 410	Scientific Data Analysis I	
STAT 202	Business Statistics II	
Mathematics/Science elective		

Computer Science Requirements

CS 164	Introduction to Computer Science	3.0
Select one of the following options:		3.0-6.0
CS 175	Computer Programming I-II (Students must contact the department to be placed into this course by programming assignment)	
CS 171 & CS 172	Computer Programming I and Computer Programming II	
CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
CS 275	Web and Mobile App Development	3.0
CS 281	Systems Architecture	4.0
CS 350 [WI]	Software Design	3.0
CS 360	Programming Language Concepts	3.0
CS 451	Software Engineering	3.0
CS 491 [WI]	Software Engineering Workshop	3.0
CS 492 [WI]	Software Engineering Workshop II	3.0
CS 493 [WI]	Software Engineering Workshop III	3.0
Computer Science electives		6.0
Computer Science Track Courses ^See Below		18.0

Other Courses

Free electives		23.5
Total Credits		186.5-189.5

*   Other options for the laboratory sequence are available; see the Computer Science department for list.

Computer Science Tracks

Students must complete two of the following Computer Science tracks for a total of 18.0 credits. The tracks may overlap by one course. Students should check with the Department for any additional Special Topics courses being offered that may be appropriate for one of the tracks.

Algorithms and Data Structures

CS 440	Theory of Computation	3.0
CS 457	Data Structures and Algorithms I	3.0
CS 458	Data Structures and Algorithms II	3.0

Artificial Intelligence

CS 380	Artificial Intelligence	3.0
Select two of the following:		6.0
CS 383	Machine Learning	
CS 385	Evolutionary Computing	

CS 387	Game AI Development	
CS 481	Advanced Artificial Intelligence	
CS 485	Special Topics in Artificial Intelligence	

Computer and Network Security

CS 472	Computer Networks: Theory, Applications and Programming	3.0
CS 475	Computer and Network Security	3.0
CS 303	Algorithmic Number Theory and Cryptography	3.0

Computer Architecture

CS 352	Processor Architecture & Analysis	3.0
Select two of the following:		6.0
CS 476	High Performance Computing	
ECEC 356	Embedded Systems	
ECEC 413	Introduction to Parallel Computer Architecture	

Computer Graphics and Vision

CS 430	Computer Graphics	3.0
CS 435	Computational Photography	3.0
Select one of the following:		3.0
CS 338	Graphical User Interfaces	
CS 431	Advanced Rendering Techniques	
CS 432	Interactive Computer Graphics	

Computing Systems

CS 361	Concurrent Programming	3.0
CS 370	Operating Systems	3.0
Select one of the following:		3.0
CS 365	System Administration	
CS 461	Database Systems	
CS 472	Computer Networks: Theory, Applications and Programming	

Game Development and Design

CS 345	Computer Game Design and Development	3.0
or GMAP 345	Game Development Foundations	
Select two of the following:		6.0
CS 347	Experimental Game Development	
CS 348	Serious Game Development	
CS 387	Game AI Development	
GMAP 377	Game Development: Workshop I	
GMAP 378	Game Development: Workshop II	
CS 445	Topics in Computer Gaming	

Human-Computer Interactions

CS 337	The Psychology of Human-Computer Interaction	3.0
or PSY 337	Human-Computer Interaction	
CS 338	Graphical User Interfaces	3.0
Select one of the following:		3.0
CS 345	Computer Game Design and Development	
or GMAP 345	Game Development Foundations	
CS 430	Computer Graphics	
CS 435	Computational Photography	
PSY 330	Cognitive Psychology	

Numeric and Symbolic Computation

CS 300	Applied Symbolic Computation	3.0
MATH 300	Numerical Analysis I	4.0

Select one of the following:

		3.0-4.0
CS 303	Algorithmic Number Theory and Cryptography	
MATH 301	Numerical Analysis II	
MATH 305	Introduction to Optimization Theory	

Programming Languages

CS 440	Theory of Computation	3.0
CS 441	Compiler Workshop I	3.0
CS 442	Compiler Workshop II	3.0

Software Engineering

SE 311	Software Architecture II	3.0
SE 320	Software Verification and Validation	3.0
SE 410	Software Evolution	3.0

Sample Plan of Study (BA)

5 YR UG Co-op Concentration

Term 1		Credits
CS 164	Introduction to Computer Science	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
UNIV E101	The Drexel Experience	1.0
MATH 101 or 121	Introduction to Analysis I Calculus I	4.0
Select one of the following:		4.5
BIO 122	Cells and Genetics	
CHEM 101	General Chemistry I	
PHYS 101	Fundamentals of Physics I	
	Term Credits	**15.5**

Term 2		
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
CS 171 or 175	Computer Programming I Computer Programming I-II	3.0
MATH 102 or 122	Introduction to Analysis II Calculus II	4.0
UNIV E101	The Drexel Experience	1.0
Select one of the following:		4.5
BIO 124	Evolution & Organismal Diversity	
CHEM 102	General Chemistry II	
PHYS 102	Fundamentals of Physics II	
	Term Credits	**15.5**

Term 3		
CS 172[*]	Computer Programming II	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
MATH 123 or 239	Calculus III Mathematics for the Life Sciences	4.0
Select one of the following:		4.5
BIO 126	Physiology and Ecology	
CHEM 103	General Chemistry III	
PHYS 201	Fundamentals of Physics III	

Free elective		3.0
	Term Credits	**17.5**

Term 4		
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
Science elective[**]		3.0
Diversity studies elective		3.0
Arts and Humanities elective		3.0
	Term Credits	**15.0**

Term 5		
CS 260	Data Structures	3.0
CS 275	Web and Mobile App Development	3.0
MATH 221	Discrete Mathematics	3.0
Social studies elective		3.0
Science elective[**]		3.0
	Term Credits	**15.0**

Term 6		
CS 281	Systems Architecture	4.0
CS 350 [WI]	Software Design	3.0
STAT 201	Introduction to Business Statistics	4.0
Social studies elective		3.0
Arts and Humanities elective		3.0
	Term Credits	**17.0**

Term 7		
COM 230	Techniques of Speaking	3.0
CS 360	Programming Language Concepts	3.0
STAT 202	Business Statistics II	4.0
Social studies elective		3.0
Computer Science elective[**]		3.0
	Term Credits	**16.0**

Term 8		
PHIL 311	Computer Ethics	3.0
Foreign language course		4.0
Computer Science elective[**]		6.0
Math/science elective		3.0
	Term Credits	**16.0**

Term 9		
CS 451	Software Engineering	3.0
Free elective		3.0
Computer science electives[**]		3.0
Foreign language course		4.0
Diversity studies elective		3.0
	Term Credits	**16.0**

Term 10		
CS 491 [WI]	Software Engineering Workshop	3.0
Computer Science elective[**]		3.0
International studies elective		3.0
Free electives		6.0
	Term Credits	**15.0**

Term 11		
CS 492 [WI]	Software Engineering Workshop II	3.0

Computer science electives[**]		6.0
International studies elective		3.0
Free electives		3.5
Term Credits		**15.5**
Term 12		
CS 493 [WI]	Software Engineering Workshop III	3.0
Social studies elective		3.0
Free electives		3.5
Computer Science elective[**]		3.0
Term Credits		**12.5**

Total Credit: 186.5

[*]   If CS 175 taken term 2.

[**]   See degree requirements (p.   ).

Degree Requirements (BS)

The Bachelor of Science (BS) program emphasizes foundation courses in the sciences and in applied mathematics, leading to careers involving applications in science and engineering.

The concentration in game programming and development provides conceptual understanding of game design and practical experience in the design and the development of games. The courses in this concentration include fundamentals of game design and development, large-scale game development, and special topics in educational and experimental game design.

General Education Requirements

COM 230	Techniques of Speaking	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 311	Computer Ethics	3.0
UNIV E101	The Drexel Experience	2.0
Business elective		4.0
Social Studies elective		3.0
Writing and Communication electives [*]		6.0
General Education electives		17.0

Freshman Design Requirements

ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0

Mathematics Requirements

MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 123	Calculus III	4.0
MATH 201	Linear Algebra	4.0
MATH 221	Discrete Mathematics	3.0
MATH 311	Probability and Statistics I	4.0
or MATH 410	Scientific Data Analysis I	

Mathematics elective [**]		3.0-4.0

Science Requirements

Twenty-five science credits are required. These must include a three-term sequence from one of the laboratory sciences. [†]		25.0
Biology Sequence		
BIO 122	Cells and Genetics	
BIO 124	Evolution & Organismal Diversity	
BIO 126	Physiology and Ecology	
Chemistry Sequence		
CHEM 101	General Chemistry I	
CHEM 102	General Chemistry II	
CHEM 103	General Chemistry III	
Physics Sequence		
PHYS 101	Fundamentals of Physics I	
PHYS 102	Fundamentals of Physics II	
PHYS 201	Fundamentals of Physics III	

Computation Requirements

CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0

Computer Science Requirements

CS 164	Introduction to Computer Science	3.0
Select one of the following:		3.0
CS 171 & CS 172	Computer Programming I and Computer Programming II	
CS 175	Computer Programming I-II	
CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
CS 275	Web and Mobile App Development	3.0
CS 281	Systems Architecture	4.0
CS 283	Systems Programming	3.0
CS 350 [WI]	Software Design	3.0
CS 360	Programming Language Concepts	3.0
CS 451	Software Engineering	3.0
CS 491 [WI]	Software Engineering Workshop	3.0
CS 492 [WI]	Software Engineering Workshop II	3.0
CS 493 [WI]	Software Engineering Workshop III	3.0
Computer Science Track Courses (See below)		18.0
Computer Science electives		6.0

Other Courses

Free electives		8.5-11.5
Total Credits		186.5

[*]   View the Computer Science Department's web site for a list of approved options (https://www.cs.drexel.edu/undergraduate/commelectives) for the writing and communication electives.

[**]   Mathematics elective options include: MATH 200 Multivariate Calculus; MATH 210 Differential Equations; MATH 262 Differential Equations; ENGR 232 Dynamic Engineering Systems; or any 300-400 level MATH course.

† Other options for the laboratory sequence are available; see the Computer Science department for a complete list of acceptable science courses.

Computer Science Tracks

Students must complete two of the following Computer Science tracks for a total of 18.0 credits. The tracks may overlap by one course. Students should check with the Department for any additional Special Topics courses being offered that may be appropriate for one of the tracks.

Algorithms and Data Structures

CS 440	Theory of Computation	3.0
CS 457	Data Structures and Algorithms I	3.0
CS 458	Data Structures and Algorithms II	3.0

Artificial Intelligence

CS 380	Artificial Intelligence	3.0
Select two of the following:		6.0
CS 383	Machine Learning	
CS 385	Evolutionary Computing	
CS 387	Game AI Development	
CS 481	Advanced Artificial Intelligence	
CS 485	Special Topics in Artificial Intelligence	

Computer and Network Security

CS 472	Computer Networks: Theory, Applications and Programming	3.0
CS 475	Computer and Network Security	3.0
CS 303	Algorithmic Number Theory and Cryptography	3.0

Computer Architecture

CS 352	Processor Architecture & Analysis	3.0
Select two of the following:		6.0
CS 476	High Performance Computing	
ECEC 356	Embedded Systems	
ECEC 413	Introduction to Parallel Computer Architecture	

Computer Graphics and Vision

CS 430	Computer Graphics	3.0
CS 435	Computational Photography	3.0
Select one of the following:		3.0
CS 338	Graphical User Interfaces	
CS 431	Advanced Rendering Techniques	
CS 432	Interactive Computer Graphics	

Computing Systems

CS 361	Concurrent Programming	3.0
CS 370	Operating Systems	3.0
Select one of following:		3.0
CS 365	System Administration	
CS 461	Database Systems	
CS 472	Computer Networks: Theory, Applications and Programming	

Game Development and Design

CS 345	Computer Game Design and Development	3.0
or GMAP 345	Game Development Foundations	
Select two of the following:		6.0
CS/GMAP 347	Experimental Game Development	
CS/GMAP 348	Serious Game Development	
CS 387	Game AI Development	
CS 445	Topics in Computer Gaming	
GMAP 377	Game Development: Workshop I	
GMAP 378	Game Development: Workshop II	

Human-Computer Interactions

CS 337	The Psychology of Human-Computer Interaction	3.0
or PSY 337	Human-Computer Interaction	
CS 338	Graphical User Interfaces	3.0
Select one of the following:		3.0
CS 345	Computer Game Design and Development	
or GMAP 345	Game Development Foundations	
CS 430	Computer Graphics	
CS 435	Computational Photography	
PSY 330	Cognitive Psychology	

Numeric and Symbolic Computation

CS 300	Applied Symbolic Computation	3.0
MATH 300	Numerical Analysis I	4.0
Select one of the following:		3.0-4.0
MATH 305	Introduction to Optimization Theory	
MATH 301	Numerical Analysis II	
CS 303	Algorithmic Number Theory and Cryptography	

Programming Languages

CS 440	Theory of Computation	3.0
CS 441	Compiler Workshop I	3.0
CS 442	Compiler Workshop II	3.0

Software Engineering

SE 311	Software Architecture II	3.0
SE 320	Software Verification and Validation	3.0
SE 410	Software Evolution	3.0

Sample Plan of Study (BS)

BS Computer Science

5 YR UG Co-op Concentration

Term 1		Credits
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
CS 164	Introduction to Computer Science	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
Select one of the following:		4.5
BIO 122	Cells and Genetics	
PHYS 101	Fundamentals of Physics I	
CHEM 101	General Chemistry I	
	Term Credits	**18.5**
Term 2		
CS 122	Computation Laboratory II	1.0

ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
UNIV E101	The Drexel Experience	1.0
Select one of the following:		4.5
BIO 124	Evolution & Organismal Diversity	
CHEM 102	General Chemistry II	
PHYS 102	Fundamentals of Physics II	
CS 171	Computer Programming I	3.0
or 175	Computer Programming I-II	
	Term Credits	**18.5**
Term 3		
CS 123	Computation Laboratory III	1.0
CS 172[*]	Computer Programming II	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 123	Calculus III	4.0
Select one of the following:		4.5
BIO 126	Physiology and Ecology	
PHYS 201	Fundamentals of Physics III	
CHEM 103	General Chemistry III	
	Term Credits	**17.5**
Term 4		
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
MATH 201	Linear Algebra	4.0
Social studies elective		3.0
Science elective[**]		3.0
	Term Credits	**16.0**
Term 5		
CS 260	Data Structures	3.0
MATH 221	Discrete Mathematics	3.0
CS 275	Web and Mobile App Development	3.0
Science elective[**]		3.0
Business elective		4.0
	Term Credits	**16.0**
Term 6		
COM 230	Techniques of Speaking	3.0
CS 281	Systems Architecture	4.0
CS 350 [WI]	Software Design	3.0
General education elective		3.0
Science elective[**]		3.0
	Term Credits	**16.0**
Term 7		
CS 283	Systems Programming	3.0
CS 360	Programming Language Concepts	3.0
Science elective[**]		3.0-4.0
Writing/Communication elective (See approved course list)		3.0
General education elective		3.0
	Term Credits	**15.0-16.0**

Term 8		
PHIL 311	Computer Ethics	3.0
MATH 410	Scientific Data Analysis I	3.0
or 311	Probability and Statistics I	
Computer science electives[**]		6.0
General education elective		3.0
	Term Credits	**15.0**
Term 9		
CS 451	Software Engineering	3.0
General education elective		3.0
Mathematics elective[**]		3.0-4.0
Free elective		3.0
Computer Science elective[**]		3.0
	Term Credits	**15.0-16.0**
Term 10		
CS 491 [WI]	Software Engineering Workshop	3.0
Computer science electives[**]		6.0
General education elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 11		
CS 492 [WI]	Software Engineering Workshop II	3.0
Computer science electives[**]		6.0
General education elective		3.0
	Term Credits	**12.0**
Term 12		
CS 493 [WI]	Software Engineering Workshop III	3.0
Writing/Communication elective (See approved course list)		3.0
Computer Science elective[**]		3.0
Free elective		3.0
	Term Credits	**12.0**

Total Credit: 186.5-188.5

[*]   If CS 175 taken term 2.
[**]   See degree requirements (p.   ).

Degree Requirements

Game Programming and Development Concentration

General Education Requirements

COM 230	Techniques of Speaking	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 311	Computer Ethics	3.0
PSY 101	General Psychology I	3.0

UNIV E101	The Drexel Experience	2.0
Business elective		4.0
Free electives		6.5
Freshman Design Requirements		
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
Mathematics Requirements		
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
CS 270	Mathematical Foundations of Computer Science	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 123	Calculus III	4.0
MATH 201	Linear Algebra [*]	4.0
MATH 221	Discrete Mathematics	3.0
MATH 410	Scientific Data Analysis I	3.0
or MATH 311	Probability and Statistics I	
Additional Mathematics and Science Requirements [**]		16.0
Mathematics elective		
Mathematics and/or Science electives		
Physics Requirements		
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Computer Science Requirements		
CS 164	Introduction to Computer Science	3.0
CS 171	Computer Programming I	3.0
CS 172	Computer Programming II	3.0
CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
CS 275	Web and Mobile App Development	3.0
CS 281	Systems Architecture	4.0
CS 283	Systems Programming	3.0
CS 350 [WI]	Software Design	3.0
CS 360	Programming Language Concepts	3.0
CS 451	Software Engineering	3.0
Computer Science Senior Design Requirements		
CS 491 [WI]	Software Engineering Workshop	3.0
CS 492 [WI]	Software Engineering Workshop II	3.0
CS 493 [WI]	Software Engineering Workshop III	3.0
Computer Science Gaming Requirements		
CS 345	Computer Game Design and Development	3.0
or GMAP 345	Game Development Foundations	
CS 337	The Psychology of Human-Computer Interaction	3.0
or PSY 337	Human-Computer Interaction	
CS 338	Graphical User Interfaces	3.0
CS 380	Artificial Intelligence	3.0
or CS 430	Computer Graphics	
CS 347	Experimental Game Development	3.0
CS 348	Serious Game Development	3.0

GMAP 377	Game Development: Workshop I	3.0
GMAP 378	Game Development: Workshop II	3.0
Digital Media Requirements		
ANIM 141	Computer Graphic Imagery II	3.0
ANIM 211	Animation I	3.0
ANIM 212	Animation II	3.0
DIGM 100	Digital Design Tools	3.0
ANIM 140	Computer Graphics Imagery I	3.0
or DIGM 110	Digital Spatial Visualization	
ANIM 152	Multimedia Timeline Design	3.0
or DIGM 252	Multimedia Timeline Design	
GMAP 260	Overview of Computer Gaming	3.0
SCRP 270 [WI]	Screenwriting I	3.0
VSST 110	Introductory Drawing	3.0
Total Credits		186.5

[*]   View the Computer Science Department's website for a list of approved options (https://www.cs.drexel/edu/undergraduate/commelectives) for the writing and communication electives.

[**]   One course must be a mathematics elective. Mathematics elective options include: MATH 200 Multivariate Calculus; MATH 210 Differential Equations; ENGR 232 Dynamic Engineering Systems; or any 300-400 level MATH course.

Sample Plan of Study (BS)

5 YR 5 YR UG Co-op Concentration /Game Programming & Development

Term 1		Credits
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
CS 164	Introduction to Computer Science	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
PSY 101	General Psychology I	3.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**17.0**
Term 2		
CS 122	Computation Laboratory II	1.0
CS 171	Computer Programming I	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
UNIV E101	The Drexel Experience	0.5
PHYS 101	Fundamentals of Physics I	4.0
	Term Credits	**17.5**
Term 3		
CS 123	Computation Laboratory III	1.0
CS 172	Computer Programming II	3.0

ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 123	Calculus III	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV 101	The Drexel Experience	0.5
	Term Credits	**17.5**
Term 4		
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
DIGM 100	Digital Design Tools	3.0
VSST 110	Introductory Drawing	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**16.0**
Term 5		
CS 260	Data Structures	3.0
CS 275	Web and Mobile App Development	3.0
ANIM 140	Computer Graphics Imagery I	3.0
MATH 221	Discrete Mathematics	3.0
COM 230	Techniques of Speaking	3.0
	Term Credits	**15.0**
Term 6		
CS 281	Systems Architecture	4.0
CS 350 [WI]	Software Design	3.0
ANIM 141	Computer Graphic Imagery II	3.0
MATH 201	Linear Algebra	4.0
GMAP 260	Overview of Computer Gaming	3.0
	Term Credits	**17.0**
Term 7		
CS 283	Systems Programming	3.0
CS 345	Computer Game Design and Development	3.0
CS 360	Programming Language Concepts	3.0
SCRP 270 [WI]	Screenwriting I	3.0
Math elective[*]		3.0
	Term Credits	**15.0**
Term 8		
ANIM 211	Animation I	3.0
CS 337	The Psychology of Human-Computer Interaction	3.0
ANIM 152	Multimedia Timeline Design	3.0
MATH 410	Scientific Data Analysis I	3.0
PHIL 311	Computer Ethics	3.0
	Term Credits	**15.0**
Term 9		
ANIM 212	Animation II	3.0
CS 338	Graphical User Interfaces	3.0
CS 347	Experimental Game Development	3.0
CS 451	Software Engineering	3.0
Math/Science elective[*]		3.0
	Term Credits	**15.0**
Term 10		

CS 380 or 430	Artificial Intelligence Computer Graphics	3.0
CS 491 [WI]	Software Engineering Workshop	3.0
GMAP 377	Game Development: Workshop I	3.0
Business elective		4.0
Math/Science elective[*]		3.0
	Term Credits	**16.0**
Term 11		
CS 492 [WI]	Software Engineering Workshop II	3.0
GMAP 378	Game Development: Workshop II	3.0
Math/Science elective[*]		3.0
Free elective		3.0
	Term Credits	**12.0**
Term 12		
CS 348	Serious Game Development	3.0
CS 493 [WI]	Software Engineering Workshop III	3.0
Free electives		3.5
Math/Science elective[*]		4.0
	Term Credits	**13.5**

Total Credit: 186.5

[*]   See degree requirements (p.   ).

Co-op/Career Opportunities

The demand for computing skills is tremendous and growing, with highly paid jobs. Most professionals in the field focus on the design and development of software and software-based applications.Typical jobs include web designer,multimedia or software developer, software engineer, programmer, systems analyst or consultant, manager of technical staff, client-server architect, network designer, and database specialist. Most positions require at least a bachelor's degree. Relevant work experience, such as that provided by co-operative education, is also very important, as cited by the Occupational Outlook Handbook published by the US Bureau of Labor Statistics.

Co-Op Experiences

The following quotes were taken from recent student reports on their co-op experiences:

Co-op programmer/analyst, petroleum products manufacturer: "Member of a team responsible for implementation of upgrade to critical mainframe computer system. Prepared functional specs, coded, and tested new online and batch processing programs . . .Modified C programs to conform to new business requirements and government mandates. . . .Challenging environment, great variety of technologies to work with. "

Co-op programmer, U.S. government agency: "Programmed on distributed systems software in C on Sun SPARC Stations. Wrote a parser for HTML. Assisted in the administration of the local area network. Wrote several scripts, including one to automate the cleaning of tape backup drives. "

Technical assistant, pharmaceuticals manufacturer: "Provided customized desktop and mobile computer solutions for senior executives. Installed and tested telecommunications solutions. Configured and installed over

100 Compaq PC workstations. Provided full workstation support to over 800 corporate users. "

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Bachelor's/Master's Accelerated Degree in Computer Science

The guidelines for the application to the Computer Science Bachelor's/Master's Accelerated Degree Program are as follows:

University regulations require application after the completion of 90 credits but before the completion of 120 credits.

Applicants must have completed the following core Computer Science courses with a minimum GPA of 3.50:

CS 171	Computer Programming I *	3.0
CS 172	Computer Programming II *	3.0
CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques (Formerly CS 390 UNIX and Advanced Programming)	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
MATH 221	Discrete Mathematics	3.0
ECE 200	Digital Logic Design	3.0
CS 281	Systems Architecture	4.0
CS 350 [WI]	Software Design (Formerly Oriented Programming)	3.0
CS 360	Programming Language Concepts	3.0
CS Track Elective		
Select one of the following:		3.0
CS 300	Applied Symbolic Computation	
CS 338	Graphical User Interfaces	
CS 361	Concurrent Programming	
CS 380	Artificial Intelligence	
CS 457	Data Structures and Algorithms I	
CS 440	Theory of Computation	
Total Credits		34.0

*   Or CS 175 (Programming I - II)

Applicants must have an overall cumulative Grade Point Average of 3.25 or higher. Letters of recommendation from two Computer Science faculty are required. Students must submit a plan of study. Consult the Graduate Advisor and course schedules for guidance.

Acceptance to the program will be decided by the graduate admissions committee with consultation from the undergraduate curriculum committee, and will be based on a combination of the student's GPA and letters of recommendation. Acceptance may be denied if the plan of study is not feasible.

For more information, contact the Department of Computer Science (http://www.cs.drexel.edu/index.php?option=com_page&Itemid=97).

Minor in Computer Science Minor

The computer science minor provides students with a breadth of knowledge in areas which form the foundation of computer science. The student adds some depth by selecting courses from a list of advanced computer science courses.

Mathematics Prerequisites

One of the following two-term mathematics sequences must be completed before entering the program:

MATH 101 Introduction to Analysis and MATH 102 Instruction to Analysis II
or
MATH 121 Calculus I and MATH 122 Calculus II

Required Courses

Students must complete at least 25.0 credits from courses listed below, subject to the following restrictions:

- The requirements of each category (*Computer Programming*, *Theoretical Foundations*, *Computer Systems*, and *Advanced Electives*) must be fulfilled
- Remaining credits are to be earned from the list of advanced electives.

Computer Programming		
Select one of the following sequences:		3.0-15.0
Sequence I		
CS 171	Computer Programming I	
CS 172	Computer Programming II	
Sequence II		
CS 175	Computer Programming I-II	
Sequence III		
CS 140	Intro Multimedia Programming	
CS 143	Comp Programming Fundamentals	
CS 171	Computer Programming I	
CS 172	Computer Programming II	
Sequence IV		
SE 101	Foundations of Software Engineering I	
SE 102	Foundations of Software Engineering II	
SE 103	Foundations of Software Engineering III	
Sequence V		
ECE 203	Programming for Engineers	
ECEC 301	Advanced Programming for Engineers	
Advanced Programming		
CS 265	Advanced Programming Tools and Techniques	3.0
Theoretical Foundations		
CS 260	Data Structures	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
Computer Systems		
Select one of the following:		4.0
CS 281	Systems Architecture	
ECEC 355	Computer Organization & Architecture	
Advanced Electives *		
Select two or more of the following:		6.0-9.0

Algorithms/Theory

CS 440	Theory of Computation	
CS 457	Data Structures and Algorithms I	
CS 458	Data Structures and Algorithms II	

Artificial Intelligence

CS 380	Artificial Intelligence
CS 383	Machine Learning
CS 385	Evolutionary Computing
CS 387	Game AI Development
CS 481	Advanced Artificial Intelligence
CS 485	Special Topics in Artificial Intelligence

Computer Game Design

CS 345	Computer Game Design and Development
CS 347	Experimental Game Development
CS 348	Serious Game Development
CS 387	Game AI Development

Computer Graphics/Vision

CS 430	Computer Graphics
CS 431	Advanced Rendering Techniques
CS 432	Interactive Computer Graphics
CS 435	Computational Photography

Computing Systems and Security

CS 283	Systems Programming
CS 352	Processor Arch & Analysis
CS 361	Concurrent Programming
CS 365	System Administration
CS 370	Operating Systems
CS 461	Database Systems
CS 472	Computer Networks: Theory, Applications and Programming
CS 475	Computer and Network Security
CS 476	High Performance Computing

Human-Computer Interaction

CS 337	The Psychology of Human-Computer Interaction
or PSY 337	Human-Computer Interaction
CS 338	Graphical User Interfaces

Numeric and Symbolic Computation

CS 300	Applied Symbolic Computation
CS 303	Algorithmic Number Theory and Cryptography
MATH 300	Numerical Analysis I

Programming Languages and Compilers

CS 360	Programming Language Concepts
CS 440	Theory of Computation
CS 441	Compiler Workshop I
CS 442	Compiler Workshop II

Software Methodology (not available to Software Engineering Students)

CS 350 [WI]	Software Design	
CS 451	Software Engineering	
Total Credits		**25.0**

*   Other courses may be approved by the Department for this purpose; contact the Computer Science Undergraduate Advisor (advisor@cs.drexel.edu).

Electrical Engineering

Bachelor of Science in Electrical Engineering (BSEE): 192.0 quarter credits

About the Program

The electrical engineering major emphasizes the fundamentals of electrical engineering, hands-on learning, and flexibility in course selection to satisfy diverse career goals. Students choose one or more areas of study beginning in their pre-junior year.

State-of-the-art interdisciplinary courses have been developed to prepare the Drexel engineer for the technical challenges and the business atmosphere of the 21st century. Strong emphasis is given to the role of the engineer in the global competitive economy, and to the need to work closely with experts and practitioners in many fields.

Students can choose courses in various areas of study, including telecommunications/digital signal processing, electronics, power and systems/control.

Mission Statement

The ECE Department at Drexel University serves the public and the university community by providing superior career-integrated education in electrical and computer engineering; by conducting research in these fields, to generate new knowledge and technologies; and by promoting among all its constituents professionalism, social responsibility, civic engagement and leadership.

Program Educational Objectives

The Electrical and Computer Engineering Program Educational Objectives are that its alumni in their early years after graduation:

1. Secure positions and continue as valued, creative, dependable, and proficient employees in a wide variety of fields and industries, in particular as electrical and computer engineers;

2. Succeed in graduate and professional studies, such as engineering, science, law, medicine and business;

3. Pursue professional development through lifelong learning opportunities for a successful and rewarding career;

4. Provide leadership in their profession, in their communities, and in the global society;

5. Contribute to their professional disciplines body of knowledge;

6. Function as responsible members of society with an awareness of the social and ethical ramifications of their work.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Areas of Study

Telecommunications/Digital Signal Processing (DSP)

Telecommunications and digital signal processing (DSP) are two of the fastest-growing fields of electrical engineering. The telecommunications/ DSP area of study prepares students for mastery of fundamental and applied knowledge in the theory and the technology of the transmission and processing of information-bearing signals such as voice, audio, data, images, and video. The curriculum includes core courses in electromagnetic propagation, communication devices and media, signal processing, analog and digital communication. Complementary electives can be taken in computers, electronics, control systems, and electric power systems.

Career opportunities include design and development of digital communications systems and telephony, speech recognition systems, fiber-optic networks, digital radio, medical diagnostic image processing, high-definition television, cellular and wireless communications, satellite communications, networked multimedia communications, and personal communication systems.

Electronics

The electronics area of study constitutes the study of electronic and optical semiconductor devices; analog and digital electronic circuits; and generation, transmission, and reception of information both in optical and microwave frequency ranges and guided or free-space conditions.

Career opportunities include jobs in telecommunications (optical, wireless, wired, satellite, and radar), VLSI (analog and digital), aerospace, remote sensing and instrumentation, computer circuitry interface, biomedical instrumentation, semiconductor device fabrication, and transportation.

Power and Systems/Control

Power and Systems/Control has at its core the areas of controls engineering and electric power engineering, the classic core of electrical

engineering, and exploits the synergies between these two areas. These areas of study explores subjects such as modeling, analysis and control of dynamic systems including power systems, planning and optimization, electromechanical energy conversion, motor operation and control, transformers, power electronics, sensors and actuators, and the electrical and economic structure of the power industry. These areas of study offer access to two state-of-the-art laboratories. In the Interconnected Power System Laboratory, students can operate and control a small power system through the fusing of computer software and hardware technology with high-voltage, high-power technology. The Ortlip Systems Laboratory houses various experiments in sensing, feedback, and control. Both laboratories stress the use of modeling software, especially MATLAB, and the integrated use of computers and hardware.

Career opportunities include options ranging from manufacturing, the power industry (generation, transmission, distribution, marketing, and consumption), robotics, and transportation to Wall Street.

Additional Information

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Additional information about the major is available on the ECE Department website (http://www.ece.drexel.edu/ Undergraduate_Programs2.html).

Timothy P. Kurzweg, PhD
Associate Professor
Associate Department Head for Undergraduate Studies
Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director – Undergraduate Advising
Department of Electrical and Computer Engineering
Bossone Research Center Suite 313
advising@ece.drexel.edu
To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30

Degree Requirements

In addition to completing 192.0 credits, students majoring in electrical engineering student must have a 2.0 cumulative overall GPA and a 2.0 cumulative GPA in their Electrical Engineering courses.

General Education/Liberal Studies Requirements

ENGL 101	Expository Writing and Reading	3.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGL 103	Analytical Writing and Reading	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
General Education Courses [*]		18.0
Foundation Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0

PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
BIO 141	Essential Biology	4.5
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ECE 200	Digital Logic Design	3.0
ECE 201	Foundations of Electric Circuits	3.0
ECE 203	Programming for Engineers	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0

Sophomore Engineering Elective Options

Select one of the following:		3.0-4.0
ENGR 210	Introduction to Thermodynamics	
MATH 221	Discrete Mathematics	
PHYS 202	Fundamentals of Physics IV	

Professional Requirements

ECE 391	Introduction to Engineering Design Methods	1.0
ECE 491 [WI]	Senior Design Project I	2.0
ECE 492 [WI]	Senior Design Project II	2.0
ECE 493	Senior Design Project III	4.0
ECEL 301 [WI]	Electrical Engineering Laboratory	2.0
ECEL 302	ECE Laboratory II	2.0
ECEL 303	ECE Laboratory III	2.0
ECEL 304	ECE Laboratory IV	2.0
ECES 302	Transform Methods and Filtering	4.0
ECE 361	Probability for Engineers	3.0
or ECE 362	Engineering Statistics	
or ENGR 361	Statistical Analysis of Engineering Systems	

Math Elective **		3.0
14 Electrical Engineering (ECE) Electives †		45.0
Free Electives		13.5
Total Credits		192.0-193.0

*   General Education Courses (p. 4).

**   The math elective is a 3.0-4.5 credit course from MATH at a 200-level or higher. MATH 291 (Complex & Vector Analysis) is encouraged for EE majors.

†   ECE Electives (ECEX electives) are at least 45 credits of ECE courses (ECEC, ECEP, ECES, ECEE). At least 9 credits must be in the major at the 400-level or higher. Up to 12 credits may be taken from other College of Engineering or School of Biomedical Engineering, Science and Health System majors.
Note: ECE 101 and ECE 102 in combination can count as 1 ECE Elective.

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Expository Writing and Reading	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Analytical Writing and Reading	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
ECE 200	Digital Logic Design	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ECE 201	Foundations of Electric Circuits	3.0
ECE 203	Programming for Engineers	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 232	Dynamic Engineering Systems	3.0

Sophomore Engineering elective[*]		3.0
Term Credits		**15.0**
Term 6		
ECES 302	Transform Methods and Filtering	4.0
ECEL 301 [WI]	Electrical Engineering Laboratory	2.0
Two Electrical Engineering electives[*]		6.0
Math elective		3.0
Term Credits		**15.0**
Term 7		
ECE 361, 362, or ENGR 361	Probability for Engineers Engineering Statistics Statistical Analysis of Engineering Systems	3.0
ECEL 302	ECE Laboratory II	2.0
PHIL 315	Engineering Ethics	3.0
Two Electrical Engineering electives[*]		6.0
Free elective		3.0
Term Credits		**17.0**
Term 8		
ECEL 303	ECE Laboratory III	2.0
Two Electrical Engineering electives[*]		6.0
General Education elective[*]		3.0
Free elective		4.0
Term Credits		**15.0**
Term 9		
ECE 391 (Also offered spring term.)	Introduction to Engineering Design Methods	1.0
ECEL 304	ECE Laboratory IV	2.0
Two Electrical Engineering electives[*]		6.0
General Education elective[*]		3.0
Free elective		3.0
Term Credits		**15.0**
Term 10		
ECE 491 [WI]	Senior Design Project I	2.0
Two Electrical Engineering electives[*]		6.0
Two General Education electives[*]		6.0
Term Credits		**14.0**
Term 11		
ECE 492 [WI]	Senior Design Project II	2.0
Two Electrical Engineering electives[*]		7.0
General Education elective[*]		3.0
Free elective		4.5
Term Credits		**16.5**
Term 12		
ECE 493	Senior Design Project III	4.0
Two Electrical Engineering electives[*]		7.0
General Education elective[*]		3.0
Term Credits		**14.0**

Total Credit: 192.0

[*] See degree requirements (p. 33).

Co-op/Career Opportunities

Electrical engineers are employed in corporations, government agencies, and other organizations. In their work, these engineers are developers of electrical equipment for digital communications (such as satellite communication, fiber-optic networks, and coding and cryptography), mobile radio, radar and surveillance, process control, robotics, speech processing, aerospace circuitry, power generation and distribution, computer hardware and software, computer networks, sensor technology, counter-crime measures, electronic compatibility, consumer electronics, and related fields.

Some positions held by recent graduates include: radar system R&D engineer, Johns Hopkins University physics labs; weather radar development team member, Lockheed-Martin; universal computer interface developer, Unisys; computer system manager, General Electric; biomedical engineer, Albert Einstein Hospital; power system engineer, PECO Energy; X-Y Table control design team, Kulicke and Soffa; software specialist for air traffic control, FAA; designer of lightning-resistant motors, NASA; designer of speech-recognition modules, AT&T Bell Labs.

A degree in electrical engineering can also serve as an excellent foundation to pursue graduate professional careers in medicine, law, business, and government.

Graduates are also pursuing advanced studies in electrical and computer engineering, aerospace engineering, and mechanical engineering at such schools as MIT, Stanford, Princeton, Georgia Institute of Technology, University of California at Berkeley, University of Pennsylvania, and University of Maryland.

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated Program

The accelerated program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. These options include opportunities for accelerated studies, dual degrees, and combined bachelor's/master's programs.

Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the "fast track" makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

With careful planning, students can complete two full degrees in the time usually required to complete one. The double major option works best in

closely related areas. For detailed information the student should contact his or her advisor.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science degree in the same period as the bachelor of science.

For more information on these and other options, visit the Department of Electrical and Computer Engineering BS/MS (http://www.ece.drexel.edu/undergrad/bsms.html) page.

Minor in Electrical Engineering

This minor is designed to provide other engineering majors or students from other disciplines an introduction to the wide-ranging content of the electrical engineering major. The minor consists of a minimum of eight ECE courses resulting in 26.0 credits. There are five required courses and an additional 12 credits of elective courses.

Prerequisites

The minor assumes that students will have a background in mathematics and physics equivalent to that covered in the first two years of the engineering curriculum. In mathematics, this would cover calculus and differential equations. Knowledge of linear algebra is also recommended. Courses taken to meet these requirements will not count toward the minor.

Required Courses

ECE 200	Digital Logic Design	3.0
ECE 201	Foundations of Electric Circuits	3.0
ECES 302	Transform Methods and Filtering	4.0
ECEL 301 [WI]	Electrical Engineering Laboratory	2.0
ECEL 302	ECE Laboratory II	2.0
Electrives *		12.0
Total Credits		26.0

* Students should choose 12 credits from 300- and/or 400-level ECE courses. These courses can come from the Computer (ECEC), Electrophysics (ECEE), Electric Power (ECEP), or Systems (ECES) groups. All prerequisites must be satisfied. Students majoring in Computer Engineering and minoring in Electrical Engineering may **only** choose elective courses from the ECEE, ECEP, and ECES course groups.

Additional information

Additional information about this minor is available on the ECE Department website (http://www.ece.drexel.edu/Undergraduate_Programs2.html).

Timothy P. Kurzweg, PhD
Associate Professor
Associate Department Head for Undergraduate Studies
Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director - Undergraduate Advising
Department of Electrical and Computer Engineering

Bossone Research Center Suite 313
advising@ece.drexel.edu
To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30

Facilities

Drexel University and the Electrical and Computer Engineering Department are nationally recognized for a strong history of developing innovative research. Research programs in the ECE Department prepare students for careers in research and development, and aim to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. The ECE Department is well equipped with state-of-the-art facilities in each of the following ECE Research laboratories:

Research Laboratories at the ECE Department

- **Adaptive Signal Processing and Information Theory Research Group** (http://www.ece.drexel.edu/aspitrg.html)
- **Applied Communications and Information Networking Center** (http://www.ece.drexel.edu/acinc.html)
- **Applied Networking Research Laboratory** (http://www.ece.drexel.edu/anrl.html)
- **Biochemical Signal Processing Laboratory** (http://www.ece.drexel.edu/bspl.html)
- **Cleanroom Microfabrication Facility** (http://www.ece.drexel.edu/cmf.html)
- **Data Fusion Laboratory** (http://www.ece.drexel.edu/dfl.html)
- **Drexel Network Modeling Laboratory** (http://www.ece.drexel.edu/dnml.html)
- **Drexel Wireless Systems Laboratory** (http://www.ece.drexel.edu/dwsl.html)
- **Electric Power Engineering Center** (http://www.ece.drexel.edu/epec.html)
- **Electronic Design Automation (EDA) Facility** (http://www.ece.drexel.edu/edaf.html)
- **Microwave Photonics Center** (http://www.ece.drexel.edu/mpc.html)
- **Microwave-Photonics Device Laboratories** (http://www.ece.drexel.edu/mpdl.html)
- **Music and Entertainment Technology Laboratory** (http://www.ece.drexel.edu/metl.html)
- **NanoPhotonics Laboratory** (http://www.ece.drexel.edu/npl.html)
- **Opto-Electro-Mechanical Laboratory** (http://www.ece.drexel.edu/oeml.html)
- **Plasma and Magnetics Laboratory** (http://www.ece.drexel.edu/pml.html)
- **Power Electronics Research Laboratory** (http://www.ece.drexel.edu/perl.html)
- **Supervisory Control Laboratory** (http://www.ece.drexel.edu/scl.html)
- **Testbed for Power/Performance Management of Enterprise Computing Systems** (http://www.ece.drexel.edu/tppm.html)

Engineering

Bachelor of Science in Engineering (BSE) Degree: 180.5 quarter credits

About the Program

The Bachelor of Science in Engineering program provides a strong grounding in the foundations of engineering, in quantitative skills, and in the analytic processes that engineers use in design of practical technology. This technologically-based pre-professional education is flexible enough for students to broaden their interests in interdisciplinary studies or to pursue pre-law or pre-med programs of study.

Drexel's engineering program was developed to provide students with educational and professional challenges not available in the traditional engineering curriculum.

Program Objectives

The key objectives of the Bachelor of Science in Engineering program are to provide the student with:

- a strong foundation in basic sciences and mathematics
- a foundation of the fundamentals of engineering as a discipline
- a strong grounding in a second cognate area (either technical, pre-professional, cultural, global, or another area worked out between the student and his/her advisor)
- an integrating experience that ties the technical and the cognate areas together. Examples of such experiences may be, but are not limited to, research projects, capstone designs, a public service assignment, etc.

Additional Information

Additional information about the BS in Engineering program is available on the Bachelor of Science in Engineering website (http://drexel.edu/engineering/programs/undergrad/Engineering).

Timothy P. Kurzweg, PhD
Associate Professor
Director Bachelor of Science in Engineering Program
Bossone Research Center, Suite 313
215.895.0549
kurzweg@coe.drexel.edu

Amy Ruymann, MS
Program Coordinator
Bachelor of Science in Engineering Program
Bossone Research Center Suite 313
215.895.2837
ajr66@drexel.edu

Degree Requirements

General Education/Liberal Studies Requirements

ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		24.0
Free Electives		24.0
Math and Science Requirements		
BIO 141	Essential Biology	4.5

CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Core Curriculum Requirements		
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Engineering Requirements		
As part of the 45.0 credits of Engineering requirements, students must include a capstone experience (Senior design sequence, research project, etc.)		45.0
Technical Electives		
Students select 18.0 credits of 200-level (or higher) courses in BMES, MATH, CHEM, PHYS, BIO or College of Engineering courses. Advisor approval is required for technical electives.		18.0
Total Credits		180.5

[*]   General Education Requirements. (p. 4)

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		**Credits**
CHEM 101	General Chemistry I	3.5
CS 121	Computation Laboratory I	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0

UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
Engineering course[*]		3.0
	Term Credits	**13.0**
Term 5		
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Engineering course[*]		3.0
General Education elective[*]		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 6		
Two Engineering courses[*]		6.0
General Education elective[*]		3.0
Free elective		3.0
	Term Credits	**12.0**
Term 7		
Two Engineering courses[*]		6.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 8		
Two Engineering eourses[*]		6.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 9		
Two Engineering courses[*]		6.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 10		
Senior Design Project I or Capstone course[*]		3.0
Engineering course[*]		3.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 11		
Senior Design Project II or Capstone course[*]		3.0
Engineering course[*]		3.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 12		
Senior Design Project III or Capstone course[*]		3.0
General Education elective[*]		3.0
Technical elective		3.0
Free elective		3.0
	Term Credits	**12.0**

Total Credit: 180.5

[*]   See degree requirements (p. 37).

Facilities

From the start of their freshman year, students learn to use the equipment they are likely to need in their careers, such as oscilloscopes, signal generators, amplifiers, and power supplies. These skills make students more useful as co-op employees and give them a competitive advantage in their engineering careers. The new 15-station laboratories equipped with Hewlett-Packard computers, software, and test and measurement instruments now add to the value of a Drexel engineering degree.

Computer/Design Center

The Drexel Curriculum boasts two types of lab experience: Instrumentation and Computer Design. Instrumentation Labs introduce Engineering Majors to the sight, sound, and feel of equipment such as digital multimeters, power supplies, oscilloscopes, and waveform generators. The Computer Labs imbue these pre-engineers with knowledge of software which they will be vital in today's work environment. Visit the Computer/Design Center (http://www.tdec.drexel.edu/?page=edl/#CDC) for more information.

Minor in Engineering Management

This minor focuses on the management of technical organizations. The required courses enhance an engineer's resume to show understanding of management and leadership behaviors, economics, and systems engineering and thinking.

While this minor is primarily designed to provide engineering management knowledge and skills to other engineers, with the equivalent science background students from other majors (biomedical engineering science, for example) can also complete this minor.

Prerequisites

The common engineering core curriculum prerequisites are required of all students in the college of engineering. Students from other colleges will need the appropriate background prerequisite courses.

Required Courses

BLAW 201	Business Law I	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
ECON 201	Principles of Microeconomics	4.0
ECON 202	Principles of Macroeconomics	4.0
EGMT 462	Introduction to Engineering Management	3.0
or MEM 462	Introduction to Engineering Management	
EGMT 465	Introduction to Systems Engineering	3.0
ORGB 300 [WI]	Organizational Behavior	4.0
Total Credits		25.0

Additional Information

More information is available on the Engineering Management Minor (http://www.drexel.edu/egmt/programs/minor) web page.

Engineering Policy Analysis Minor

An increasingly complex, interrelated, and technological society has come to rely on quantitative models of engineering systems to make decisions. While these models are used to make decisions in domains as varied as telecommunications, energy, and environmental quality, a common set of tools for the use of such models in decision making has been developed and forms the basis of an emerging discipline in engineering policy analysis. The practitioners of this discipline need training in mathematical and social science analytic approaches, as well as an understanding of the human factors that inevitably influence real-world policy choices. The minor in engineering policy analysis is designed to introduce students to these topics.

This minor broadens the exposure of engineering students to societal issues and provides an initial introduction to analytic skills which they may use both in engineering practice and as managers (given that many engineers become managers both in the private and public sector). Graduates will have additional training and a credentials relevant not only to engineering careers, but also to other fields, including urban planning, management consulting, and public administration. The program provides a basis for students to evaluate their interest and aptitude for graduate studies in fields such as business administration, public administration, and public policy. For pre-law students, the minor introduces them to analytic methods that inform the establishment and interpretation of laws as a mechanism of public policy implementation.CIM Program Requirements

Students are required to complete a total of 24.0 credits. At least 12.0 of these credits may not be counted as part of their major.

Applied Quantitative Methods (6.0 credits)
Students select one sequence in probability and statistics consisting of one introductory course and one advanced course. Any introductory course may be combined with any advanced course provided that the prerequisites of the advanced course are met.

24.0 credits

An increasingly complex, interrelated, and technological society has come to rely on quantitative models of engineering systems to make decisions. While these models are used to make decisions in domains as varied as telecommunications, energy, and environmental quality, a common set of tools for the use of such models in decision making has been developed and forms the basis of an emerging discipline in engineering policy analysis. The practitioners of this discipline need training in mathematical and social science analytic approaches, as well as an understanding of the human factors that inevitably influence real-world policy choices. The minor in engineering policy analysis is designed to introduce students to these topics.

This minor broadens the exposure of engineering students to societal issues and provides an initial introduction to analytic skills which they may use both in engineering practice and as managers (given that many engineers become managers both in the private and public sector). Graduates will have additional training and a credentials relevant not only to engineering careers, but also to other fields, including urban planning, management consulting, and public administration. The program provides a basis for students to evaluate their interest and aptitude for graduate studies in fields such as business administration, public administration, and public policy. For pre-law students, the minor introduces them to analytic methods that inform the establishment and interpretation of laws as a mechanism of public policy implementation.

Requirements

Students will be required to complete a total of 24.0 credits. At least 12.0 of these credits may not be counted as part of their major.

Applied Quantitative Methods

6.0 credits

Students select one sequence in probability and statistics consisting of one introductory course and one advanced course. Any introductory course may be combined with advanced course provided that the prerequisites of the advanced course are met.

Introductory Course Options

Select one of the following:		3.0-4.0
CHE 335	Statistics and Design of Experiments	
ENGR 361	Statistical Analysis of Engineering Systems	
MATH 311	Probability and Statistics I	
MEM 361	Engineering Reliability	
STAT 205	Statistical Inference I	
Advanced Course Options		
Select one of the following:		3.0-4.0
MATH 312	Probability and Statistics II	
STAT 206	Statistical Inference II	
ENVE 750	Data-based Engineering Modeling	
Additional Quantitative Method Electives		
MATH 300	Numerical Analysis I	
MATH 305	Introduction to Optimization Theory	
MATH 318 [WI]	Mathematical Applications of Statistical Software	
STAT 321	Statistical Decision Methods	
OPR 320	Linear Models for Decision Making	
OPR 330	Advanced Decision Making and Simulation	
Policy Analytic Methods		

Students are required to take at least 11.0 credits, including a course on capital investment decision making and a two-course sequence in economics.

CIVE 240 [WI]	Engineering Economic Analysis	3.0
ECON 201	Principles of Microeconomics	4.0
ECON 202	Principles of Macroeconomics	4.0
Additional Policy Analytic Methods Electives		
ECON 250	Game Theory and Applications	
ECON 301	Microeconomics	
ECON 330	Managerial Economics	
ECON 334	Public Finance	
ECON 351	Resource and Environmental Economics	
ENVS 370	Practice of Environmental Economics	
ENVE 727	Risk Assessment	
Human Factors		
Select two of the following:		6.0
PSCI 110	American Government I	
PSCI 211	American Government II	
PSCI 220	Constitutional Law I	
PSCI 329	Theories of Justice	
PSCI 331	Environmental Politics	
PSCI 372	City in United States Political Development	
SOC 215	Industrial Sociology	
SOC 240	Urban Sociology	
SOC 347	Introduction to Environmental Policy Analysis	
Elective		
One additional credit of coursework is required for the minor. This credit may be any of the three areas above. It is permissible to count 3.0 of the credits from a 4.0 credit class towards fulfilling one of the other areas, thereby using the 4th credit to meet the elective credit requirement.		1.0
Total Credits		**24.0**

Minor in Entertainment Engineering

Digital technologies have revolutionized the world of entertainment and created a new field combining the foundations of electrical engineering with entertainment media. This minor is designed for students with the technical literacy to effectively use, as well as develop, new tools for digital content creation and manipulation for entertainment applications.

The entertainment engineering minor consists of a minimum of six (6) required courses and an additional two (2) elective courses.

Entertainment Engineering Option for Non-Engineering Majors

The minor assumes students have a background in mathematics (equivalent to Calculus II). Courses taken to meet these pre-requisite requirements will not count toward the minor.

Required Courses

DIGM 105	Overview of Digital Media	3.0
ECE 101	Electrical and Computer Engineering in the Real World	1.0
ECE 121	Introduction to Entertainment Engineering	3.0
ECES 201	Introduction to Audio-Visual Signals	4.0
ECES 352	Introduction to Digital Signal Process	4.0
PSY 101	General Psychology I	3.0
Electives		
Select one of the following:		3.0
PSY 213	Sensation and Perception	
CS 337	The Psychology of Human-Computer Interaction	
Select one of the following:		3.0
FMVD 110	Basic Shooting and Lighting	
FMVD 115	Basic Editing	
FMVD 120	Basic Sound	
MIP 133	Computer and Digital Applications I	
Total Credits		**24.0**

Additional Information

Additional information about this minor is available on the ECE Department (http://www.ece.drexel.edu) website.

Timothy P. Kurzweg, PhD
Associate Professor
Associate Department Head for Undergraduate Studies
Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director - Undergraduate Advising
Department of Electrical and Computer Engineering
Bossone Research Center Suite 31
advising@ece.drexel.edu

To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30

Environmental Engineering

Bachelor of Science in Environmental Engineering (BSENE): 193.5 quarter credits

About the Program

Environmental engineering is concerned with the design of systems, policies and processes to protect human, animal, and plant populations from the effects of adverse environmental factors, including toxic chemicals and wastes, pathogenic bacteria, and global warming, and to design systems that enable a more sustainable society.

Environmental engineers try to minimize the effect of human activities on the physical and living environment so that we can all live more healthy and sustainable lives.This field builds on other branches of engineering, especially civil, chemical, and mechanical engineering. It also builds on information from many of the sciences, such as chemistry, physics, hydrology, geology, atmospheric science, and several specializations of biology (ecology, microbiology, and biochemistry). Students who elect to study environmental engineering will become familiar with many of these areas because maintaining and improving the environment requires

that problems be evaluated and solutions found using a multidisciplinary approach.

Mission

The mission of the undergraduate environmental engineering program at Drexel University is to graduate outstanding engineers who can identify, evaluate and solve complex environmental problems, and who desire to continue their education on a lifelong basis.

Program Educational Objectives

Environmental engineering graduates will become professionals who analyze, design, construct, manage or operate facilities or systems to protect or enhance the environment of people and other living things, or advance knowledge of the field.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

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

Additional Information

The Environmental Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For more information about this major, visit the Civil, Architectural and Environmental Engineering Department (http://www.cae.drexel.edu) and the BS in Environmental Engineering (http://www.cae.drexel.edu/EnvE) page.

Degree Requirements

General Education/Liberal Studies Requirements

ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		15.0
Engineering Core Courses		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
Environmental Engineering Requirements		
CAEE 201	Introduction to Infrastructure Engineering	3.0
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CHE 201	Process Material Balances	3.0
CHEM 230	Quantitative Analysis	4.0
CHEM 231 [WI]	Quantitative Analysis Laboratory	2.0
CHEM 241	Organic Chemistry I	4.0
CHEM 242	Organic Chemistry II	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 320	Introduction to Fluid Flow	3.0
CIVE 330	Hydraulics	4.0
CIVE 430	Hydrology	3.0
CIVE 431	Hydrology-Ground Water	3.0
ENVE 300	Introduction to Environmental Engineering	3.0
ENVE 302	Environmental Transport and Kinetics	3.0
ENVE 410	Solid and Hazardous Waste	3.0
ENVE 421	Water and Waste Treatment II	3.0
ENVE 422	Water and Waste Treatment Design	3.0
ENVE 435	Groundwater Remediation	3.0

ENVE 460	Fundamentals of Air Pollution Control	3.0
or ENVE 465	Indoor Air Quality	
ENVE 485	Professional Environmental Engineering Practice	1.0
ENVE 486	Environmental Engineering Processes Laboratory I	2.0
ENVE 487	Environmental Engineering Processes Laboratory II	2.0
ENVE 491 [WI]	Senior Project Design I	3.0
ENVE 492 [WI]	Senior Design Project II	3.0
ENVE 493 [WI]	Senior Design Project III	3.0
ENVS 284 [WI]	Physiological and Population Ecology	3.0
or BIO 221	Microbiology	
ENVS 401	Chemistry of the Environment	3.0
Technical Electives		12.0
Total Credits		193.5

* General Education Requirements (p. 4).

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
CS 121	Computation Laboratory I	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
CS 122	Computation Laboratory II	1.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		

Term 4		
CAEE 201	Introduction to Infrastructure Engineering	3.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
ENVS 284 [WI] or BIO 221	Physiological and Population Ecology Microbiology	3.0
	Term Credits	**15.0**
Term 6		
CHE 201	Process Material Balances	3.0
CHEM 230	Quantitative Analysis	4.0
CHEM 231 [WI]	Quantitative Analysis Laboratory	2.0
CIVE 320	Introduction to Fluid Flow	3.0
ENGR 361	Statistical Analysis of Engineering Systems	3.0
ENVE 300	Introduction to Environmental Engineering	3.0
	Term Credits	**18.0**
Term 7		
CAEE 211	Measurements in Civil, Architectural and Environmental Engineering II	4.0
CIVE 330	Hydraulics	4.0
ENVE 302	Environmental Transport and Kinetics	3.0
PHIL 315	Engineering Ethics	3.0
General Education elective*		3.0
	Term Credits	**17.0**
Term 8		
CHEM 241	Organic Chemistry I	4.0
CIVE 240 [WI]	Engineering Economic Analysis	3.0
CIVE 430	Hydrology	3.0
Technical elective		3.0
General Education elective*		3.0
	Term Credits	**16.0**
Term 9		
CHEM 242	Organic Chemistry II	4.0
Technical elective		3.0
Free elective		3.0
General Education elective*		3.0
	Term Credits	**13.0**
Term 10		
ENVE 485	Professional Environmental Engineering Practice	1.0
ENVE 491 [WI]	Senior Project Design I	3.0
ENVS 401	Chemistry of the Environment	3.0

ENVE 465	Indoor Air Quality	3.0
or 460	Fundamentals of Air Pollution Control	
Technical elective		3.0
	Term Credits	**13.0**
Term 11		
CIVE 431	Hydrology-Ground Water	3.0
ENVE 410	Solid and Hazardous Waste	3.0
ENVE 421	Water and Waste Treatment II	3.0
ENVE 486	Environmental Engineering Processes Laboratory I	2.0
ENVE 492 [WI]	Senior Design Project II	3.0
Technical elective		3.0
	Term Credits	**17.0**
Term 12		
ENVE 422	Water and Waste Treatment Design	3.0
ENVE 435	Groundwater Remediation	3.0
ENVE 487	Environmental Engineering Processes Laboratory II	2.0
ENVE 493 [WI]	Senior Design Project III	3.0
General elective*		3.0
	Term Credits	**14.0**

Total Credit: 193.5

*   See degree requirements (p. 41).

Co-op/Career Opportunities

Environmental Engineers pursue careers with many different industries, such as chemical, pharmaceutical and manufacturing, in groundwater and hazardous waste remediation, in water or wastewater treatment, in air pollution abatement and control, and in mining. Some also join environmental consulting firms which serve several engineering areas. In addition, some students go to graduate school. The breadth of an environmental engineering education prepares the student to follow many career paths.

Co-op Experiences

Past co-op employers of Environmental Engineering majors have included:

- Exelon, Philadelphia, PA
- U.S. Environmental Protection Agency, Philadelphia, PA
- Philadelphia Water Department, Philadelphia, PA
- Sun Co., Philadelphia, PA
- Aqua America, Bryn Mawr, PA
- Fairmount Park Commission, Philadelphia, PA
- Weston Solutions, West Chester, PA
- CDM Consultants, Philadelphia PA and other offices

Dual/Accelerated Degree

The Accelerated Program of the College of Engineering provides opportunities for highly-talented and strongly-motivated students to progress toward their educational goals essentially at their own pace.

Through advanced placement, credit by examination, flexibility of scheduling, and independent study, the program makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Bachelor's/Master's Dual Degree Program

Drexel offers a combined MS/BS degree program for our top engineering students who want to obtain both degrees in the same time period as most students obtain a Bachelors degree.

For more information on this program visit the Department's BS /MS Dual Degree Program (http://www.drexel.edu/academics/coe/cae/dual_degree.asp) page.

Minor in Environmental Engineering

The Environmental Engineering minor focuses on pollution control and is primarily designed to broaden the professional capabilities of engineering students. For example, chemical and mechanical engineers working in process and manufacturing plants will be provided with a better understanding of the natural context of their facilities, better equipped to perform fate and risk analyses, and better able to apply the appropriate technology to control air and water discharges.

While this minor is designed to provide technical knowledge and skills to other engineers, with the appropriate prerequisites students from disciplines other than engineering can also complete this minor.

The minor consists of five required core courses and nine additional credits taken from a list of options.

Prerequisites

The common engineering core curriculum prerequisites are required of all students in the College of Engineering. Students from other colleges will need the appropriate background in physics, mathematics and thermodynamics.

Required Courses

CAEE 210	Measurements in Civil, Architectural and Environmental Engineering I	3.0
ENVE 300	Introduction to Environmental Engineering	3.0
ENVE 302	Environmental Transport and Kinetics	3.0
CIVE 330	Hydraulics	4.0
ENVS 401	Chemistry of the Environment	3.0
Select three of the following:		8.0
ENVE 410	Solid and Hazardous Waste	
ENVE 460	Fundamentals of Air Pollution Control	
ENVE 486	Environmental Engineering Processes Laboratory I	
ENVE 487	Environmental Engineering Processes Laboratory II	
CIVE 430	Hydrology	
Total Credits		24.0

Facilities

The Department is well equipped with state-of-the-art facilities:

- The department computer labs are in operation: a computer-assisted design (CAD) and computerized instructional lab; and a graduate-level

lab (advanced undergraduates can become involved in graduate-level work).

- External labs are used for surveying, building diagnostics, and surface and ground-water measurements.
- Molecular microbiology laboratory to conduct PCR and qPCR analyses, as well as classical measurements
- Analytical equipment for chemical contaminants
- Instrumentation for characterization of indoor and outdoor atmospheric aerosols

Minor in Global Engineering

The Minor in Global Engineering is designed to train engineering students to become global citizens, skilled in meeting the challenges of a global work environment. Coursework in this minor aims at developing students' international historical, political, and cultural awareness as well as their knowledge of international business in order to succeed in the global economy. In addition to the required coursework, students must successfully complete an experience abroad prior to graduation. Experiences other than approved Study Abroad or Co-Op Abroad programs must receive prior approval from the College of Engineering Associate Dean for Undergraduate Affairs.

Foreign language

Foreign language is not required for the Minor in Global Engineering, but it may be required as a prerequisite to a student's experience abroad. In addition, a student can choose to apply as many as eight (8) credits of 200-level or higher foreign language toward the credit requirements for the minor.

Restrictions

Currently, only students enrolled in either the the College of Engineering or the School of Biomedical Engineering, Science and Health Systems can enroll in this minor.

Required Courses

ENGR 280	Introduction to Global Engineering	2.0
Select seven of the following (a minimum of one course from each of the three categories):		22.0
International Business		
INTB 200	International Business	
BLAW 340	International Business Law	
ECON 342	Economic Development [*]	
INTB 332	Multinational Corporations [*]	
INTB 334	International Trade [*]	
INTB 336	International Money and Finance [*]	
Political Science/History		
PSCI 140	Introduction to Comparative Political Analysis	
PSCI 150	International Politics	
PSCI 351	International Organizations	
PSCI 352	Ethics and International Relations	
PSCI 353	International Human Rights (i)	
PSCI 354	United States & the Third World	
PSCI 357	The European Union	
HIST 220	History of American Business	
HIST 259	History of Europe in the 20th Century	

Culture and Communications		
IAS 359	Culture and Values (recommended)	
COM 360	International Communication	
PHIL 335	Global Ethical Issues [**]	
SOC 330	Developing Nations and the International Division of Labor	
WMST 240	Women and Society in a Global Context	
Total Credits		24.0

[*]	Require ECON 201 and ECON 202 as pre-requisites.

[**]	Requires PHIL 105 as a prerequisite.

Note: Students may petition the College of Engineering's Associate Dean for Undergraduate Affairs for permission to apply other courses they believe relevant to the Minor in Global Engineering toward their credit requirements. Such requests will be handled on a case-by-case basis.

Materials Science and Engineering

Bachelor of Science in Materials Science and Engineering (BSMSE): 192.0 quarter credits

About the Program

Materials science and engineering (MSE) is concerned with the production, structure, characterization, properties and utilization of metals, ceramics, polymers, composites, electronic, optical, nano- and bio-compatible materials. Materials scientists and engineers play a key role in our increasingly complex technological society by extending the limited supply of materials, improving existing materials, and developing and designing new and superior materials and processes with an awareness of their cost, reliability, safety, and societal/environmental implications.

Students majoring in materials science and engineering (MSE) receive a thorough grounding in the basic sciences and engineering of all materials. All students are required to take course sequences that include materials processing, thermodynamics and kinetics of materials, and their physical and mechanical behavior, plus laboratories designed to familiarize them with the instruments and advanced techniques used to characterize materials and evaluate their structure, properties and performance. A number of custom tracks allow upper level students to focus their technical electives in areas of specialization, including nanoscale materials and nanotechnology, biomaterials, electronic and photonic materials, soft materials and polymers, advanced materials design and processing, or in a custom track. In addition, several required senior level courses emphasize the role of materials selection and specification in design.

Throughout the senior year, students majoring in materials science and engineering work on a capstone senior design project over the course of three terms, with guidance from a faculty advisor and graduate student mentor. Students, working individually or in small groups, synthesize information from their courses to arrive at solutions to real-world engineering problems.

Some recent senior design projects include:

- Analyzing Nonskid Material for Naval Applications
- Core-Cladding Electrospun Nanofibers for Controlled Release Applications

- Adsorption of Antiobiotics onto Nanodiamond Platforms
- Effect of Nickel Distribution on Hardenability
- Synthesis and Characterization of Mo_2GaC, Mo_2GaN and Mo_2AlC MAX Phases
- Design and Synthesis of ITO-Free Flexible Organic Solar Cells.

Mission Statement

The Department of Materials Science and Engineering (http://www.materials.drexel.edu) will provide our BS, MS and PhD graduates with the technical and theoretical knowledge, design capabilities, professionalism, and communications skills necessary for them to excel in leadership positions in academia, industry, and government at the national and international levels.

Vision

Materials science and engineering is a multi-disciplinary field that is at the forefront of all emerging technologies. Advances in the understanding of the process-structure-property-performance relationships of materials is critical for future developments in energy storage and power generation, biomaterials and nanomaterials. The Department of Materials Science and Engineering at Drexel University is recognized as a leader in these areas through teaching and scholarly research.

Program Educational Objectives

The educational objectives of the Materials Science and Engineering BS degree program are:

- Materials Science and Engineering program graduates possess the core technical competencies in their field necessary to successfully interface with other engineering disciplines in the workplace
- At least 30% of Materials Science and Engineering program graduates have progressed towards graduate education
- Materials Science and Engineering program graduates are leaders in their chosen fields.
- Materials Science and Engineering program graduates are engaged in lifelong learning.
- Materials Science and Engineering program graduates posses written and verbal communication skills appropriate for professional materials engineers and/or scientists.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a. an ability to apply a knowledge of mathematics, science and engineering.

b. an ability to design and conduct an experiments, as well as to analyze and interpret data.

c. an ability to design a material, 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. an ability to function on multi-disciplinary teams.

e. an ability to identify, formulate and solve *materials* engineering problems.

f. an understanding of professional and ethical responsibility.

g. an 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. a recognition of the need for, and an ability to engage in, lifelong learning.

j. a knowledge of contemporary issues.

k. an ability to use the techniques, skills and modern engineering tools necessary for materials science and engineering practice.

Additional Information

The Materials Science and Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For additional information about this major, contact:

Sarit Kunz
Academic Program Coordinator
215.895.2328
skunz@coe.drexel.edu

Degree Requirements

General Education/Liberal Studies Requirements

ECON 201	Principles of Microeconomics	4.0
ECON 202	Principles of Macroeconomics	4.0
HIST 285	Technology in Historical Perspective	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
Technical Electives/Track Courses [*]		12.0
Non-designated General Education Requirements [**]		9.0
Free Electives		6.0
Foundation Requirements		
CHE 335	Statistics and Design of Experiments	3.0
CHEC 353	Physical Chemistry and Applications III	4.0
CHEM 241	Organic Chemistry I	4.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5
ENGR 100	Beginning Computer Aided Drafting for Design	1.0

ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0
ENGR 180	Special Topics in Engineering (Computation Lab I)	2.0
ENGR 180	Special Topics in Engineering (Computation Lab II)	1.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Professional Requirements		
MATE 214	Introduction to Polymers	4.0
MATE 221	Introduction to Mechanical Behavior of Materials	3.0
MATE 240	Thermodynamics of Materials	4.0
MATE 245	Kinetics of Materials	4.0
MATE 280	Advanced Materials Laboratory	4.0
MATE 315	Processing Polymers	4.5
MATE 341	Defects in Solids	3.0
MATE 345	Processing of Ceramics	4.5
MATE 351	Electronic and Photonic Properties of Materials	4.0
MATE 355	Structure and Characterization of Crystalline Materials	3.0
MATE 366 [WI]	Processing of Metallic Materials	4.5
MATE 370	Mechanical Behavior of Solids	3.0
MATE 410	Case Studies in Materials	3.0
MATE 455	Biomedical Materials	3.0
MATE 460	Engineering Computational Laboratory	4.0
MATE 491 [WI]	Senior Project Design I	2.0
MATE 492	Senior Project Design II	2.0
MATE 493 [WI]	Senior Project Design III	4.0
Total Credits		192.0

* A "Track" is a sequence of 4-5 technical electives (12-18 credits) with an underlying connection to a specific area of materials science and engineering. With the rapid expansion of the technical and scientific knowledge in the field of materials science and engineering, organizing technical electives into thematic tracks benefits students. Combined with relevant co-op experiences and senior design, the tracks can provide strong evidence of specialization, which will benefit students in future job searches.

Technical electives can be taken during the junior and (mostly during) the senior year. For planning reasons, better coordination with senior design, and to accommodate students with an out-of-cycle schedule (e.g., transfer students), tracks need to be declared by the beginning of the pre-junior year. Students may change their track selection after consulting with their MSE department advisor.

** Non-designated General Education Requirements (p. 4).

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
COOP 101	Career Management and Professional Development	0.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 180	Special Topics in Engineering (Computation Lab I)	2.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
Term Credits		**16.5**
Term 2		
ENGR 102	Engineering Design Laboratory II	2.0
CHEM 102	General Chemistry II	4.5
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGR 180	Special Topics in Engineering (Computation Lab II)	1.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
Term Credits		**19.0**
Term 3		
BIO 141	Essential Biology	4.5
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
Term Credits		**18.0**
Term 4		
CHEM 241	Organic Chemistry I	4.0
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
PHYS 201	Fundamentals of Physics III	4.0
Term Credits		**18.0**
Term 5		
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATE 221	Introduction to Mechanical Behavior of Materials	3.0
Free elective		3.0
Term Credits		**15.0**
Term 6		
ECON 201	Principles of Microeconomics	4.0
MATE 214	Introduction to Polymers	4.0
MATE 240	Thermodynamics of Materials	4.0
MATE 355	Structure and Characterization of Crystalline Materials	3.0
Term Credits		**15.0**
Term 7		

ECON 202	Principles of Macroeconomics	4.0
MATE 245	Kinetics of Materials	4.0
MATE 315	Processing Polymers	4.5
MATE 341	Defects in Solids	3.0
	Term Credits	**15.5**
Term 8		
HIST 285	Technology in Historical Perspective	3.0
MATE 280	Advanced Materials Laboratory	4.0
MATE 366 [WI]	Processing of Metallic Materials	4.5
MATE 370	Mechanical Behavior of Solids	3.0
Technical elective/Track course		3.0
	Term Credits	**17.5**
Term 9		
CHEC 353	Physical Chemistry and Applications III	4.0
MATE 345	Processing of Ceramics	4.5
MATE 351	Electronic and Photonic Properties of Materials	4.0
PHIL 315	Engineering Ethics	3.0
	Term Credits	**15.5**
Term 10		
MATE 455	Biomedical Materials	3.0
MATE 460	Engineering Computational Laboratory	4.0
MATE 491 [WI]	Senior Project Design I	2.0
General education elective[*]		3.0
Technical elective/Track course		3.0
	Term Credits	**15.0**
Term 11		
CHE 335	Statistics and Design of Experiments	3.0
MATE 492	Senior Project Design II	2.0
Free elective		3.0
Technical elective/Track course		3.0
General education elective[*]		3.0
	Term Credits	**14.0**
Term 12		
MATE 410	Case Studies in Materials	3.0
MATE 493 [WI]	Senior Project Design III	4.0
Technical elective/Track course		3.0
General education elective[*]		3.0
	Term Credits	**13.0**

Total Credit: 192.0

[*]   See degree requirements (p. 45).

Co-op/Career Opportunities

Examples of industries in which materials science and engineering graduates play major roles include: base metals industries; specialist alloys; advanced ceramics; petrochemical; biomaterials and implants; pharmaceuticals; consumer products; electronics and photonics; nanotechnology; power generation; energy conversion, storage and conservation (fuel cells, advanced batteries, supercapacitors and

solar cells); environmental protection and remediation; information and telecommunications; and transportation (aerospace, automotive, bicycles, railways).

Typical job functions include design and development of new materials, materials selection for specific applications, manufacturing, performance and failure analysis, quality control and testing, research and development, technical management, sales and marketing, teaching, technical services, and technical writing.

Please visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) for more detailed information on Co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated Program

The Accelerated Program of the College of Engineering provides opportunities for highly talented and motivated students to progress toward their educational goals essentially at their own pace. These options include opportunities for accelerated studies, dual degrees, as well as a combined bachelor's/master's (BS/MS) program. Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, this "fast-track" makes it possible to complete the undergraduate curriculum and initiate graduate studies in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

With careful planning, students can complete two full degrees in the time usually required to complete one. For detailed information, students should contact their advisors.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science (MS) degree in the same period as the bachelor of science (BS). The combined BS/MS degree in Materials Science and Engineering differs from the standard BS degree in that there are two Co-op periods instead of three and in the last two years, specific graduate courses are taken.

For more information about this program, please visit the Department's BS/MS Dual Degree Program (http://www.mse.drexel.edu/academics/undergrad/bs-ms) page.

Minor in Materials Engineering

In addition to the core engineering curriculum and the courses required for majors in chemical, civil, electrical, or mechanical engineering, engineering students from other majors can obtain a minor in materials engineering by taking 24.0 credits from the courses listed below.

Required Courses		
MATE 221	Introduction to Mechanical Behavior of Materials	3.0
Select six (at least 21.0 credits) of the following:		21.0
MATE 214	Introduction to Polymers [*]	
MATE 240	Thermodynamics of Materials	
MATE 245	Kinetics of Materials	
MATE 280	Advanced Materials Laboratory	
MATE 341	Defects in Solids	

MATE 351	Electronic and Photonic Properties of Materials	
MATE 355	Structure and Characterization of Crystalline Materials	
MATE 370	Mechanical Behavior of Solids [**]	
MATE 455	Biomedical Materials	
Total Credits		24.0

[*]   MATE 214 requires CHEM 241 as a pre-requisite. If MATE 214 is elected, the credits for CHEM 241 can count toward the 21 credits.

[**]   MATE 370 requires MATH 201 as a pre-requisite. If MATE 370 is elected, the credits for MATH 201 can count toward the 21 credits.

Note:Only one of the prerequisites (either or MATH 201) can count toward the required 24.0 credits. In other words, both MATE 214 and MATE 370 can be used to fulfill the requirements for the minor, but only the pre-requisite for one of those courses will be calculated into the 24.0 credits. Similarly, MATH 201 or CHEM 241 cannot be counted alone as fulfilling the requirements for this minor. The credits for MATH 201 or CHEM 241 will only count toward the minor when the course(s) is/are taken as a prerequisite for MATE 214 or MATE 370. Substitution for these courses of equivalent courses offered by other departments and/or institutions may be made with the approval of the Department of Materials Science and Engineering on a case-by-case basis.

At least two-thirds of the content of a substitute course must be the same as that of the course in the list above. It is imperative that students check each course carefully with respect to prerequisites since some may be included in the list above and some may be from other departments. Courses taken outside the department as prerequisites do not count towards the 24.0 credits required for the minor. They may, however, be used as technical or free electives in students' home department. Students pursuing the minor in Materials Science and Engineering are also encouraged to select a senior design topic that relates to the field of materials.

Facilities

Biomaterials and Biosurfaces Laboratory
This laboratory contains 10 kN biaxial and 5 kN uniaxial servo-hydraulic mechanical testing machines, a Fluoroscan X-ray system, a microscopic imaging system, a spectra fluorometer, a table autoclave, centrifuge, vacuum oven, CO_2 incubators, biological safety cabinet, thermostatic water baths, precision balance and ultrasonic sterilizer.

Nanobiomaterials and Cell Engineering Laboratory
This laboratory contains fume hood with vacuum/gas dual manifold, vacuum pump and rotary evaporator for general organic/polymer synthesis; gel electrophoresis and electroblotting for protein characterization; bath sonicator, glass homogenizer and mini-extruder for nanoparticle preparation; centrifuge; ultrapure water conditioning system; precision balance; pH meter and shaker.

Ceramics Processing Laboratory
This laboratory contains a photo-resist spinner, impedance analyzer, Zeta potential meter, spectrofluorometer, piezoelectric d33 meter, wire-bonder, and laser displacement meter.

Dynamic Characterization Laboratory
This laboratory contains metallographic sample preparation (sectioning, mounting and polishing) facilities; inverted metallograph; microhardness tester; automated electropolishing for bulk and TEM sample preparation;

SEM tensile stage for EBSD; magneto-optical Kerr effect (MOKE) magnetometer.

MAX Phase Ceramics Processing Laboratory
This laboratory contains a vacuum hot-press; cold isostatic press (CIP) and hot isostatic press (HIP) for materials consolidation and synthesis; precision dilatometer; laser scattering particle size analyzer; impedance analyzer, creep testers, and assorted high temperature furnaces.

Mechanical Testing Laboratory
This laboratory contains mechanical and closed-loop servo-hydraulic testing machines, hardness testers, impact testers, equipment for fatigue testing, metallographic preparation facilities and a rolling mill with twin 6" diameter rolls.

Mesoscale Materials Laboratory
This laboratory contains instrumentation for growth, characterization, device fabrication, and design and simulation of electronic, dielectric, ferroelectric and photonic materials. Resources include physical and chemical vapor deposition and thermal and plasma processing of thin films, including oxides and metals, and semiconductor nanowire growth. Facilities include pulsed laser deposition, atomic layer deposition, chemical vapor deposition, sublimation growth, and resistive thermal evaporation. Variable-temperature high-vacuum probe station and optical cryostats including high magnetic field, fixed and tunable-wavelength laser sources, several monochromators for luminescence and Raman scattering spectroscopies, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

Nanomaterials Laboratory
This laboratory contains instrumentation for testing and manipulation of materials under microscope, high-temperature autoclaves, Sievert's apparatus; glove-box; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; electro-spinning system for producing nano-fibers.

Oxide Films and Interfaces Laboratory
This laboratory contains an oxide molecular beam epitaxy (MBE) thin film deposition system; physical properties measurement system for electronic transport and magnetometry measurements from 2 – 400K, up to 9 T fields; 2 tube furnaces.

Powder Processing Laboratory
This laboratory contains vee blenders, ball-mills, sieve shaker + sieves for powder classification, several furnaces (including one with controlled atmosphere capability); and a 60-ton Baldwin press for powder compaction.

Soft Matter Research and Polymer Processing Laboratories
These laboratories contain computerized thermal analysis facilities including differential scanning calorimeters (DSC), dynamic mechanical analyzer (DMA) and thermo-gravimetric analyzer (TGA); single-fiber tensile tester; strip biaxial tensile tester; vacuum evaporator; spincoater; centrifuge; optical microscope with hot stage; liquid crystal tester; microbalance; ultrasonic cleaner; laser holographic fabrication system; polymer injection molder and single screw extruder.

Natural Polymers and Photonics Laboratory
This laboratory contains a spectroscopic ellipsometer for film characterization; high purity liquid chromatography (HPLC) system; lyophilizer; centrifuge; refractometer; electro-spinning system for producing nano-fibers.

X-ray Tomography Laboratory

This laboratory contains a high resolution X-ray tomography instrument and a cluster of computers for 3D microstructure reconstruction; mechanical stage, a positioning stage and a cryostage for in-situ testing. For more information on departmental facilities, please visit the Department's Facilities page at http://www.materials.drexel.edu/research/facilities/

Centralized Research Facilities

The Department of Materials Science & Engineering relies on Core Facilities within the University for materials characterization and micro- and nano-fabrication. These facilities contain state-of-the-art materials characterization instruments, including environmental and variable pressure field-emission scanning electron microscopes with Energy Dispersive Spectroscopy (EDS) for elemental analysis, and Orientation Image Microscopy (OIM) for texture analysis; a Transmission Electron Microscope (TEM) with STEM capability and TEM sample preparation equipment; a dual beam focused ion beam (FIB) system for nano-characterization and nano fabrication; a femtosecond/ terahertz laser Raman spectrometer; visible and ultraviolet Raman micro spectrometers with a total of 7 excitation wavelengths for non-destructive chemical and structural analysis and Surface Enhanced Raman (SERS); a Fourier Transform Infrared (FTIR) spectrometer with a microscope and full array of accessories; a Nanoindenter; an X-ray Photoelectron Spectrometer (XPS)/Electron Spectroscopy for Chemical Analysis (ESCA) system; and X-Ray Diffractometers (XRD), including small angle/wide angle X-Ray scattering (SAX/WAX).

More details of these instruments, information how to access them and instrument usage rates can be found at http://crf.coe.drexel.edu/

Mechanical Engineering

Bachelor of Science in Mechanical Engineering (BSME): 192.5 quarter credits

About the Program

The role of the mechanical engineer in today's society is rapidly changing. Advances in manufacturing, transportation, infrastructure systems, materials, communications, and high-performance computing have introduced new demands, opportunities, and challenges for mechanical engineers. What was once an individual endeavor has now become a team activity. Today's industries require that mechanical engineers possess diverse interdisciplinary skills, a global viewpoint, entrepreneurial and managerial abilities, and an understanding of the forces governing the marketplace.

Traditionally, mechanical engineers have been associated with industries like automotive, transportation, and power generation, and with activities involving the design, analysis, and manufacturing of products useful to society. While today such activities are still dominated by mechanical engineers, the spectrum of opportunities for these professionals has expanded tremendously. For example, mechanical engineers are involved in the design and analysis of biomedical instrumentation, electronic components, smart structures, and advanced materials; they are involved in sophisticated studies of human motion, control of satellites, and the development of more efficient energy-transfer techniques.

Drexel's Department of Mechanical Engineering and Mechanics (http://www.drexel.edu/coe/departments/mech_eng) prides itself on providing its students with a comprehensive program of courses, laboratories, design projects, and co-op experiences. The MEM curriculum is designed to balance technical breadth (provided by a set of fundamental required core courses) with technical depth (provided by optional concentrations that emphasize particular fields within the profession). Thus, the MEM program not only prepares its graduates to become successful mechanical engineers needed in industry and government, but also provides an excellent springboard to pursue graduate studies in medical sciences, law, business, information technology, and any other disciplines where technological and analytical skills play an important role.

Mission Statement

The mission of the Department of Mechanical Engineering and Mechanics of Drexel University is to transfer and acquire knowledge through: (a) the education of engineers for leadership in industry, business, academia, and government; and (b) the establishment of internationally recognized research programs. This mission is accomplished by the delivery of an outstanding curriculum, by the participation of our students in one of the nation's most prestigious co-operative educational programs, and by the scholarly activities of the faculty.

Program Educational Objectives

- Graduates will be successful in careers that deal with the design, simulation and analysis of engineering systems, experimentation and testing, manufacturing, technical services, and research.
- Graduates will enter and complete academic and professional programs in engineering, business, management, law and medicine.
- Graduates will communicate effectively with peers and be successful working with and leading multi-disciplinary and multi-cultural teams.
- Graduates will recognize the global, legal, societal, and ethical contexts of their work.
- Graduates will advance in their careers; for example, assuming increasing levels of responsibility and acquiring professional licensure.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

a) an ability to apply knowledge of mathematics, science, and engineering;

b) an ability to design and conduct experiments, as well as to analyze and interpret data;

c) an 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) an ability to function on multidisciplinary teams;

e) an ability to identify, formulate, and solve engineering problems;

f) an understanding of professional and ethical responsibility;

g) an 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) a recognition of the need for, and an ability to engage in life-long learning;

j) a knowledge of contemporary issues;

k) an ability to use the techniques, skills, and modern engineering tools necessary for mechanical engineering and mechanics practice.

Additional Information

The Mechanical Engineering and Mechanics program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

For additional information about this major, contact:

Angela Thomas
athomas@coe.drexel.edu
215.895.2336
Randell 115

Sheena Butler
sbutler@coe.drexel.edu
215.895.1474
Randell 115

Degree Requirements

The mechanical engineering and mechanics curriculum is designed to balance technical breadth (provided by a set of fundamental required core courses) with technical depth (provided by optional concentrations that emphasize particular fields within the profession).

General Education/Liberal Studies Requirements

HIST 285	Technology in Historical Perspective	3.0
ENGL 101	Expository Writing and Reading	3.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGL 103	Analytical Writing and Reading	3.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	2.0
General Education Requirements [*]		12.0

Mathematics Requirements

MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0

Physics Requirements

PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0

Chemistry/Biology Requirements

CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
BIO 141	Essential Biology	4.5

Design/Laboratory Requirements

CS 121	Computation Laboratory I	1.0
CS 122	Computation Laboratory II	1.0
CS 123	Computation Laboratory III	1.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
ENGR 102	Engineering Design Laboratory II	2.0
ENGR 103	Engineering Design Laboratory III	2.0

Engineering Requirements

ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0

Engineering Economics Requirements

| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |

Materials Requirements

| ENGR 220 | Fundamentals of Materials | 4.0 |

Mechanical Requirements

MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Engineering Mechanics-Statics	3.0
MEM 220	Basic Fluid Mechanics	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 351	Dynamic Systems Laboratory I	2.0
MEM 333	Mechanical Behavior of Materials	3.0
MEM 345	Heat Transfer	4.0
MEM 355	Performance Enhancement of Dynamic Systems	4.0
MEM 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I	3.0
MEM 492 [WI]	Senior Design Project II	3.0
MEM 493 [WI]	Senior Design Project III	3.0

Elective Courses

MEM Fundamental Courses [**]	12.0
MEM Open Electives (Any two MEM courses 300 level or higher.)	6.0-8.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher.)	6.0-8.0
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.)	6.0-8.0
Free Electives	6.0-8.0
Total Credits	192.5

[*]   General Education Requirements (p. 4).

[**] All MEM students must complete a minimum of four of the MEM Fundamentals courses. (See List Below)

MEM Fundamental Courses

Select four of the following:	
MEM 320	Fluid Dynamics I
MEM 330	Mechanics of Materials II
MEM 410	Thermodynamic Analysis II
MEM 417	Introduction to Microfabrication
MEM 423	Mechanics of Vibration
MEM 431	Machine Design I
MEM 437	Manufacturng Process I

MEM 440	Thermal Systems Design
MEM 458	Micro-Based Control Systems I
MEM 459	Micro-Based Control Systems II

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
CHEM 101	General Chemistry I	3.5
CS 121	Computation Laboratory I	1.0
ENGL 101	Expository Writing and Reading	3.0
ENGR 100	Beginning Computer Aided Drafting for Design	1.0
ENGR 101	Engineering Design Laboratory I	2.0
MATH 121	Calculus I	4.0
UNIV E101	The Drexel Experience	1.0
	Term Credits	**15.5**
Term 2		
CHEM 102	General Chemistry II	4.5
COOP 001	Co-op Essentials	0.0
CS 122	Computation Laboratory II	1.0
ENGL 102	Persuasive Writing and Reading	3.0
ENGR 102	Engineering Design Laboratory II	2.0
MATH 122	Calculus II	4.0
PHYS 101	Fundamentals of Physics I	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 3		
BIO 141	Essential Biology	4.5
CS 123	Computation Laboratory III	1.0
ENGL 103	Analytical Writing and Reading	3.0
ENGR 103	Engineering Design Laboratory III	2.0
MATH 200	Multivariate Calculus	4.0
PHYS 102	Fundamentals of Physics II	4.0
UNIV E101	The Drexel Experience	0.5
	Term Credits	**19.0**
Term 4		
ENGR 201	Evaluation & Presentation of Experimental Data I	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
MEM 202	Engineering Mechanics-Statics	3.0
PHYS 201	Fundamentals of Physics III	4.0
	Term Credits	**17.0**
Term 5		
ENGR 202	Evaluation & Presentation of Experimental Data II	3.0
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MEM 201	Foundations of Computer Aided Design	3.0
MEM 238	Dynamics	4.0
	Term Credits	**16.0**
Term 6		

CIVE 240 [WI]	Engineering Economic Analysis	3.0
HIST 285	Technology in Historical Perspective	3.0
MEM 230	Mechanics of Materials I	4.0
MEM 310	Thermodynamic Analysis I	4.0
Free Elective		3.0
	Term Credits	**17.0**
Term 7		
MEM 220	Basic Fluid Mechanics	4.0
MEM 255	Introduction to Controls	4.0
MEM 331	Experimental Mechanics I	2.0
MEM 333	Mechanical Behavior of Materials	3.0
PHIL 315	Engineering Ethics	3.0
	Term Credits	**16.0**
Term 8		
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 355	Performance Enhancement of Dynamic Systems	4.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 345	Heat Transfer	4.0
MEM Fundamentals Course*		3.0
	Term Credits	**17.0**
Term 9		
MEM 351	Dynamic Systems Laboratory I	2.0
MEM 361	Engineering Reliability	3.0
Two MEM Fundamentals Courses*		6.0
General Education Elective*		3.0
	Term Credits	**14.0**
Term 10		
MEM 491 [WI]	Senior Design Project I	3.0
General Education Elective*		3.0
A MEM or College of Engineering Elective (300+)		3.0
MEM Fundamentals Course*		3.0
Math/Science Course*		3.0
	Term Credits	**15.0**
Term 11		
MEM 492 [WI]	Senior Design Project II	3.0
General Education Elective*		3.0
Any 300-level or Higher MEM Elective		3.0
A MEM or College of Engineering Elective (300+)		3.0
Math/Science Course*		3.0
	Term Credits	**15.0**
Term 12		
MEM 493 [WI]	Senior Design Project III	3.0
Free Electives		3.0
Any 300-level or Higher MEM Elective		3.0

General Education Elective[*]		3.0
Term Credits		**12.0**

Total Credit: 192.5

[*]   See degree requirements (p. 50).

Co-op/Career Opportunities

Mechanical engineers are employed in a growing number of areas, including aerospace, automotive, biomechanics, computer systems, electronic entertainment, energy, environmental, health care, manufacturing, nuclear technology, and utilities.
Most mechanical engineering graduates begin full-time employment immediately upon graduation. However, there are a number of graduates who go on to pursue master's and/or doctoral degrees in mechanical engineering.The graduate schools that Drexel's mechanical engineers have attended include Harvard, UC Berkeley, and the University of Pennsylvania.
Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated Program

The Accelerated Program of the College of Engineering provides opportunities for highly talented and strongly motivated students to progress toward their educational goals essentially at their own pace. These options include opportunities for accelerated studies, dual degrees, a combined bachelor's/master's program as well as participation in the University Honors Program (http://www.drexel.edu/honors/curriculum/requirements).

Primarily through advanced placement, credit by examination, flexibility of scheduling, and independent study, the "fast track" makes it possible to complete the undergraduate curriculum and initiate graduate study in less than the five years required by the standard curriculum.

Dual Degree Bachelor's Programs

With careful planning, you can complete two full degrees in the time usually required to complete one. The double major option works best in closely related areas. For detailed information please contact your advisor.

Bachelor's/Master's Dual Degree Program

Exceptional students can also pursue a master of science degree in the same period as the bachelor of science. For MEM undergraduate students, the following are the possible graduate programs for the Master's degree in the BS/MS dual degree program:

- Electrical Engineering
- Computer Engineering
- Engineering Management
- Material Science Engineering
- Mechanical Engineering and Mechanics
- Biomedical Engineering
- Chemical Engineering

For more information about this program, visit the Department's BS / MS Dual Degree Program (http://drexel.edu/mem/resources/current/BSMSProgram) page.

Minor in Mechanical Engineering and Mechanics

Any undergraduate student in good standing who has completed more than 30.0 credits at Drexel may apply for the minor in mechanical engineering.

The minor must contain a minimum of 24.0 MEM credits according to the following distribution: (a) 16.0 credits from any four of the 4-credit required course options; (b) at least eight credits from additional required courses or from the laboratory components and recommended electives.

Required Course Options		
Select four of the following:		16.0
MEM 220	Basic Fluid Mechanics	
MEM 230	Mechanics of Materials I	
MEM 238	Dynamics	
MEM 255	Introduction to Controls	
MEM 310	Thermodynamic Analysis I	
MEM 345	Heat Transfer	
MEM 355	Performance Enhancement of Dynamic Systems	
MEM 361	Engineering Reliability	
MEM 435	Introduction to Computer-Aided Design and Manufacturing	
Select three of the following:		8.0
Laboratories		
MEM 311	Thermal Fluid Science Laboratory	
MEM 331	Experimental Mechanics I	
MEM 351	Dynamic Systems Laboratory I	
Recommended Electives		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 361	Engineering Reliability	
MEM 410	Thermodynamic Analysis II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 430	Advanced Stress Analysis	
MEM 437	Manufacturng Process I	
MEM 438	Manufacturing Process II	
MEM 440	Thermal Systems Design	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 455	Introduction to Robotics	
MEM 458	Micro-Based Control Systems I	
MEM 459	Micro-Based Control Systems II	
MEM 462 [WI]	Introduction to Engineering Management	
Total Credits		24.0

Facilities

Advanced Design and Manufacturing Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=6)
This laboratory provides research opportunities in design ethodology,computer-aided design, analysis and manufacturing, and materials processing and manufacturing. Facilities include various computers and software, I-DEAS, Pro/E,ANSYS, MasterCAM, Mechanical DeskTop, SurfCAM, Euclid, Strim, ABQUS, and more.The machines include two Sanders Model Maker rapid prototyping machines, a BridgePort CNC Machining Center, a BOY 220 injection molding machine, an Electra high-temperature furnace for metal sintering, infiltration, and other heat treatment.

Biofluid Mechanics Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=5)
The biofluid mechanics laboratory conducts computational and experimental research on the dynamics of flow in the cardiovascular and respiratory system, and the effects of flow on biological processes, particularly hemostasis and thrombosis. Lab resources include high-performance engineering workstations, commercial computational fluid dynamics (CFD) software, and basic experimental facilities including Laser Doppler Velocimetry (LDV), pressure and flow transducers, pumps, and microscopes.

Biomechanics Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=2)
Emphasis in this laboratory is placed on understanding the mechanical properties of human joints, characterization of the mechanical properties of biological materials, studies of human movements, and design and development of artificial limbs. Facilities include a 3-D kinematic measuring system, Instron testing machine, and microcomputers for data acquisition and processing. Additional biomechanical laboratory facilities are available at Moss Rehab

Combustion and Fuels Chemistry Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=1)
Emphasis in this laboratory is placed on developing an understanding of both the chemical and physical factors that control and, hence, can be used to tailor combustion processes for engineering applications. Facilities include continuous spectroscopic reaction monitoring systems, static reactors, combustion bombs, flat flame burner systems, flow reactors, and complete analytical and monitoring instrumentation.

Combustion and Thermal-Science Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=9)
Research is conducted in the areas of (1) low temperature hydrocarbon oxidation, (2) cool flames, (3) auto-ignition, (4) flame instabilities, (5) flame structure, (6) flame ignition, and (7) flame extinction (quelching). New ways to improve fuel efficiency in practical combustors and recover waste energy in the transportation sector are also being explored.

Combustion Emissions/Engine Laboratory
In this laboratory the effects of engine operating variables, fuel type, ambient conditions, and control devices on engine performance and emissions are studied. The laboratory contains both diesel and spark ignition engines, as well as extensive engine and emissions monitoring instrumentation, including dynamometers and continuous gaseous emission analyzers. The laboratory has a high-pressure flow reactor for detailed kinetic studies of hydrocarbon oxidation processes in engines.

Composite Mechanics Laboratory

Emphasis in this laboratory is placed on the characterization of performance of composite materials. Current interest includes damage mechanisms, failure processes, and time-dependent behavior in resin-, metal-, and ceramic-matrix composites. Major equipment includes servo-hydraulic and electromechanical Instron testing machines, strain/displacement monitoring systems, environmental chambers, microcomputers for data acquisition and processing, composites fabrication facility, interferometric displacement gauge, X-radiography, and acoustic emission systems.

Drexel Plasma Institute
The Drexel Plasma Institute (DPI) was formed in 2002 to stimulate and coordinate research projects related to plasma and other modern high energy engineering techniques. Today the DPI is an active multidisciplinary organization involving 23 faculty members from 6 engineering departments working in close collaboration with School of Biomedical Engineering, College of Arts and Sciences and College of Nursing and Health Professions.

Heat Transfer Laboratory
The heat transfer laboratory is outfitted with an array of instrumentation and equipment for conducting single- and multiphase heat transfer experiments in controlled environments. Facilities include computer-controlled data acquisition (LabVIEW and MacAdios) systems, a Newport holographic interferometric system with associated lasers and optics, image enlargers, power amplifiers, precision voltmeters, slip-ring assemblies, and an IBM RISC/6000 workstation for large-scale computing and simulation. A draft-free room is available with independent temperature control for carrying out natural convection experiments. An experimental test-rig is available for studying heat transfer from rotating surfaces. A bubble column has been recently built to study multiphase flow and heat transfer problems. Facilities are also available for measuring thermal conductivities of thin films using a thermal comparator.

Industrial Robot Performance Laboratory
Emphasis in this laboratory is placed on determining the relationship between robot design parameters and performance criteria.

Microcomputer Controls Laboratory
This laboratory provides an environment conducive to appreciating aspects of systems and control through hands-on experiments. They range from data acquisition and processing to modeling of dynamical systems and implementing a variety of controllers to control systems, such as DC motors and the inverted pendulum. Active research is being conducted on control reconfiguration in the event of actuator failures in aircrafts.

Non-Newtonian Fluid and Heat Transfer Laboratory
Emphasis in this laboratory is placed on the study of hydrodynamic and thermal performance of various non-Newtonian viscoelastic fluids in complex flow geometries. Facilities and equipment include a 20-foot-long recirculating flow loop with a 500-gallon reservoir tank and a thermal conductivity measurement cell. A complete data acquisition system provides fully automated experimental operation and data reduction. State-of-the-art finite element codes provide three-dimensional flow and heat transfer simulations of flows in complex geometrics, with a complete post-processing graphic capability backed by template.

Polymer Processing Laboratory
This laboratory is devoted to understanding the basic controlling parameters in polymer processing and the procedures for communicating between the automated processing machine and the rest of the

manufacturing facilities, such as the material handling system and the intelligent monitoring system. Facilities include a BOY 55-ton injection molding machine with necessary equipment for processing fiber-reinforced polymers, an IBM microcomputer for data acquisition and control, a Macintosh II microcomputer with software for mold design and process simulation, a Brookfield digital viscometer, and a Tinius Olsen tensile strength tester for material property evaluation.

Precision Instrumentation and Metrology Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=7)
This laboratory is focused on activities related to precision measurement, computer-aided inspection, and precision instrument design. Facilities include 3D Coordinate Measuring Machine (Brown & Sharpe) with Micro Measurement and Reverse engineering software, Surface Profilometer, and Laser Displacement Measuring System.

Program for Robotics, Intelligent Sensing, and Mechatronics (PRISM) Laboratory (http://prism.mem.drexel.edu)
The PRISM Laboratory is a state-of-the-art laboratory for pursuing research in the areas of medical robotics, haptic (sense of touch) and vision feedback through a user interface for augmenting a surgeon's capability in performing surgery, and visual servoing.The laboratory is equipped with a robotic arm, haptic interface devices, head-mounted display for immersion in the surgical environment, and dedicated hardware and software for the above research areas.

Rheology Laboratory
Emphasis in this laboratory is placed on developing tools for rheological property measurement of various non-Newtonian fluids, including friction-reducing viscoelastic fluids, molten polymers, coal-water slurries, ceramic slurries, and bonding cements for biomedical applications. A capillary tube viscometer, falling ball and needle viscometers, and Brookfield rotating viscometer are available. In particular, the capillary tube viscometer is designed to allow fully automated operation, thus avoiding time-consuming data collection procedures. A high-temperature and high-pressure capillary tube viscometer is under development, so that viscosities of advanced polymer materials can be measured at relatively high temperatures and shear rates.

Stress Wave and Ballistics Laboratory
Emphasis in this laboratory is placed on studying the effects of stress waves in structures. Equipment and facilities include a pendulum impact system, small air gun, high-air-pressure mass accelerator, drop impact system, exploding wire, explosion chamber, and instrumented charpy impact system.

Rapid Product Development Center (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=4)
This center provides fundamental research, educational instruction, and engineering services in product design and manufacturing, solid freeform fabrication, and computer-aided tissue engineering.The center is equipped with state-of-the-art CAD/CAE/CAM, medical imaging processing, and 3D reconstruction software, and a rapid prototyping system.

Minor in Nuclear Engineering

The minor assumes that students will have a background in mathematics and physics equivalent to that covered in the first two years of the engineering curriculum. Specifically, students are required to complete the following pre-requisites: PHYS 101 Fundamentals of Physics I; PHYS 102 Fundamentals of Physics II

ENGR 210 Introduction to Thermodynamics and ENGR 220 Fundamentals of Materials. Courses taken to meet these pre-requisite requirements will not count toward the minor.

Required Courses

ECEP 401	Radiation Detection & Control	3.0
ECEP 402	Theory of Nuclear Reactors	4.0
ECEP 404/ MEM 371	Introduction to Nuclear Engineering	2.0
ECEP 406	Introduction to Radiation Health Principles	3.0
MATE 450	The Nuclear Fuel Cycle & Materials	3.0
PHYS 330	Introduction to Nuclear Physics	2.0
Select 9.0 credits from at least two of the following principal areas		9.0
Industrial Applications Electives		
ECEP 403	Nuclear Power Plant Design & Operation	
MEM 402	Power Plant Design	
MEM 448	Applications of Thermal Plasmas	
MEM 449	Applications of Non-Thermal Plasmas	
Power Engineering Electives		
ECEP 352	Electric Motor Control Principles	
ECEP 354	Energy Management Principles	
ECEP 411	Power Systems I	
ECEP 412	Power Systems II	
Nuclear & Thermal Engineering & Science Electives		
MEM 446	Fundamentals of Plasmas I	
MEM 447	Fundamentals of Plasmas II	
Materials Electives		
MATE 221	Introduction to Mechanical Behavior of Materials	
MATE 341	Defects in Solids	
MATE 355	Structure and Characterization of Crystalline Materials	
MATE 370	Mechanical Behavior of Solids	
Transport Phenomena Electives		
CHE 302	Process Fluid Mechanics	
CHE 303	Process Heat Transfer	
CHE 310	Transport Phenomena	
CHE 311	Fluid Flow and Transport	
CIVE 320	Introduction to Fluid Flow	
MEM 220	Basic Fluid Mechanics	
MEM 345	Heat Transfer	
Simulation Electives		
PHYS 105	Computational Physics I	
PHYS 305	Computational Physics II	
PHYS 405	Advanced Computational Physics	
Total Credits		26.0

The Nuclear Engineering minor is open to all engineering majors. The minor consists of a minimum of six required courses for 17.0 credits and an additional 9.0 credits of elective courses.

Additional Information

Additional information about the minor is available on the ECE Department website (http://www.ece.drexel.edu/Undergraduate_Programs2.html).

Timothy P. Kurzweg, PhD
Associate Professor
Associate Department Head for Undergraduate Studies
Department of Electrical and Computer Engineering
Bossone Research Center, Suite 313
3120-40 Market Street
advising@ece.drexel.edu

Amy Ruymann, MS
Associate Director – Undergraduate Advising
Department of Electrical and Computer Engineering
Bossone Research Center Suite 313
advising@ece.drexel.edu
To make an appointment, please call 215.895.2241
Drop-in hours: Mon - Fri 1:30 - 2:30

Software Engineering

About the Program

Bachelor of Science in Software Engineering (BSSE): 188.0 quarter credits
The major in software engineering degree is a multidisciplinary degree sponsored by the College of Engineering and The iSchool at Drexel. The program, drawing on the strengths of existing Drexel programs in computer science and information systems, provides a curriculum that encompasses behavioral, managerial and technical aspects of software engineering and attempts to synthesize disciplinary paradigms and themes.

Advances in information technology have captured the public imagination and had tremendous economic and social impact over the last 50 years. These advances offer great benefit, but have also created a great need for highly dependable systems developed at predictable cost. Unfortunately, it has become increasingly clear that our ability to produce the software for these systems in a way that meets cost and quality requirements is quite limited.

For example:

- Studies conclude that cost and schedule overruns on commercial software projects commonly average at least 100%. Some studies report averages as high as 300 - 400%.

- Studies of large projects indicate that about 25% of them are abandoned and never completed.

- There is a growing list of incidents in which software failures have caused injury and death.

Software engineering is an attempt to solve this problem. The notion can be traced to a conference sponsored by NATO in 1967. The conference was organized to discuss the problems in creating software systems reliably. In the years since, there has been some progress, but the problems that motivated the original conference are still very much in evidence. There is good reason to believe that the creation of software will never be easy. But there is tremendous incentive to make the process as efficient and reliable as possible.

In summary, software engineering can be defined as the application of processes, methods, and tools to the problem of building and maintaining computer software with a defined level of quality, at a predictable cost, on a predictable schedule.

Program Educational Objectives

- Graduates of the program obtain employment as software developers, where their software and communication skills eventually propel them toward technical and administrative leadership positions in industry and government.

- Graduates of the program demonstrate an ability to continue to learn throughout their career and to keep pace with changing technology as appropriate to their positions.

- Graduates of the program specialize and enhance their software engineering knowledge by enrolling and completing technical graduate courses and other technical education to position them to advance software engineering practice as senior technical staff members or managers.

- Graduates of the program specialize and enhance their software engineering knowledge by enrolling and graduating from MSc and PhD degree programs to position them to contribute to the intellectual foundations of the discipline of software engineering as researchers in industrial and government laboratories as well as in academia.

- Graduates of the program advance toward becoming leaders in disciplines other than software engineering by enrolling and graduating from graduate-level degree programs in complimentary disciplines such as law and business, where the BS in Software Engineering program serves as an educational foundation.

- Graduates of the program will demonstrate an awareness of their professional and social responsibility a software engineers by participation in professional activities and application of their knowledge for the good of society.

Student Outcomes

The department's student outcomes reflect the skills and abilities that the curriculum is designed to provide to students by the time they graduate. These are:

- for students to be able to apply an engineering approach to the development of software systems by learning how to specify, design, implement, verify, and maintain software systems in a variety of problem domains;

- for students to be able to attain the necessary organizational and business skills to work in teams effectively and to be able to predict the time and cost needed to create and to maintain software systems;

- for students to attain the necessary communication skills to elicit the requirements of a software systems and to create well-written software documentation;

- for students to attain the necessary mathematics and programming skills to solve complex problems by creating and subsequently testing software systems;

- for students to gain an appreciation of the important role that software plays in modern societies and to prepare to make positive contributions to enhance that role.

Additional Information

The Software Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Degree Requirements

University and College Requirements

COOP 101	Career Management and Professional Development	0.0
UNIV E101	The Drexel Experience	2.0

Software Engineering Requirements

SE 101	Foundations of Software Engineering I	3.0
SE 102	Foundations of Software Engineering II	3.0
SE 103	Foundations of Software Engineering III	3.0
SE 210	Software Specification and Design I	3.0
SE 211	Software Specification and Design II	3.0
SE 310	Software Architecture I	3.0
SE 311	Software Architecture II	3.0
SE 320	Software Verification and Validation	3.0
SE 410	Software Evolution	3.0
SE 491 [WI]	Design Project I	3.0
SE 492 [WI]	Design Project II	3.0
SE 493 [WI]	Design Project III	3.0

Computer Science Requirements

CS 260	Data Structures	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
CS 281	Systems Architecture	4.0
CS 283	Systems Programming	3.0

Networking Elective

CS 472	Computer Networks: Theory, Applications and Programming	3.0-4.0
or INFO 330	Computer Networking Technology I	

Information Systems Requirements

INFO 210	Database Management Systems	3.0
INFO 310	Human-Computer Interaction II	3.0
INFO 420 [WI]	Software Project Management	3.0

Computing Electives

Any non-required INFO, CS or SE course at the 300+ level	18.0

Mathematics/Statistics Requirements

CS 270	Mathematical Foundations of Computer Science	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 123	Calculus III	4.0
MATH 221	Discrete Mathematics	3.0
STAT 201	Introduction to Business Statistics	4.0
STAT 202	Business Statistics II	4.0

Science Sequence Requirements — 21.0

Select one of the following sequences:

Chemistry

CHEM 101	General Chemistry I
CHEM 102	General Chemistry II
CHEM 103	General Chemistry III

Physics

PHYS 101	Fundamentals of Physics I
PHYS 102	Fundamentals of Physics II
PHYS 201	Fundamentals of Physics III

Biology

BIO 122	Cells and Genetics
BIO 124	Evolution & Organismal Diversity
BIO 126	Physiology and Ecology

Science Electives

Students select 7.5 - 9.0 additional credits from any natural science courses

Liberal Studies Requirements

ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
PHIL 105	Critical Reasoning	3.0
PHIL 311	Computer Ethics	3.0
COM 230	Techniques of Speaking	3.0
COM 310 [WI]	Technical Communication	3.0
PSY 101	General Psychology I	3.0
PSY 330	Cognitive Psychology	3.0
Liberal Studies Electives [*]		6.0
Select two of the following:		8.0
ACCT 115	Financial Accounting Foundations	
ECON 201	Principles of Microeconomics	
ECON 202	Principles of Macroeconomics	

Free Electives

Free Electives	16.0-19.0
Total Credits	188.0

[*] Any non-required course in ENGL, PHIL, COM, PSY, SOC, ANTH, WMST, AFAM, PSCI.

Sample Plan of Study

5 YR UG Co-op Concentration

Term 1		Credits
COOP 101	Career Management and Professional Development	0.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
MATH 121	Calculus I	4.0
SE 101	Foundations of Software Engineering I	3.0
UNIV E101	The Drexel Experience	1.0
First course in a 3-part laboratory science sequence		4.0-4.5
	Term Credits	**15.0-15.5**
Term 2		
ENGL 102	Composition and Rhetoric II: The Craft of Persuasion	3.0
MATH 122	Calculus II	4.0

SE 102	Foundations of Software Engineering II	3.0
UNIV E101	The Drexel Experience	0.5
Second course in a 3-part laboratory science sequence		4.0-4.5
	Term Credits	**14.5-15.0**
Term 3		
ENGL 103	Composition and Rhetoric III: Thematic Analysis Across Genres	3.0
MATH 123	Calculus III	4.0
SE 103	Foundations of Software Engineering III	3.0
UNIV E101	The Drexel Experience	0.5
Third course in a 3-part laboratory science sequence		4.0-4.5
Liberal studies elective		3.0
	Term Credits	**17.5-18.0**
Term 4		
COM 230	Techniques of Speaking	3.0
SE 210	Software Specification and Design I	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
CS 270	Mathematical Foundations of Computer Science	3.0
Natural science elective		3.0
	Term Credits	**15.0**
Term 5		
CS 260	Data Structures	3.0
INFO 210	Database Management Systems	3.0
MATH 221	Discrete Mathematics	3.0
SE 211	Software Specification and Design II	3.0
Natural science elective		3.0
	Term Credits	**15.0**
Term 6		
COM 310 [WI]	Technical Communication	3.0
CS 281	Systems Architecture	4.0
PSY 101	General Psychology I	3.0
SE 310	Software Architecture I	3.0
STAT 201	Introduction to Business Statistics	4.0
	Term Credits	**17.0**
Term 7		
CS 283	Systems Programming	3.0
SE 311	Software Architecture II	3.0
STAT 202	Business Statistics II	4.0
Natural science elective		3.0
Free elective		3.0
	Term Credits	**16.0**
Term 8		
INFO 420 [WI]	Software Project Management	3.0
PHIL 105	Critical Reasoning	3.0
SE 320	Software Verification and Validation	3.0
Computing elective (300-level or higher INFO, SE, CS)		3.0
Free elective		3.0
	Term Credits	**15.0**
Term 9		
INFO 310	Human-Computer Interaction II	3.0
PHIL 311	Computer Ethics	3.0

SE 410	Software Evolution	3.0
Free elective		3.0
Computing electives (300-level or higher INFO, SE, CS)		3.0
	Term Credits	**15.0**
Term 10		
SE 491 [WI]	Design Project I	3.0
INFO 330 or CS 472	Computer Networking Technology I Computer Networks: Theory, Applications and Programming	4.0
Select one of the following:		4.0
ECON 201	Principles of Microeconomics	
ECON 202	Principles of Macroeconomics	
ACCT 115	Financial Accounting Foundations	
Computing elective (300-level or higher INFO, SE, CS)		3.0
Free elective		3.0
	Term Credits	**17.0**
Term 11		
PSY 330	Cognitive Psychology	3.0
SE 492 [WI]	Design Project II	3.0
Select one of the following:		4.0
ACCT 115	Financial Accounting Foundations	
ECON 202	Principles of Macroeconomics	
ECON 201	Principles of Microeconomics	
Computing electives (300-level or higher INFO, SE, CS)		6.0
	Term Credits	**16.0**
Term 12		
SE 493 [WI]	Design Project III	3.0
Liberal studies elective		3.0
Computing elective (300-level or higher INFO, SE, CS)		3.0
Free electives		6.0
	Term Credits	**15.0**

Total Credit: 188.0-189.5

Co-op/Career Opportunities

The demand for software engineering professionals is quite strong. Graduates can expect career opportunities in software design and development in a variety of application areas. Software engineering graduates are particularly well suited to work as members or leaders of software project teams. They have knowledge and skills to help them develop quality software within schedule and cost constraints.

According to the Bureau of Labor Statistics, computer systems software engineers among the 30 fastest growing US careers requiring at least a bachelor's degree, with an estimated 120,000 new jobs by 2018. Although they have jobs in most industries, many computer software engineers work in computer systems design and related services. Employers range from start-ups to well-known industry leaders. A growing number of these workers get jobs on a temporary basis, or work as consultants.

That computer systems software engineers are among the projected fasted growing occupations means good opportunities for college graduates, especially those with co-op experience. According to the Bureau of Labor Statistics, employers are seeking software engineers with strong backgrounds in programming and systems analysis, along with business and people skills.

Most software engineering students enter the professional world right after graduation, but some continue their studies in advanced software engineering programs.

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc) page for more detailed information on co-op and post-graduate opportunities.

Dual/Accelerated Degree

Accelerated degree programs combine the practical work experience of a Drexel undergraduate education with the credentials of a graduate degree. Some programs offer the co-operative education option. Students may earn both degrees in the same major or, in some programs, complete a master's degree in a different field. Each dual degree program has specific requirements and students should work closely with advisors to map out a clear plan of study.

According to University regulations, students can only apply to participate in accelerated/dual degree programs after the completion of 90 credits and before the completion of 120.0 credits.

Requirements for the Bachelor's/Master's Dual Degree in Software Engineering

Applicants to the program must have an overall cumulative Grade Point Average of 3.25 or higher. Letters of recommendation from faculty members from either the Department of Computer Science or the College of Information Science and Technology are required. Students must submit a plan of study. Consult the Graduate Advisor and course schedules for guidance.

Acceptance to the program will be based on a combination of the student's GPA and letters of recommendation. Acceptance may be denied if the plan of study is not feasible. For more information, contact the Department of Computer Science (http://www.cs.drexel.edu) or the College of Information Science and Technology (http://www.ischool.drexel.edu).

Applicants must have completed the following core Software Engineering courses with a minimum GPA of 3.25:

SE 101	Foundations of Software Engineering I	3.0
SE 102	Foundations of Software Engineering II	3.0
SE 103	Foundations of Software Engineering III	3.0
SE 210	Software Specification and Design I	3.0
SE 211	Software Specification and Design II	3.0
SE 310	Software Architecture I	3.0

Minor in Software Engineering

The software engineering minor is available to all University students in good standing, with the exception of software engineering majors. A total of 24.0 credits is needed to complete the academic minor in software engineering.

Prerequisites

Computer programming competence may be established by completing one of the following course sequences:

- CS 171-2 (Computer Programming I & II)
- CS 175 (Computer Programming I-II)
- CS 140/143/171/172 (Intro Multimedia Programming/Computer Programming Fundamentals/Computer Programming I & II)
- SE 101-2-3 (Fundamentals of Software Engineering I-II-III)
- ECE 203-ECEC 301 (Programming for Engineers, Advanced Programming for Engineers)
- INFO 151-2-3-4 (IS Software I-II-III-IV)

Additional computer programming competence must be established by completing both CS 265 Advanced Programming Tools and Techniques and CS 260 Data Structures.

Minor Requirements

SE 210	Software Specification and Design I	3.0
SE 211	Software Specification and Design II	3.0
SE 310	Software Architecture I	3.0
SE 311	Software Architecture II	3.0
SE 320	Software Verification and Validation	3.0
SE 410	Software Evolution	3.0
Two Computing/Software Engineering Electives		6.0
Total Credits		24.0

College of Engineering: Graduate Studies

The College of Engineering has played a vital role in the success of Drexel University for more than a century. Over the past decade, the College has experienced enormous growth in research activities, as well as construction of major facilities.

About the College

Drexel University's College of Engineering has emphasized its strengths in engineering, science and technology to train students to become the leaders of the future. In little over a century, Drexel University has transformed itself into a large, comprehensive institution committed to excellence in education, research and service to the engineering society and to the broader community. Although much has changed, the original mission of the University still rings true today.

As Drexel moves into the 21st century, the College of Engineering will continue to offer students a diverse academic learning and research environment, while continuing to build on its national reputation for excellence in engineering and research.

The graduate programs at Drexel College of Engineering integrate evolving engineering science with the growing fields of engineering applications and processes. The Software Engineering and Engineering Management programs are offered in concert with other Drexel University colleges.

Majors

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- Civil Engineering (MS,PhD) (p. 64)
- Computer Engineering (MS) (p. 65)
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- Electrical Engineering (MS,PhD) (p. 72)
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- Environmental Engineering (MS,PhD) (p. 78)
- Materials Science and Engineering (MS,PhD) (p. 79)
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Certificates

- Engineering Management (p. 76)
- Infrastructure Engineering Management (p. 89)
- Power Engineering Management (p. 90)

*   Multidisciplinary program, offered in concert with other Drexel University Colleges.

About Graduate Co-op

Drexel University's long tradition in the field of experiential learning has now been extended into many of its master's programs in science, business, and engineering.

This option, called the Graduate Co-op Program (http://www.drexel.edu/scdc/gcp.asp) (GCP), provides students with the opportunity to gain work experience directly related to their career goals while earning academic credit. Students who have earned a minimum of 24 credits with a GPA of at least 3.0 are eligible to participate. Employment typically lasts six months, during which students enroll in a special 3 credit GCP course coinciding with their term of employment. Students gain work experience while earning salaries. It is important to note that the GCP program does not guarantee a job. It is a market-driven process for the candidates as well as employers. GCP provides the tools and contacts; the student must qualify for the job on the basis of merit, qualifications, and skills.

Further information on the GCP program is available at the Drexel Steinbright Career Development Center. (http://www.drexel.edu/scdc)

Chemical Engineering

Master of Science in Chemical Engineering (MSCHE): 45.0 quarter credits
Doctor of Philosophy*: 90.0 quarter credits*

About the Program

The graduate program in the Chemical and Biological Engineering Department integrates current chemical engineering science with the growing fields of engineering applications and processes, emphasizing engineering design and scientific analysis. The department intends to develop broadly educated individuals who are knowledgeable in modern theories, cognizant of the behavior of engineering systems, and aware of current mathematical and engineering tools that are useful for the solution of problems in complex processes and systems, especially those in the fields of chemical, environmental, biochemical, and materials process engineering. Areas of particular strength include biological engineering, energy and the environment, multiscale modeling and process systems engineering, and polymer science and engineering.

Programs are arranged to meet the needs and interests of individual students. The plan of study is initially formulated in consultation with the departmental graduate advisor and subsequently guided by the thesis advisor.

Graduates have pursued a variety of careers, ranging from faculty positions in academia to research and development in industry, in the U.S. and overseas.

Additional Information

For more information about this program, visit Drexel University's Department of Chemical and Biological Engineering (http://www.chemeng.drexel.edu) web page.

Admission Requirements

Students should fulfill Drexel University's general requirements for admission to graduate studies. The subjects normally included in an undergraduate program in chemical engineering provide a satisfactory background. Decisions regarding prerequisite qualifications for students who may be deficient in some areas are made after consultation with the departmental graduate advisor.

The core courses are designed for students with undergraduate training in chemical engineering. However, students with a background in biological sciences and engineering can also enroll in the core courses after completing the necessary basic engineering courses and disciplinary chemical engineering courses. Programs for such students are determined on an individual basis after consultation with the departmental graduate advisor.

Graduate study in chemical engineering is offered on a regular full-time basis and on a part-time basis. Details not covered in the following information may be obtained by contacting the departmental graduate advisor. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

Financial Assistance

Financial aid in the form of teaching assistantships, research assistantships, and fellowship grants is available to qualified full-time PhD students. Awards are made annually on a competitive basis.

For additional information on how to apply, visit Drexel's Admissions page for Chemical Engineering (http://www.drexel.edu/grad/programs/coe/apply/requirements/p_che).

Master of Science in Chemical Engineering

Degree Requirements

In general, each program leading to the Master of Science in Chemical Engineering must meet the following requirements: core chemical engineering, 15 credits; area of concentration, at least 15 credits; electives, at most 6 credits; research, at most 15 credits. Core courses in the chemical engineering Master's program are listed below. A Master's Thesis is optional.

Thesis option: The thesis may be based on either a theoretical or an experimental investigation, or both, of limited scope but involving a significant degree of originality. The nature of the research may involve multidisciplinary areas such as biological engineering, materials processing and engineering, energy and the environment, and other topics. The scope and content of the thesis is guided by the thesis advisor. All students pursuing a Master's with Thesis must complete 9 credits of thesis research (CHE 898) and, at the discretion of the research advisor, up to 6 credits of independent study (CHE 799). Credits not devoted to independent study may be applied to general (non-concentration) graduate-level electives or to additional credits of thesis research.

Coursework-only (non-Thesis) option: Students not pursuing Master's with Thesis may take up to 9.0 credits of independent study (CHE 799) and 6.0 credits of general graduate-level electives. Independent study is **not** required for a non-thesis Master's. Non-thesis students may also take additional concentration electives beyond the required 15.0-credit series. Non-thesis students may **not** register for thesis research.

Concentration: All Master's students must complete a 15-credit series of concentration electives. Concentration electives may be chosen from course offerings in chemical engineering, mathematics, science, and other engineering disciplines, and are subject to approval by the departmental graduate advisor. Sample concentration series courses are listed below; there are many other possibilities. Non-concentration electives need only be graduate-level.

Full-time students usually take the core courses in the first year. Other courses may be substituted for the core courses, if equivalent courses are available and if the substitution is approved by the graduate advisor. Full-time students normally require a minimum of one calendar year to complete their study and research. Some courses are offered in the late afternoon or evening for the convenience of part-time students. The current schedule of evening courses for part-time students are available upon request.

Curriculum

CHE 502	Mathematical Methods in Chemical Engineering	3.0
CHE 513	Chemical Engineering Thermodynamics	3.0
CHE 525	Transport Phenomena I	3.0
CHE 543	Kinetics & Catalysis I	3.0
CHE 554	Process Systems Engineering	3.0
Area of Concentration		15.0
Thesis/Research		9.0
Electives		6.0

Sample Areas of Concentration

Biochemical Engineering

Sample Courses

BIO 500	Biochemistry I
BIO 610	Biochemistry of Metabolism
BMES 501	Medical Sciences I
CHE 562	Bioreactor Engineering
CHE 564	Unit Operations in Bioprocess Systems

Computer Science

Sample Courses

CS 543	Operating Systems
CS 551	Compiler Construction I
CS 552	Compiler Construction II
CS 550	Programming Languages

Engineering Management

Sample Courses

EGMT 501	Engineering Management I
EGMT 502	Engineering Management II
EGMT 504	Communications
EGMT 531	Economics for Engineering Management
EGMT 581	Problems in Human Relations

Environmental Engineering

Sample Courses

ENVS 501	Chemistry of the Environment
ENVS 608	Fate of Pollutants in Air and Water
ENVE 661	Env Engr Op-Chem & Phys
ENVE 662	Enviro Engr Unit Oper-Bio
ENVE 865	Spec Topics Envr Engineering

Materials Science and Engineering

Sample Courses

MATE 500	Structure and Properties of Metals

MATE 501	Structure and Properties of Polymers	
MATE 502	Structure and Properties of Ceramic and Electronic Materials	
MATE 505	Phase Equilibria	
MATE 507	Kinetics	
Total Credits		45.0

PhD in Chemical Engineering

Superior students with MS or BS degrees will be considered for the doctoral program in chemical engineering. Students joining with a Master's degree may satisfy up to 45 credit hours of the PhD course/research credit requirements depending on the courses taken and/or research carried out in their Master's programs, subject to approval by graduate program advisor.

Requirements

The following general requirements must be satisfied in order to complete the PhD in chemical engineering:

- 90 credit hours total
- Qualifying exam (first year)
- Establishing a plan of study (first term)
- 18 core credits
- 15 credit hours of specialized plan of study
- 57 credit hours of research
- Candidacy exam (5th term)
- Dissertation/Thesis
- Defense of Dissertation/Thesis
- GPA requirements: 3.0 overall; 3.0 in graduate Chemical Engineering (CHE) courses; 3.0 core graduate courses

Qualifying Exam

The qualifying exam takes place in the first year. The department administers the exam twice a year – in January and June. The objective of the exam is to evaluate proficiency in core undergraduate chemical engineering material. The format is made up of seven problems, each covering a separate core topic from the undergraduate curriculum, including thermodynamics, heat transfer, mass transfer, fluid mechanics, kinetics, control, and separations. Students must display mastery of five out of the seven topics to pass the qualifying exam. Each student will be given two opportunities to pass the qualifying exam.

Thesis Advisor/Plan of Study

All students must meet with their advisor in their first term to work out a plan of study.

Core Requirements

CHE 502	Mathematical Methods in Chemical Engineering	3.0
CHE 513	Chemical Engineering Thermodynamics	3.0
CHE 525	Transport Phenomena I	3.0
CHE 543	Kinetics & Catalysis I	3.0
CHE 614	Chemical Engineering Thermodynamics II	3.0
CHE 626	Transport Phenomena II	3.0
Specialized Plan of Study Courses		**15.0**

15.0 credit hours of courses approved by research advisor. All students are expected to develop competence in their area(s) of specialization.

| **Research** | | **57.0** |

57.0 credit hours of research (CHE 998), which may include up to 6.0 credit hours of electives.

| CHE 998 | Ph.D. Dissertation | |
| Total Credits | | 90.0 |

Candidacy Exam

The components of the candidacy exam are as follows::

- Proposal Document (Written): The student is required to write a research proposal of about 15 pages, including background, preliminary results, and a research plan (with his/her advisor's input). The proposal must be submitted to each member of the student's thesis committee and to the Graduate Program Advisor **before 5:00 pm on the first day of the student's 5th term.**
- Proposal Defense (Oral): The student provides a formal defense of his/her proposal to his/her thesis committee **before the end of the student's 5th term.**

Thesis/Dissertation and Defense

As the culmination of intensive study and independent research, the doctoral dissertation represents a major scholarly endeavor; accordingly, it is recognized as the most important requirement of the degree. All doctoral candidates must present an acceptable dissertation based on significant work. The dissertation must represent a unique contribution to chemical engineering or biochemical engineering knowledge. A final oral examination is conducted, in part, as a defense of the dissertation.

A preliminary exam is targeted for the student's 12th term, with this scheduling subject to the research advisor's discretion. This preliminary exam is to ensure that the student has made adequate progress in his/her project and that s/he has gained skills to write an independent research proposal.

The requirements of the thesis/dissertation and defense include:

- Proposal Document, a.k.a. "Second Proposal": The student is required to write a research proposal of about 15 pages, including background, summary of results to date, and a plan for completion of the thesis work (with minimal advisor input). The proposal must be submitted to each member of the student's thesis committee well in advance of the oral exam date.
- Preliminary Defense (Oral Examination): The student must defend the second proposal and the thesis work to-date in an oral examination by his/her thesis committee.
- Manuscript Submission: Before taking the preliminary exam, the student is required to submit at least one paper based on his/her PhD research to a refereed journal. This must be an original article, not a review.
- A copy of the written proposal, together with a copy of the submitted paper with acknowledgment of submission from the journal editor, must be submitted to the Graduate Program Advisor before the Preliminary Defense and at least 6 months before the Thesis Defense.
- The student is responsible for scheduling the Preliminary Defense

- Students should submit a copy of the Preliminary Exam Reporting Form (http://www.chemeng.drexel.edu/graduate/phd/Preliminary%20Ex%20Form.doc) no later than three days after the exam.

For more information, visit the Chemical and Biological Engineering Department (http://www.drexel.edu/academics/engineering/departments/che_dept/home.html) web page.

Facilities

Abrams Laboratory (ABRAMS)
Cat-472 (Server room) and Cat-361 (Student offices)

- High-performance computer clusters
  - lamneth -- 90-core DDR Infiniband
  - narpet -- 40-core DDR Infiniband
- Workstation computers (panacea, maelstrom, cygnus, redstar, syrinx, presto)
- 24TB RAID server (nlgn)

Access to:

- The University Research Computing Facility (URCF)
- The Draco Cluster (Dept. Physics)
- TeraGrid/XSEDE Allocation (TACC Stampede)

Nanomaterials for Energy Applications and Technology Laboratory (BAXTER)
Cat-266

- Amplified Ti:Sapphire laser with time-resolved teraherterz spectroscopy and femtosecond UV/vis/NIR transient absorption spectroscopy (Bossone 106)
- Solar simulator with monochromator and photovoltaic/photoelectrochemical test station
- Electrochemical impedance spectroscopy
- Layer-by-layer deposition robot
- Dip coater
- Spin coater
- Electrodeposition station
- Continuous flow microreactors

Biofuels Laboratory (CAIRNCROSS)
Cat-265

- Bubble column biodiesel reactors
- Recirculating heated oil baths
- Quartz crystal microbalance / heat conduction calorimeter (Masscal G1)
- Maxtek quartz crystal microbalance with phase lock oscillator
- Parr reactor

Elabd Laboratory (ELABD)
Cat-262, 263, 264

- Electrochemical Impedance Spectrometer (EIS) (Solartron: 1260 impedance analyzer, 1287 electrochemical interface, Zplot software) with many custom made 4 and 2 electrode cells
- Fuel Cell Test Station (Scribner 850C with fuel cell software) equipped for gas and liquid fuels and PEM and AEM test cells
- FTIR spectrometer (Nicolet Nexus 6700) equipped with multiple multi-bounce ATR flow-through cell attachments (Specac)
- FTIR spectrometer (Nicolet Nexus 6700)
- Golden GateTM diamond single-bounce ATR attachment (Specac)
- Silver GateTM zinc selenide single-bounce ATR attachment (Specac)
- Silver GateTM germanium single-bounce ATR attachment retrofit for electrochemical measurements (Specac)
- Dynamic Vapor Sorption (DVS) (TA Instruments Q5000 SA)
- Dynamic Vapor Sorption (DVS) with Cahn balance (Surface Measurement Systems)
- Differential Scanning Calorimeter (DSC) (TA Instruments Q200) with cooling accessory with temperature range of -180 to 725°C
- Gel Permeation Chromatography (GPC) (Waters Breeze 2) with 1525 Binary HPLC Pump for two separate columns (columns for THF and DMF), 214 Refractive Index Detector
- Environmental Chamber (Tenney) with high temperature/humidity control ranging from 25-200°C and 5-95%RH and integrated with vapor permeation and EIS
- Electrospinning Apparatus with custom-built enclosed chamber, 2 syringe pumps, and high voltage power supply (Glassman High Voltage, Inc. Series EL)
- Multipycnometer (Quantachrome)
- Two Liquid Diffusion Cells (PermeGear) integrated to flow-through ATR cell for detection with temperature control
- Vapor Sorption Apparatus (custom-built) with pressure transducer, temperature-controlled chamber, and quartz springs for the measurement of vapor and vapor mixture diffusion and sorption in polymers. This equipment is also integrated to an FTIR-ATR spectrometer for the measurement of molecular transport of pure vapors and vapor mixtures in polymers
- Gas Permeation and Sorption Apparatus (custom-built) with pressure and sorption cells, pressure transducer, and temperature-controlled chamber for the measurement of gas permeation and sorption in polymers
- Mass Spectrometer (MS) (HP 5989B), Gas Chromatograph (GC) (HP 5890), Liquid Chromatograph (LC) (HP 1090)
- Gravimetric Balances (Precisa XR 125 SM-FR, 10 μg accuracy; Mettler Toledo AB 54-S, 100 μg accuracy; Mettler Toledo B2002-S, 10 mg accuracy)
- Sonicators (QSONICA Q125, Cole-Parmer 8890)
- Heat Press (Carver 3351-0)
- Charged-Coupled Device (CCD) camera (Cognex in-sight 5403 vision sensor with patmax)
- Tube Furnace (Barnstead/Thermolyne 21100)
- Convection Oven
- Three Vacuum Ovens
- Three Vacuum Pumps
- 2x Water Bath (Thermo Scientific Neslab RTE 10)

- Rotary Evaporator (Buchi Rotovapor®)
- Many stir/hot plates and other wet chemistry accessories

Nanofibers for Energy Storage and Conversion Laboratory (KALRA)

Cat-471

- Four Electrospinning Staions (with core-shell spinning capability)
- Tube Furnaces/Convection Ovens/Vacumm Ovens
- Mbraun Dual User Glove Box
- Carver Heat Press
- Gamry Ref 3000 Potentiostat
- 32-channel Maccor Battery Cycler

Access to:

- Drexel's Centralized Research Facilties (SEM, TEM, Ultramicrotome, FTIR, XPS, XRD, Multi-angle x-ray scattering)
- XSEDE Compute Hours Allocation
- Synchrotron at Brookhaven National Lab
- BET Surface are and Porosity Analyzer

Thin Film and Devices Laboratory (LAU)

CAT-382

- Chemical Vapor Deposition Thin Film Reactor System I
- Chemical Vapor Deposition Rotating Bed Reactor System
- Gamry Reference 600 Electrochemical Testing Station
- Solar Illuminator
- Nicolet 6700 FTIR Spectrometer
- Laurell Technologies Spin Coater

Bossone-521

- Chemical Vapor Deposition Thin Film Reactor System II

Access to:

- Centralized Research Facilities (SEM, TEM, XRD, SAXS, XPS, Raman, Profilometer)
- Thermogravimetric Analyzer
- Differential Scanning Calorimeter
- Dynamic Mechanical Analyzer
- UV-Vis Spectrophotometer

Biosensor and Bioanalytics Laboratory (MUTHARASAN)

Cat-466, 469

- Custom-built bio-analytical flow apparatus for conducting in situ surface chemistry and detection assays of pathogens, biomarkers, DNA and RNA
- Impedance Analyzers Agilent 4294A and Agilent HP4192A with bridge circuits for device characterization
- Electrochemical Impedance Spectrometer, Gamry Interface 1000 with three electrode cells, and interfaces to biosensor flow cell; Ag/AgCl and Pt electrodes
- Stanford Research System QCM200 and flow cells
- Signal Recovery 875 Lock-In amplifier (plus computer-interface)

- Function/Arbitrary Waveform Generator, 80 MHz Agilent 33250A
- Agilent precision Giga-ohmmeter
- Bausch & Lomb optical Microscopes interfaced with image acquisition system
- Olympus OM-10 Fluorescence Microscope, coupled to Canon digital imaging and video systems
- PTI SS Fluorescence Spectrometer with PMT 750 detector
- UV-VIS spectrometer – Shimadzu UV-1800
- Denton Desktop high vacuum sputtering system; 6-inch target, one or two cathode configuration, Base vacuum 10^{-6}
- Harrick RF Plasma Reactor (Model PDC-001, 200 W) modified for conducting plasma-assisted surface reactions
- UVP UV Radiation Oven, Model OG-1. Radiation at 185 and 254 nm
- 1550 nm DFB laser (Anritsu GB5A016) and 1310 nm DFB laser (QPhotonics), and associated power supplies
- High speed micro-centrifuge (200 – 15000 rpm)
- Vacuum ovens
- Incubators, 9 ft^3, 20-70°C
- Spectrum analyzer (ANDO AQ-6310B), LabView interface
- Ericsson FSU 975 fusion splicer
- Laminar Flow Hoods, Precision CO_2 Incubators, Spinners, bioreactors (0.1L to 1L)

Access to:

- Bruker Daltonics Autoflex III Smartbeam TOF-MALDI mass spectrometer
- 8 M#, Milli-Q system
- Autoclave
- Hot room 37°C, 100 ft^2
- Refrigerated room 4°C, 100 ft^2

Polymers and Composites Laboratory (PALMESE)

Bossone-521

- TA Instruments TGA Q50 Thermogravimetric Analyzer
- KSV Instruments CAM 200 Contact Angle and Surface Tension Meter
- TA Instruments DSC Q2000 Differential Scanning Calorimeter
- Instron 8872
- Thermo Nicolet Nexus 870 FTIR
- TA Instruments DMA Dynamic Mechanical Analysis
- Perkin Elmer DSC7 Differential Scanning Calorimeter
- Waters GPC/HPLC (RI, UV Detectors)
- Electrospinning station
- TA Instruments AR Rheometer
- Thinky planetary centrifugal mixer ARE-250
- Melt Press
- Portable Near Infrared Spectrometer
- Brookfield digital viscometer
- Glove Box
- Supercritical Dryer (2x)
- Dielectric Barrier Discharge (DBD) plasma reactor

Process Systems Engineering Laboratory (SOROUSH)

- Interacting liquid level tanks
- 2-liter RC1 Calorimeter

Wrenn Laboratory (WRENN)

Cat-470

- PTI, Inc. C-71 Time-Resolved Fluorescence Spectrometer (pulsed nitrogen and dye lasers)
- PTI, Inc. A-710 Steady State Fluorescence Spectrometer
- Brookhaven 90Plus Dynamic Light Scattering Apparatus
- Brookhaven Goniometer-based, Static Light Scattering Apparatus
- Perkin-Elmer BUV40XW0 UV-Visible Absorbance Spectrometer
- Zeiss Axioskop2 Fluorescence microscope
- Zeiss Ultraviolet Digital Image Analysis System (contains Orca Camera, Sony 17" monitor, and Axiovision II software)
- Beckman Coulter Allegra64 Centrifuge
- Misonix, Inc. XL2020 Sonicator
- Lipex Biomembranes, Inc. Lipid Extruder (10 mL)

Civil Engineering

Master of Science in Civil Engineering (MSCE): 45.0 quarter credits
Doctor of Philosophy*: 90.0 quarter credits*

About the Program

Objectives

The graduate program in civil engineering offers students the opportunity to develop a more fundamental and complete understanding of the principles that govern their field as well as current design methodology. Students are encouraged to be innovative and imaginative in their quest for recognizing, stating, analyzing, and solving engineering problems.

The goal of the master's program is to develop technical depth of expertise for a professional career in the planning, design, construction, and operation of large-scale infrastructure systems, built facilities, and water resources management. The goal of the PhD program is to develop the abilities to discover, pursue, and apply basic knowledge. PhD recipients are prepared to engage in teaching and research or in an industrial career in the development of new concepts and innovative systems.

General Information

The civil engineering programs comprise the following areas of specialization: building systems, geotechnical engineering, hydraulic and coastal engineering, structural engineering, and water resources.

For more information, visit the Department of Civil, Architectural and Environmental Engineering (http://www.cae.drexel.edu) web page.

Admission Requirements

MS admission is based on an academic record demonstrating adequate preparation and potential for successful graduate study. This typically includes a BS from an engineering curriculum accredited by the Accrediting Board for Engineering and Technology (ABET) or the equivalent from a non-U.S. institution. Submission of results from the Graduate Record Exam (GRE) is required. A grade point average (GPA) of 3.0 is usually required. Graduates who do not have a bachelor's degree in either Civil, Architectural or Environmental Engineering may be required to take preparatory undergraduate courses.

For additional information on how to apply, visit Drexel's Admissions page for Civil Engineering (http://www.drexel.edu/grad/programs/coe/civil-engineering).

Master of Science in Civil Engineering

The programs of study at the master's level continue the specialization developed at the senior level of the undergraduate program or newly developed interests. The Master of Science in Civil Engineering program may be elected by graduates of ABET-accredited undergraduate programs in civil engineering and related fields. Admission and prerequisites are determined on the basis of a student's undergraduate transcript.

Most MSCE graduates work as professional engineers in consulting firms, industry, or governmental agencies. A number of our graduates have started consulting and construction firms in the Philadelphia area and have been very successful. Other former students hold prominent positions in public utilities, local government agencies, and industry.

The full-time graduate academic program is closely associated with the research efforts of the faculty. Full-time master's degree candidates are encouraged to base their master's thesis on some aspect of faculty research. The one-to-one relationship between student and faculty member provides an invaluable learning experience. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

The master's degree requires a total of 45.0 credits, of which 24.0 credits must be in the major field of interest and 6.0 credits are to fulfill math requirements. The remaining credits are taken as electives in related areas. The choice of core and elective courses is made in consultation with the student's graduate advisor.

Areas of concentration include:

- Structural
- Geotechnical/geoenvironmental/geosynthetics
- Water resources
- Building systems/energy

Dual graduate degrees are possible. Among the more popular programs are combining the MS in Civil Engineering with an MS in Environmental Engineering, or Engineering Management. The required credits must meet all civil engineering program requirements and will be determined on the basis of the student's proposed program of study.

PhD in Civil Engineering

The PhD degree is awarded for original research on a significant civil engineering problem. Graduate students who have completed their MS degrees work closely with individual faculty members (see Faculty Research Interests below). PhD dissertation research is usually supported by a research grant from a government agency or an industrial contract.

The full-time graduate academic program is closely associated with the research efforts of the faculty. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursing full-time study.

Doctoral students normally take at least 45.0 credits, including research credits, beyond the master's degree requirements. Full-time residency for one continuous academic year is required for the PhD degree to ensure students the opportunity for intellectual association with other scholars. Many doctoral students take two, three, or four years of full-time graduate study to complete their degrees. Involvement in the teaching activity of the Civil, Architectural and Environmental Engineering Department is required of all PhD applicants.

After approximately one year of study beyond the master's degree, doctoral students take a candidacy examination, consisting of written and oral parts. Each PhD candidate is supervised by a major professor and a doctoral committee chaired by the major professor.

PhD candidates submit a detailed proposal for dissertation research to the doctoral committee. The students then take a proposal examination; successful completion of this examination is required to become a PhD candidate. After approval of the proposal, the committee meets from time to time to review the progress of the research. The dissertation must be submitted to the doctoral committee at least 90 days before the graduation date. The committee schedules and conducts a final oral examination before approval of the dissertation.

Areas of research include:

- Structural
- Geotechnical/geoenvironmental/geosynthetics
- Water resources
- Sustainable engineering
- Building systems/energy

Dual Degree Programs

Civil Engineering students may find it useful to pursue dual MS degrees. Such programs have been pursued in concert with Environmental Engineering/Science, Mechanical Engineering, Information Studies and Engineering Management. A dual degree student must complete the required coursework for each degree. Depending upon the concentration, up to 15.0 credits from another program may count as electives for the MSCE. with the advisor's approval. The student is responsible for obtaining approval of MSCE. courses that apply to the second degree.

Bachelor's/Master's Dual Degree Program

Exceptional undergraduate students can also pursue a master of science degree in the same period as the bachelor of science. Many students deepen their knowledge with a Master's degree in Civil Engineering, while others have broadened their knowledge with a Master's degree in related areas such as Environmental Science, Engineering Management, Software Engineering and Information Technology.

Facilities

Construction Materials Laboratory
This laboratory contains facilities for the study of concrete, asphalt, mortar, soil-cement, and timber materials, and moist cure facilities.

Geosynthetics Laboratory
This laboratory contains a complete suite of physical, mechanical, hydraulic, endurance, and environmental test devices for assessing behavior of geotextiles, geogrids, geonets, geomembranes, and geocomposites.

HVAC and Refrigeration Laboratory
This laboratory contains complete models of heating, ventilation, air conditioning, refrigeration, and pumping system models.

Hydromechanics Laboratory
This laboratory contains a wave channel tilting flume, pipe friction equipment, bench demonstration equipment, and a beach erosion model.

Soil Mechanics and Geoenvironmental Laboratory
This laboratory contains triaxial and direct shear equipment, controlled environmental chambers, consolidation tests, flexwall permeameters, and a test bed.

Structural Testing Laboratory
This laboratory contains universal testing machines with 150,000- and 300,000-pound capacity and test beds with MTS dynamic load equipment.

Computer Engineering

Master of Science in Computer Engineering (MSCPE): 45.0 - 48.0 quarter credits
PhD: 90.0 quarter credits

About the Program

The computer engineering curriculum is designed to: (1) address the needs of students with a variety of different backgrounds; (2) ensure that graduates will have adequate knowledge and skills in at least one area of specialization; (3) meet the immediate needs of working students as well as to adequately prepare full-time students for a real-world technological environment; and (4) equip students with tools to grasp and develop new technologies and trends.

The Master of Science in Computer Engineering degree requires a minimum of 45.0 approved credits chosen in accordance with a plan of study arranged in consultation with the student's advisor and the departmental graduate advisor. Up to but not exceeding 9 research/thesis credits may be taken by students who choose to write a Master's thesis. Students who elect a non-thesis option are also encouraged to engage in research, by registering for supervised research credits (not to exceed 9 credits).

For more information, visit the Department of Electrical and Computer Engineering (http://www.ece.drexel.edu) web site.

Admission Requirements

Applicants should preferably have an undergraduate degree equivalent to a U.S. bachelor's degree in computer engineering, computer science, or electrical engineering. Students holding degrees in other engineering and science disciplines with appropriate coursework or training will also be considered.

Appropriate coursework includes experience with all of the following: Software (advanced programming and operating systems); Computer Architecture (digital systems design, computer organization and architecture); Algorithms and Data Structures; Computer Networks.

Students must have a minimum 3.0 GPA (on a 4.0 scale) for the last two years of undergraduate studies, as well as for any subsequent graduate-level work.

The GRE General Test is required of applicants to full-time MS and PhD programs. Students whose native language is not English and who do not hold a degree from a US institution must take the Test of English as a Foreign Language (TOEFL).

For additional information on how to apply, visit Drexel's Admissions page for Computer Engineering (http://www.drexel.edu/grad/programs/coe/computer-engineering).

Master of Science in Computer Engineering

The Master of Science in Computer Engineering curriculum encompasses 45.0 or 48.0 (with the Graduate Co-op option) approved credit hours, chosen in accordance with the following requirements and a plan of study arranged with the departmental graduate advisor in consultation with the student's research advisor, if applicable. Before the end of the first quarter in the Department of Electrical and Computer Engineering, for a full-time student, or by the end of the first year for a part-time student, said plan of study must be filed and approved with the departmental graduate advisor.

A total of at least 30.0 credit hours must be taken from among the graduate course offerings of the Department of Electrical and Computer Engineering. These credits must be taken at Drexel University. No transfer credit may be used to fulfill these requirements, regardless of content equivalency.

The remaining courses needed to reach the minimum credit hour requirement for the degree program are considered elective courses. Elective courses can be chosen from among the graduate course offerings of the Department of Electrical and Computer Engineering; other departments within the College of Engineering; the School of Biomedical Science, Engineering and Health Systems; the Department of Mathematics; the Department of Physics; the Department of Chemistry and the Department of Biology. In order to have courses outside of these departments and schools count towards degree completion, they must be approved by the departmental graduate advisors prior to registration for said courses.

Please note that ECEC 500 (p. 72) (Fundamentals of Computer Hardware) and ECEC 600 (p. 72) (Fundamentals of Computer Networks) do **not** count toward the credit requirements to complete the MS in Electrical Engineering degree program.

Computer Engineering (ECEC) Courses	21.0
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses	9.0
Elective Courses	15.0
Total Credits	45.0

Options for Degree Fulfillment

Although not required, students are encouraged to complete a Master's Thesis as part of the MS studies. Those students who choose the thesis option may count up to 9.0 research/thesis credits as part of their required credit hour requirements.

Students may choose to participate in the Graduate Co-Op Program, where 6.0 credit hours can be earned for a six month co-operative education experience in industry, working on curriculum related projects. The total number of required credit hours is increased to 48.0 for those students who choose to pursue the Graduate Co-Op option. This change represents an increase in non-departmental required credit hours to a total of 18.0 credit hours, 6.0 of which are earned from the co-operative education experience.

For more information on curricular requirements, visit the Department of Electrical and Computer Engineering' (http://www.ece.drexel.edu)s web site.

PhD in Electrical Engineering

General Requirements

The following general requirements must be satisfied in order to complete the PhD in Electrical Engineering:

- 90.0 credit hours total
- candidacy examination
- research proposal
- dissertation defense

Students entering with a master's degree in electrical or computer engineering or a related field will be considered a post-masters PhD student and will only be required to complete a total of 45.0 credit hours, in accordance with University policy.

Curriculum

Appropriate coursework is chosen in consultation with the student's research advisor. A plan of study must be developed by the student to encompass the total number of required credit hours. Both the departmental graduate advisor and the student's research advisor must approve this plan.

Candidacy Examination

The candidacy examination explores the depth of understanding of the student in his/her specialty area. The student is expected to be familiar with, and be able to use, the contemporary tools and techniques of the field and to demonstrate familiarity with the principal results and key findings.

The student, in consultation with his/her research advisor, will declare a principal technical area for the examination. The examination includes the following three parts:

- A self-study of three papers from the archival literature in the student's stated technical area, chosen by the committee in consultation with the student.

- A written report (15 pages or less) on the papers, describing their objectives, key questions and hypotheses, methodology, main results and conclusions. Moreover, the student must show in an appendix independent work he/she has done on at least one of the papers – such as providing a full derivation of a result or showing meaningful examples, simulations or applications.

- An oral examination which takes the following format:

  - A short description of the student's principal area of interest (5 minutes, by student).

- A review of the self-study papers and report appendix (25-30 minutes, by students).
- Questions and answers on the report, the appendix and directly related background (40-100 minutes, student and committee).

In most cases, the work produced during the candidacy examination will be a principal reference for the student's PhD dissertation; however, this is not a requirement.

Research Proposal

Each student, after having attained the status of PhD Candidate, must present a research proposal to a committee of faculty and industry members, chosen with his/her research advisor, who are knowledgeable in the specific area of research. This proposal should outline the specific intended subject of study, i.e. , it should present a problem statement, pertinent background, methods of study to be employed, expected difficulties and uncertainties and the anticipated form, substance and significance of the results.

The purpose of this presentation is to verify suitability of the dissertation topic and the candidate's approach, and to obtain the advice and guidance of oversight of mature, experienced investigators. It is not to be construed as an examination, though approval by the committee is required before extensive work is undertaken. The thesis proposal presentation must be open to all; announcements regarding the proposal presentation must be made in advance.

The thesis advisory committee will have the sole responsibility of making any recommendations regarding the research proposal. It is strongly recommended that the proposal presentation be given as soon as possible after the successful completion of the candidacy examination. The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.

Dissertation Defense

Dissertation Defense procedures are described in the Office of Graduate Studies policies regarding Doctor of Philosophy Program Requirements (http://www.drexel.edu/provost/graduatestudies). The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.

Dual Degree

The ECE Department offers outstanding students the opportunity to receive two diplomas (BS and MS) at the same time. The program requires five (5) years to complete. Participants, who are chosen from the best undergraduates students, work with a faculty member on a research project and follow a study plan that includes selected graduate classes. This program prepares individuals for careers in research and development; many of its past graduates continued their studies toward a PhD.

For more information on eligibility, academic requirements, and tuition policy visit the Engineering Combined BS/MS (http://www.ece.drexel.edu/undergrad/bsms.html) page.

Facilities

Drexel University and the Electrical and Computer Engineering Department are nationally recognized for a strong history of developing innovative research. Research programs in the ECE Department prepare students for careers in research and development, and aim to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. The ECE Department is well equipped with state-of-the-art facilities in each of the following ECE Research laboratories:

Research Laboratories at the ECE Department

- Adaptive Signal Processing and Information Theory Research Group (http://www.ece.drexel.edu/aspitrg.html)
- Applied Communications and Information Networking Center (http://www.ece.drexel.edu/acinc.html)
- Applied Networking Research Laboratory (http://www.ece.drexel.edu/anrl.html)
- Biochemical Signal Processing Laboratory (http://www.ece.drexel.edu/bspl.html)
- Cleanroom Microfabrication Facility (http://www.ece.drexel.edu/cmf.html)
- Data Fusion Laboratory (http://www.ece.drexel.edu/dfl.html)
- Drexel Network Modeling Laboratory (http://www.ece.drexel.edu/dnml.html)
- Drexel Wireless Systems Laboratory (http://www.ece.drexel.edu/dwsl.html)
- Electric Power Engineering Center (http://www.ece.drexel.edu/epec.html)
- Electronic Design Automation (EDA) Facility (http://www.ece.drexel.edu/edaf.html)
- Microwave Photonics Center (http://www.ece.drexel.edu/mpc.html)
- Microwave-Photonics Device Laboratories (http://www.ece.drexel.edu/mpdl.html)
- Music and Entertainment Technology Laboratory (http://www.ece.drexel.edu/metl.html)
- NanoPhotonics Laboratory (http://www.ece.drexel.edu/npl.html)
- Opto-Electro-Mechanical Laboratory (http://www.ece.drexel.edu/oeml.html)
- Plasma and Magnetics Laboratory (http://www.ece.drexel.edu/pml.html)
- Power Electronics Research Laboratory (http://www.ece.drexel.edu/perl.html)
- Supervisory Control Laboratory (http://www.ece.drexel.edu/scl.html)
- Testbed for Power/Performance Management of Enterprise Computing Systems (http://www.ece.drexel.edu/tppm.html)

Computer Science

Master of Science in Computer Science (MSCS): 45.0 quarter credits
Doctor of Philosophy*: 90.0 quarter credits*

About the Program

The Department of Computer Science has graduate programs in artificial intelligence, algorithms, computer algebra, graphics, HCI, networks, security, scientific computing, and software engineering. The Department emphasizes both interdisciplinary and applied research and is supported by major federal research grants from the National Science Foundation, Department of Defense, Department of Energy, and the National Institute of Standards and Technology, as well as by private sources.

The Master of Science in Computer Science

The Master of Science in Computer Science program is designed to provide breadth of understanding in the core topics of computer science, in-depth advanced material, and a range of topics courses in the research areas of the faculty. A balance of theory and practice is presented preparing students to perform cutting edge research as well as training students to become practicing computational scientists, computer specialists or software engineers in business, industry or government. A thesis option is available to prepare students for doctoral studies or other research-oriented career paths.

The Doctorate in Computer Science

Students enrolled in the PhD program are expected to acquire broad knowledge in all areas of computer science and an overall perspective of the field, its structure, and its problems. They are expected to study at least one subfield in considerable depth, and to make substantial contributions to that subfield through creative research and serious scholarship. The program is designed for students to advance their basic understanding of information processes and to contribute to the creation and consolidation of knowledge in computer science. In addition, they should be able to see and understand new problems between different areas within computer science, as well as between computer science and other fields, and to find and implement imaginative solutions.
For more information, visit the Department of Computer Science (http://www.cs.drexel.edu) web site.

Admission Requirements

Applicants should hold a BS degree in computer science or some related technical area and meet the graduate admission standards for Drexel University. Students without a bachelor's degree in computer science may be admitted to the computer science program only after completing a set of prerequisite courses.
All applicants must take the Graduate Record Exam (GRE). All international students must have an acceptable score on the Test of English as a Foreign Language (TOEFL) exam.

For more information regarding international applicant requirements, view the International Students Admissions Information (http://drexel.edu/isss/NewStudent.html) page.

Applicants for post-master's status must show potential for further study by having maintained at least a 3.0 average in their master's level studies.

Applications are evaluated by the department Admissions Committee and admission is determined by the department's Graduate Advisor. The Admissions Committee evaluates all credentials submitted by applicants to determine a student's ability and potential to succeed in graduate study. In addition, the committee is interested in the applicant's potential to contribute to his/her program of study and to the University community as a whole.

Application forms may be obtained from the Drexel Admissions (http://www.drexel.edu/em/grad) web site.

Master of Science in Computer Science

General Requirements

Students must complete a minimum of 45.0 graduate credits for the MS degree. All students are required to submit a plan of study form with the Graduate Advisor at the beginning of their studies. Significant changes to the plan of study should be discussed with the Graduate Advisor.

Precore Classes

Precore classes are graduate level courses, but are not considered graduate level CS courses. These courses only count towards the degree requirement listed below as free electives with approval from the Graduate Coordinator. Precore courses are intended for students without adequate CS background. The material in these courses is considered prerequisite knowledge for all other graduate CS courses.

- CS 520 Foundations of Computer Science

- CS 571 Programming Tools and Environments

Degree Requirements

Required Courses

CS 521	Data Structures and Algorithms I	3.0
CS 525	Theory of Computation	3.0
CS 550	Programming Languages	3.0
Flexible Core		9.0
Select three of the following courses:		
CS 510	Introduction to Artificial Intelligence	
CS 522	Data Structures and Algorithms II	
CS 530	Developing User Interfaces	
CS 536	Computer Graphics	
CS 540	High Performance Computing	
CS 543	Operating Systems	
CS 544	Computer Networks	
CS 567	Applied Symbolic Computation	
CS 576	Dependable Software Systems	
CS 583	Introduction to Computer Vision	
Breadth Requirements		9.0

In addition, all students are required to take an additional three (3) breadth requirement electives, developing background knowledge in an area of particular interest. These courses are organized into the following seven areas.

Students must take courses from at least three different areas. Some additional courses, such as Special Topics, may count toward the Breadth Requirement. Contact the Graduate Advisor for more information regarding substitutions.

Artificial Intelligence and Robotics		
CS 510	Introduction to Artificial Intelligence	
CS 511	Robot Laboratory	
CS 610	Advanced Artificial Intelligence	
CS 612	Knowledge-based Agents	
CS 613	Machine Learning	
Algorithms and Theory		
CS 522	Data Structures and Algorithms II	
CS 620	Advanced Data Structure and Algorithms	
CS 621	Approximation Algorithms	
CS 623	Computational Geometry	
CS 676	Parallel Programming	
CS 680	Special Topics in Computer Science	

Computer Graphics and Vision

CS 536	Computer Graphics
CS 583	Introduction to Computer Vision
CS 634	Advanced Computer Vision
CS 636	Advanced Computer Graphics
CS 637	Interactive Computer Graphics

Human Computer Interaction

CS 530	Developing User Interfaces
CS 630	Cognitive Systems
CS 631	HCI: Computing Off The Desktop

Numeric and Symbolic Computation

CS 540	High Performance Computing
CS 567	Applied Symbolic Computation
CS 668	Computer Algebra I
CS 669	Computer Algebra II

Programming Languages and Compilers

CS 551	Compiler Construction I
CS 552	Compiler Construction II
CS 650	Program Generation and Optimization
CS 676	Parallel Programming

Software Engineering

CS 575	Software Design
CS 576	Dependable Software Systems
CS 675	Reverse Software Engineering
CS 780	Advanced Topics in Software Engineering

Systems

CS 500	Database Theory
CS 543	Operating Systems
CS 544	Computer Networks
CS 643	Advanced Operating Systems
CS 645	Network Security
CS 647	Distributed Systems Software
CS 741	Computer Networks II
CS 751	Database Theory II

Computer Science Depth Requirement   6.0

MS students are required to complete at least two Computer Science (CS) courses beyond the breadth requirement. These courses should be 600 or 700-level courses. The CS 690 Independent Study course may be taken, if approved by the Department's Graduate Advisor.

| CS 690 | Independent Study in Computer Science |

Additional Graduate-Level Courses   6.0

Two additional graduate level courses are required. These courses may come from either the 600 or 700 level Computer Science (CS) courses. In addition, courses may be taken from outside the department, if on the list of approved external courses, and may include CS 690 Independent Study and CS 997 Research in Computer Science, if approved by the graduate advisor.

| CS 690 | Independent Study in Computer Science |
| CS 997 | Research in Computer Science |

CS 520 and CS 571 may only be used to fulfill the additional course requirement with permission of the Graduate Committee. Any course not explicitly listed above, including independent study and research courses, must be approved by the Department's Graduate Advisor.

| CS 520 | Computer Science Foundations |

| CS 571 | Programming Tools and Environments |

Other courses, such as intermediate 500-level and special topics, that the department offers may qualify for fulfilling this requirement. Students must check with the department to see if this is the case, and have these courses approved by the Graduate Committee. Any course offered by other departments that is not on the list of approved external courses must be approved by the Department's Graduate Advisor, or it will not count towards the degree.

Thesis or Non-Thesis Option   6.0

Thesis Option

Usually students pursuing a Master's Thesis will first do 3.0 research credits (CS 690 or CS 997) to obtain background knowledge required by the thesis topic. It is the responsibility of the student to find a thesis supervisor.

CS 690	Independent Study in Computer Science
CS 997	Research in Computer Science
CS 898	Master's Thesis

Non-thesis Option

The non-thesis option requires two additional 600 or 700 level Computer Science (CS) courses taken in place of the 6.0 thesis credits.

| 600 or 700-level Courses |

| Total Credits | 45.0 |

PhD in Computer Science

General Requirements

90.0 quarter credits

The following general requirements must be satisfied in order to complete the PhD in Computer Science:

- 90.0 quarter credit hours total
- Establishing a plan of study with your Advisor
- Qualifying courses
- Candidacy exam
- Approval of dissertation proposal
- Defense of dissertation

Students entering with a master's degree may be exempted from some or all of the courses in the breadth requirement; however, they are still required to meet all milestones of the program. Individual courses may also be transferred with approval of the Graduate Advisor. The total credit amount, candidacy exam, and dissertation are University Requirements. Additional requirements are determined by the department offering the degree.

Qualifying Courses

To satisfy the qualifying requirements, students must earn a grade of B+ or better in the first 6 Computer Science graduate courses taken at Drexel, and must earn an overall GPA of 3.5 or better in these courses. Normally these courses comprise the 3 mandatory#core and 3 flexible#core courses taken as part of the PhD program; however, they may in some cases include more advanced courses (e.g., if the student has received transfer credit for a core course). Undergraduate courses, independent studies, research credits, and courses from other departments cannot be counted toward the qualifying requirements. Student progress toward these requirements will be assessed in the

Annual Review following the student's first year in the PhD program. For more information visit the Department's PhD Qualifying Requirements (https://www.cs.drexel.edu/graduate/phd/milestones/qualifying) page.

Required Courses

CS 521	Data Structures and Algorithms I	3.0
CS 525	Theory of Computation	3.0
CS 550	Programming Languages	3.0

Flexible Core

Select three of the following:		9.0
CS 510	Introduction to Artificial Intelligence	
CS 522	Data Structures and Algorithms II	
CS 530	Developing User Interfaces	
CS 536	Computer Graphics	
CS 540	High Performance Computing	
CS 543	Operating Systems	
CS 544	Computer Networks	
CS 567	Applied Symbolic Computation	
CS 576	Dependable Software Systems	
CS 583	Introduction to Computer Vision	

In addition, all students are required to take an additional four (4) breadth requirement electives, developing background knowledge in areas of particular interest. These courses are organized into the following seven areas.

Select four courses from at least three different areas:		12.0

Artificial Intelligence

CS 510	Introduction to Artificial Intelligence	
CS 511	Robot Laboratory	
CS 610	Advanced Artificial Intelligence	
CS 612	Knowledge-based Agents	
CS 613	Machine Learning	
CS 770	Topics in Artificial Intelligence	

Algorithms and Theory

CS 522	Data Structures and Algorithms II	
CS 620	Advanced Data Structure and Algorithms	
CS 621	Approximation Algorithms	
CS 623	Computational Geometry	
CS 676	Parallel Programming	

Human Computer Interaction/Computer Graphics and Vision

CS 530	Developing User Interfaces	
CS 536	Computer Graphics	
CS 583	Introduction to Computer Vision	
CS 630	Cognitive Systems	
CS 631	HCI: Computing Off The Desktop	
CS 634	Advanced Computer Vision	
CS 636	Advanced Computer Graphics	
CS 637	Interactive Computer Graphics	

Numeric and Symbolic Computation

CS 680/ MATH 540	Special Topics in Computer Science	
CS 680/ MATH 521	Special Topics in Computer Science	
CS 680/ MATH 522	Special Topics in Computer Science	
CS 540	High Performance Computing	
CS 567	Applied Symbolic Computation	
CS 668	Computer Algebra I	
CS 669	Computer Algebra II	

Programming Languages and Compilers

CS 551	Compiler Construction I	
CS 552	Compiler Construction II	
CS 650	Program Generation and Optimization	
CS 676	Parallel Programming	
CS 759	Complexity Theory	

Software Engineering

CS 575	Software Design	
CS 576	Dependable Software Systems	
CS 675	Reverse Software Engineering	
CS 780	Advanced Topics in Software Engineering	

Networks and Operating Systems

CS 500	Database Theory	
CS 543	Operating Systems	
CS 544	Computer Networks	
CS 643	Advanced Operating Systems	
CS 645	Network Security	
CS 647	Distributed Systems Software	
CS 741	Computer Networks II	
CS 751	Database Theory II	

Total Credits	30.0

Depth Requirement

Doctoral students are required to complete at least 18 credits of CS courses beyond the breadth requirement. These courses should be 600- or 700-level courses or topics courses covering current research in selected areas. Course selection must be approved by the student's research advisor. The department will periodically offer topics courses, typically run in a seminar fashion, on current research areas of interest to faculty, for instance:

- Topics in Artificial Intelligence
- Topics in Algorithms and Theory
- Topics in Human Computer Interaction
- Topics in Computer Graphics
- Topics in Numeric and Symbolic Computation
- Topics in Software Engineering

As part of the depth requirement 3 out of the 18 credits but no more than 9 credits are to be Independent Study work (CS 690).

Plan of Study

Upon entering the PhD program, each student will be assigned an academic advisor, and with the help of the advisor will develop and file a plan of study (which can be brought up to date when necessary). The plan of study should be filed with the Graduate Coordinator no later than the end of the first term.

Candidacy Exam

The Computer Science candidacy examination serves to define the student's research domain and to evaluate the student's knowledge and understanding of various fundamental and seminal results in that domain.

At this point the student is expected to be able to read, understand, analyze, and explain advanced technical results in a specialized area of computer science at an adequate level of detail. The candidacy examination will evaluate those abilities using a defined set of published manuscripts. The student will prepare a written summary of the contents of the material, present the summary orally, and answer questions about the material. The examination committee will evaluate the written summary, the oral presentation, and the student's answers.

Thesis Proposal

After completing the candidacy examination successfully, the PhD candidate must prepare a thesis proposal that outlines, in detail, the specific problems that will be solved in the PhD dissertation. The quality of the research proposal should be at the level of, for example, a peer-reviewed proposal to a federal funding agency, or a publishable scientific paper. The candidate is responsible for sending the research proposal to the PhD committee two weeks before the oral presentation. The PhD committee need not be the same as the candidacy exam committee, but it follows the same requirements and must be approved by the Office of Graduate Studies. The oral presentation involves a 30-minute presentation by the candidate followed by an unspecified period during which the committee will ask questions.

After the question and answer period, the candidate will be asked to leave the room and the committee will determine if the research proposal has been accepted. The research proposal can be repeated at most once. A thesis proposal must be approved within two years of becoming a PhD candidate.

Thesis Defense

After completing the research proposal successfully, the PhD candidate must conduct the necessary research and publish the results in a PhD dissertation. The dissertation must be submitted to the PhD committee two weeks prior to the oral defense. The oral presentation involves a 45-minute presentation by the candidate, open to the public, followed by an unspecified period during which the committee will ask questions. The question-and-answer period is not open to the public. After the question and answer period, the candidate will be asked to leave the room and the committee will determine if the candidate has passed or failed the examination. The candidate will be granted one more chance to pass the final defense if (s)he fails it the first time. Paperwork selecting the thesis committee and indicating the results of the thesis defense must be filed with the Department of Computer Science (https://www.cs.drexel.edu) and the Office of Graduate Studies (https://www.cs.drexel.edu).

Dual MS Degree Opportunities

Graduate students already enrolled in a master's degree program at Drexel have the opportunity, through the dual master's program, to work simultaneously on two master's degrees and to receive both upon graduation. To be eligible, graduate students must be currently working on their first degree when requesting admission to the second. They must obtain approval from the graduate advisors of both programs and work out a plan of study encompassing coursework and/or research (thesis) credits for both degrees.

To satisfy dual degree requirements for the MSCS and another degree the plan of study must include the following: mandatory core, flexible core, breadth and one depth course for a total of 30.0 credits. To obtain a dual degree you must have a minimum of 60 credits, thesis and research credits will be in excess of the 30.0 credits required by MSCS. The dual degree for MSCS students is only available to on-campus students.

The dual master's student must complete the Graduate Dual Degree Form and obtain approvals from both graduate advisors. Final approval is granted by the Office of Graduate Studies. The student is then registered in both majors simultaneously. Upon graduation, the student must file two Application for Degree forms. Students should contact the Office of Graduate Studies (http://www.drexel.edu/provost/graduatestudies) for copies of the forms.

Facilities

The department is fully networked, including Internet access and Internet II connection. Department computers are accessible from the residence halls over the campus network and from off campus via modem or Internet service provider. Students use UNIX, Macintosh, and Windows NT platforms.

For information on additional Computer Science research facilities, visit the Department of Computer Science Research Laboratories (http://www.drexel.edu/cs/research/laboratories) web page.

Cybersecurity

Master of Science: 45.0 quarter credits (or 48.0 credits for the 6-month graduate co-op option)

About the Program

As a greater percentage of people worldwide use computers, there is a marked increase in cybersecurity concerns. Motivated through discussions with the National Security Agency (NSA), Drexel University's MS in Cybersecurity program prepares students with both academic and practical training to be competitive in today's rapidly changing technical landscape. The program provides deeply technical and specialized training and enable graduates to understand, adapt, and develop new techniques to confront emerging threats in cybersecurity.

Administered by the Electrical (http://www.ece.drexel.edu/index.php?page=Graduate_Program) & Computer Engineering Department in the College of Engineering, this program is interdisciplinary in nature and includes courses from Drexel University's *i*School, College of Information Sciences and Technology as well as the Goodwin College for Professional Studies. Topics covered include the principles of computer networking, probability concepts, techniques for analyzing algorithms, as well as ethics of privacy, confidentiality, authenticity, medical information, copyright, intellectual freedom, censorship, social networking and cyberbullying.

The program offers multidisciplinary "research rotations" as an independent study component of the degree program, and a graduate co-op option for credit.

Additional Information

For additional information about this program, please visit the ECE Department's Cybersecurity degree page (http://ece.drexel.edu/mscybr.html).

Degree Requirements

The Master of Science in Cybersecurity program encompasses a minimum of 45.0 or 48.0 (with the 6-month graduate co-op option) approved credit hours, chosen in accordance with the following requirements. A plan of study should be arranged with the departmental graduate advisors, and in consultation with the student's research advisor, if applicable.

The required core courses provide students with a theoretical foundation in the field of cybersecurity and a framework to guide the application of knowledge gained in technical electives to the practice of cybersecurity.

Core Courses		
CST 510	Ethics, Privacy and Legal Issues	3.0
INFO 517	Principles of Cybersecurity	3.0
INFO 725	Information Policy	3.0
Networking Foundation		3.0
CS 544	Computer Networks	
or ECEC 631	Principles of Computer Networking	
Mathematical Foundations		3.0
CS 521	Data Structures and Algorithms I	
or ECES 521	Probability & Random Variables	
Cybersecurity Technical Electives [*]		18.0
General Electives [**]		12.0
Total Credits		45.0

[*]   Cybersecurity technical electives are used to build a deep understanding of one or more areas of technical expertise within the field of cybersecurity. All students are required to take a minimum of 18.0 credits of cybersecurity technical electives. Students choose cybersecurity technical electives from the graduate course offerings of the Department of Computer Science; the Department of Computing and Security Technology, and the Department of Electrical and Computer Engineering.

[**]   General electives are the remaining courses needed to reach the minimum credit hour requirement for the degree program. General electives can be chosen from among the graduate course offerings of The *i*School, College of Information Science and Technology; the Department of Computer Science; the Department of Computing and Security Technology; the Department of Electrical and Computer Engineering and the Department of Mathematics. In order to have courses outside of these departments and schools count towards degree completion, they must be approved by the departmental graduate advisors prior to registration for said courses.

Graduate Co-op/Career Opportunities

Graduate Co-Op

Students may choose to participate in the graduate co-op program, working on curriculum related projects. Up to 6.0 credit hours can be earned for a six month full-time co-operative education experience in the industry. There are two options. Students participating in a three month full-time co-op experience earn 3.0 credits, which is the equivalent of one general elective course. Students engaging in a six month full-time co-op experience earn 6.0 credits, of which 3.0 credits is be considered equivalent to a general elective course; the other 3 credits are considered

an additional course, increasing the total minimum credit requirement for graduation from the MS program with a six month full-time graduate co-op to 48.0 credits.

Further information on the Graduate Co-Op Program (http://www.drexel.edu/scdc/coop/graduate) is available at the Drexel Steinbright Career Development Center. (http://www.drexel.edu/scdc)

Career Opportunities

The program was deliberately designed to address needs of the Federal Cyber Service, the Department of Defense, and the National Security Agency. The program strengthens ties between these agencies and Drexel University and will provide professional opportunities for students pursuing this degree.

Research

Students in the MS in Cybersecurity program opportunities to perform research-oriented coursework for academic credit. Research-oriented coursework can be divided into three categories: research rotations, master's thesis, and independent research.

A total of 9.0 credits of research-oriented coursework may be counted towards the minimum credit hour requirement of the degree program. These credits are considered general electives.

Electrical Engineering

Master of Science in Electrical Engineering (MSEE): 45.0 - 48.0 quarter credits
Doctor of Philosophy: 90.0 quarter credits

About the Program

The program in electrical engineering prepares students for careers in research and development, and aims to endow graduates with the ability to identify, analyze and address new technical and scientific challenges. At present, the department offers graduate coursework in six general areas: (1) computer engineering; (2) control, robotics and intelligent systems; (3) electrophysics; (4) image and signal processing and interpretation; (5) power engineering and energy; and (6) telecommunications and networking.

The Master of Science in Electrical Engineering degree requires a minimum of 45.0 approved credits chosen in accordance with a plan of study arranged with the permission of a student's advisor and the departmental graduate advisor. Students who complete a six-month period of internship through Drexel's Graduate Co-op Program (GCP) (http://www.ece.drexel.edu/grad/cie.html) must complete 48.0 credits including 6.0 GCP credits.

The plan must contain a selection of core courses from the department's offerings and may include appropriate graduate courses from other engineering departments or from physics or mathematics. Further information can be obtained from the department office or from the graduate advisor.

All students also are encouraged to engage in thesis research. The combined thesis and research cannot exceed 9 credits. The program is organized so that a student may complete the degree requirements in two years of full-time study or three years of part-time study.

For more information about the programs, including information about teaching and research assistantships, visit the Department's Electrical Engineering (http://www.ece.drexel.edu/MSEE.html) web site.

Admission Requirements

Applicants must satisfy general requirements for graduate admission, including a minimum 3.0 GPA (on a 4.0 scale) for the last two years of undergraduate studies, as well as for any subsequent graduate work, and hold a bachelor's degree or the equivalent in electrical engineering, computer engineering, or the equivalent from an accredited college or university. A degree in science (physics, mathematics, computer science, etc.) is also acceptable. Applicants with degrees in sciences may be required to take a number of undergraduate engineering courses. An undergraduate degree earned abroad must be deemed equivalent to a US bachelor's.

Applicants for full-time MS and PhD programs must take the GRE general test. Students whose native language is not English and who do not hold a degree from a U.S.institution must take the TOEFL within two years before application.

For additional information on how to apply, visit Drexel's Admissions page for Electrical Engineering (http://www.drexel.edu/grad/programs/coe/electrical-engineering).

Master of Science in Electrical Engineering

The Master of Science in Electrical Engineering curriculum encompasses 45.0 or 48.0 (with the Graduate Co-op option) approved credit hours, chosen in accordance with the following requirements and a plan of study arranged with the departmental graduate advisor in consultation with the student's research advisor, if applicable. Before the end of the first quarter in the Department of Electrical and Computer Engineering, for a full-time student, or by the end of the first year for a part-time student, said plan of study must be filed and approved with the departmental graduate advisor.

A total of at least 30.0 credit hours must be taken from among the graduate course offerings of the Department of Electrical and Computer Engineering. These credits must be taken at Drexel University. No transfer credit may be used to fulfill these requirements, regardless of content equivalency.

The remaining courses needed to reach the minimum credit hour requirement for the degree program are considered elective courses. Elective courses can be chosen from among the graduate course offerings of the Department of Electrical and Computer Engineering; other departments within the College of Engineering; the School of Biomedical Science, Engineering and Health Systems; the Department of Mathematics; the Department of Physics; the Department of Chemistry and the Department of Biology. In order to have courses outside of these departments and schools count towards degree completion, they must be approved by the departmental graduate advisors prior to registration for said courses.

Please note that ECEC 500 (Fundamentals of Computer Hardware) and ECEC 600 (Fundamentals of Computer

Networks) do **not** count toward the credit requirements to complete the MS in Electrical Engineering degree program.

Customizable Specialization

Required Courses		
Electrical Engineering (ECEE, ECEP, ECES, ECET) Courses		21.0
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses		9.0
Elective Courses		15.0
Total Credits		45.0

Electrophysics Specialization

Required Courses		
Electrophysics (ECEE) Courses		18.0
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses		12.0
Elective Courses		15.0
Total Credits		45.0

Controls, Robotics, Intelligent Systems Specialization

Required Courses		
ECES 511	Fundamentals of Systems I	3.0
ECES 512	Fundamentals of Systems II	3.0
ECES 521	Probability & Random Variables	3.0
ECES 522	Random Process & Spectral Analysis	3.0
Select three of the following:		9.0
ECES 604	Optimal Estimation & Stochastic Control	
ECES 642	Optimal Control	
ECES 644	Computer Control Systems	
ECES 651	Intelligent Control	
ECES 817	Non-Linear Control Systems	
ECES 818	Machine Learning & Adaptive Control	
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses		9.0
Elective Courses		15.0
Total Credits		45.0

Power Engineering Specialization

Required Courses		
ECEP 501	Power System Analysis	3.0
ECEP 502	Computer Analysis of Power Systems	3.0
ECEP 503	Synchronous Machine Modeling	3.0
Select one of the following sequences:		6.0
ECES 511 & ECES 512	Fundamentals of Systems I and Fundamentals of Systems II	
ECES 521 & ECES 522	Probability & Random Variables and Random Process & Spectral Analysis	
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses		15.0
Elective Courses		15.0
Total Credits		45.0

Signal/Image Processing Specialization

Required Courses		
ECES 521	Probability & Random Variables	3.0

ECES 522	Random Process & Spectral Analysis	3.0
ECES 523	Detection & Estimation Theory	3.0
ECES 631	Fundamentals of Deterministic Digital Signal Processing	3.0
ECES 682	Fundamentals of Image Processing	3.0
General Electrical and Computer Engineering (ECEC, ECEE, ECEP, ECES, ECET) Courses		15.0
Elective Courses		15.0
Total Credits		45.0

Options for Degree Fulfillment

Although not required, students are encouraged to complete a Master's Thesis as part of the MS studies. Those students who choose the thesis option may count up to 9.0 research/thesis credits as part of their required credit hour requirements.

Students may choose to participate in the Graduate Co-Op Program, where 6.0 credit hours can be earned for a six month co-operative education experience in industry, working on curriculum related projects. The total number of required credit hours is increased to 48.0 for those students who choose to pursue the Graduate Co-Op option. This change represents an increase in non-departmental required credit hours to a total of 18.0 credit hours, 6.0 of which are earned from the co-operative education experience.

For more information on curricular requirements, visit the Department of Electrical and Computer Engineering' (http://www.ece.drexel.edu)s web site.

PhD in Electrical Engineering

General Requirements
The following general requirements must be satisfied in order to complete the PhD in Electrical Engineering:

- 90.0 credit hours total
- candidacy examination
- research proposal
- dissertation defense

Students entering with a master's degree in electrical or computer engineering or a related field will be considered a post-masters PhD student and will only be required to complete a total of 45.0 credit hours, in accordance with University policy.
Curriculum
Appropriate coursework is chosen in consultation with the student's research advisor. A plan of study must be developed by the student to encompass the total number of required credit hours. Both the departmental graduate advisor and the student's research advisor must approve this plan.
Candidacy Examination
The candidacy examination explores the depth of understanding of the student in his/her specialty area. The student is expected to be familiar with, and be able to use, the contemporary tools and techniques of the field and to demonstrate familiarity with the principal results and key findings.

The student, in consultation with his/her research advisor, will declare a principal technical area for the examination. The examination includes the following three parts:

- A self-study of three papers from the archival literature in the student's stated technical area, chosen by the committee in consultation with the student.
- A written report (15 pages or less) on the papers, describing their objectives, key questions and hypotheses, methodology, main results and conclusions. Moreover, the student must show in an appendix independent work he/she has done on at least one of the papers – such as providing a full derivation of a result or showing meaningful examples, simulations or applications.
- An oral examination which takes the following format:
  - A short description of the student's principal area of interest (5 minutes, by student).
  - A review of the self-study papers and report appendix (25-30 minutes, by students).
  - Questions and answers on the report, the appendix and directly related background (40-100 minutes, student and committee).

In most cases, the work produced during the candidacy examination will be a principal reference for the student's PhD dissertation; however, this is not a requirement.
Research Proposal
Each student, after having attained the status of PhD Candidate, must present a research proposal to a committee of faculty and industry members, chosen with his/her research advisor, who are knowledgeable in the specific area of research. This proposal should outline the specific intended subject of study, i.e. , it should present a problem statement, pertinent background, methods of study to be employed, expected difficulties and uncertainties and the anticipated form, substance and significance of the results.

The purpose of this presentation is to verify suitability of the dissertation topic and the candidate's approach, and to obtain the advice and guidance of oversight of mature, experienced investigators. It is not to be construed as an examination, though approval by the committee is required before extensive work is undertaken. The thesis proposal presentation must be open to all; announcements regarding the proposal presentation must be made in advance.

The thesis advisory committee will have the sole responsibility of making any recommendations regarding the research proposal. It is strongly recommended that the proposal presentation be given as soon as possible after the successful completion of the candidacy examination. The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.
Dissertation Defense
Dissertation Defense procedures are described in the Office of Graduate Studies policies regarding Doctor of Philosophy Program Requirements (http://www.drexel.edu/provost/graduatestudies). The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.

Dual Degree

The Department of Electrical and Computer Engineering offers outstanding students the opportunity to receive two diplomas (BS and MS) at the same time. The program requires five (5) years to complete.

Participants, who are chosen from the best undergraduates students, work with a faculty member on a research project and follow a study plan that includes selected graduate classes. This program prepares individuals for careers in research and development; many of its past graduates continued their studies toward a PhD.

For more information on eligibility, academic requirements, and tuition policy visit the Engineering Combined BS/MS (http://www.ece.drexel.edu/undergrad/bsms.html) page.

Facilities

Drexel University and the Electrical and Computer Engineering Department are nationally recognized for a strong history of developing innovative research. Research programs in the ECE Department prepare students for careers in research and development, and aim to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. The ECE Department is well equipped with state-of-the-art facilities in each of the following ECE Research laboratories:

Research Laboratories at the ECE Department

- **Adaptive Signal Processing and Information Theory Research Group** (http://www.ece.drexel.edu/aspitrg.html)
- **Applied Communications and Information Networking Center** (http://www.ece.drexel.edu/acinc.html)
- **Applied Networking Research Laboratory** (http://www.ece.drexel.edu/anrl.html)
- **Biochemical Signal Processing Laboratory** (http://www.ece.drexel.edu/bspl.html)
- **Cleanroom Microfabrication Facility** (http://www.ece.drexel.edu/cmf.html)
- **Data Fusion Laboratory** (http://www.ece.drexel.edu/dfl.html)
- **Drexel Network Modeling Laboratory** (http://www.ece.drexel.edu/dnml.html)
- **Drexel Wireless Systems Laboratory** (http://www.ece.drexel.edu/dwsl.html)
- **Electric Power Engineering Center** (http://www.ece.drexel.edu/epec.html)
- **Electronic Design Automation (EDA) Facility** (http://www.ece.drexel.edu/edaf.html)
- **Microwave Photonics Center** (http://www.ece.drexel.edu/mpc.html)
- **Microwave-Photonics Device Laboratories** (http://www.ece.drexel.edu/mpdl.html)
- **Music and Entertainment Technology Laboratory** (http://www.ece.drexel.edu/metl.html)
- **NanoPhotonics Laboratory** (http://www.ece.drexel.edu/npl.html)
- **Opto-Electro-Mechanical Laboratory** (http://www.ece.drexel.edu/oeml.html)
- **Plasma and Magnetics Laboratory** (http://www.ece.drexel.edu/pml.html)
- **Power Electronics Research Laboratory** (http://www.ece.drexel.edu/perl.html)
- **Supervisory Control Laboratory** (http://www.ece.drexel.edu/scl.html)
- **Testbed for Power/Performance Management of Enterprise Computing Systems** (http://www.ece.drexel.edu/tppm.html)

Engineering Management

Master of Science in Engineering Management (MSEM): 51.0 quarter credits

About the Program

The engineering management program (http://www.drexel.edu/egmt) is designed to provide the background in management science necessary to advance from purely technical positions to supervisory responsibilities in such areas as research and development, production, engineering, design, and technical marketing. Study can be on a part-time or full-time basis, and all courses are offered online.

In our increasingly complex, technologically-oriented economy, demand has risen for professionals with the expertise to manage both human and technological resources — a combination of talents crucial to organizations competing in the global marketplace. Students graduating with the master's in engineering management are significantly better positioned to meet the challenge.

Engineering management is a multidisciplinary program offering a core curriculum and specialization in a selected area of technology or management. Majors in engineering management must hold a bachelor's degree in engineering, basic science, or a related field. The program is open to those professionals who aspire to be engineering or technically based managers.

Dual-Degree Requirements

Students may simultaneously pursue the master's in engineering management and another master's degree. Students must satisfy program requirements for each degree, with a maximum of 15.0 credits transferred from one program to the other. (The master's in engineering management requires 51.0 credits; if the other degree requires 45.0 credits, then 66.0 credits are required under the dual degree program.) Approval for the dual degree program must be obtained from the program advisor in each department or program.

Graduate Co-op Program (GCP)

The Graduate Co-op Program (graduate intern or co-op program) is available to master's-level engineering management students. The opportunity to spend six months in industry provides a significant opportunity for the engineer in transition to management. Through Drexel's Steinbright Career Development Center (http://www.drexel.edu/scdc/coop/graduate), students can explore new career directions. This program requires 6.0 additional credits, 3.0 for each term in industry.

Certificate Opportunity

The engineering management program also offers a four-course graduate certificate in engineering management.

Students can apply to pursue the graduate certificate in engineering management, earn the credential, and subsequently apply those credits toward completion of a master's in engineering management. However, current students in pursuit of the master's in engineering management may not simultaneously pursue the graduate certificate.

Non-engineering management graduate students in the college of engineering (including those in the accelerated bachelor's/master's program) are welcome to apply for the certificate in engineering

management, with advisor approval, and they can do so while simultaneously pursuing their primary degree.

Additional Information

For more information about the program, visit the Drexel Online Engineering Management (http://www.drexel.com/online-degrees/engineering-degrees/ms-egmt) program page.

Admission Requirements

Admission to this program requires:

- A four-year bachelor of science degree in engineering from an ABET-accredited institution in the United States or an equivalent international institution. Bachelor's degrees in math or the physical sciences may also be considered for provisional admission.
- Minimum cumulative undergraduate GPA of 3.0. If any other graduate work has been completed, the average GPA must be at least 3.0.
- Complete graduate school application.
- Official transcripts from all universities or colleges and other post-secondary educational institutions (including trade schools) attended.
- Two letters of recommendation, professional or academic (professional preferred).
- Resume
- A 750-word essay on one of two prompts: technical analysis problem or human resource problem (details of each problem are included in the essay tab of the online application).
- International students must submit an Internet-based TOEFL (IBT = score of 100 or higher).

At least five years of relevant professional work experience are recommended, but not required.

Interested students should complete the Drexel University Online admission application (http://www.drexel.com/online-degrees/engineering-degrees/ms-egmt/admissions.aspx) for admission into this online program.

Degree Requirements

The master's in engineering management degree requires 51.0 credits, including 30.0 credits in required core courses and 21.0 graduate elective credits, of which 6.0 or more credits are in a major area of interest. These electives may be taken in other colleges at Drexel consistent with the plan of study and any required prerequisites.

Students with a particular interest in technology or management who can satisfy the prerequisite and departmental requirements are free to select any 6.0- to 21.0-credit sequence with the approval of the program advisor. Alternatively, students may take the balance of required elective credits from any other graduate-level course(s) in engineering, business, or another college for which they have adequate preparation and can obtain approvals from the college and the engineering management program.

All candidates are encouraged to discuss areas of interest with the program advisor and to develop a proposed plan of study during the early stages of the program.

Note: Specific course requirements will be waived for students who have taken equivalent courses elsewhere.

Engineering Management		
EGMT 501	Engineering Management I	3.0
EGMT 502	Engineering Management II	3.0
EGMT 504	Communications	3.0
EGMT 581	Problems in Human Relations	3.0
Finance & Business Policy		
EGMT 531	Economics for Engineering Management	3.0
EGMT 535	Financial Management I	3.0
EGMT 536	Financial Management II	3.0
EGMT 537	Problems In Engineering Administration	3.0
Quantitative Analysis		
EGMT 571	Managerial Statistics I	3.0
EGMT 572	Managerial Statistics II [*]	3.0
EGMT 573	Operations Research I	3.0
EGMT 574	Operations Research II	3.0
Electives		
Select five of the following:		15.0
EGMT 605	Research & Development Management I	
EGMT 515	Infrastructure Systems & Performance Evaluation	
EGMT 516	Infrastructure Project & Program Planning	
EGMT 517	Public Value & Participation in Infrastructure Decision	
EGMT 520	Infrastructure Capstone Project	
EGMT 606	Research & Development Management II	
EGMT 607	Marketing for Engineers	
EGMT 610	Engineering Ethics & Business Practices for Engineers	
EGMT 620	Project Management for Engineers	
EGMT 625	Project Planning and Control	
EGMT 630	Global Engineering Project Management	
EGMT 635	Visual System Mapping	
EGMT 650	Systems Engineering Leadership	
EGMT 652	Engineering Law	
EGMT 660	Sustainable Business Practices for Engineers	
EGMT 685	Systems Engineering Management	
EGMT 680	Special Topics in Engineering Management	
Total Credits		51.0

[*]   EGMT 572 requires as a prerequisite EGMT 571 (Managerial Statistics I) or approval from the department by completing a waiver and requesting to take and pass the STAT Placement exam in place of EGMT 571. EGMT 571 is offered in the winter and summer terms.

Certificate in Engineering Management

This program is a superb training ground for engineers and scientists who want to obtain a solid foundation in critical areas in management, communications, economics and finance without having to commit to the entire graduate program. After completing the program, students have the option of applying the earned credits toward a master's degree in engineering management.

Admission to this program requires:

- A four-year bachelor of science degree in engineering from an ABET-accredited institution in the United States or an equivalent international institution. Bachelor's degrees in math or the physical sciences may also be considered for provisional admission.
- Minimum cumulative undergraduate GPA of 3.0. If any other graduate work has been completed, the average GPA must be at least 3.0.
- Complete graduate school application.
- Official transcripts from all universities or colleges and other post-secondary educational institutions (including trade schools) attended.
- Two letters of recommendation, professional or academic (professional preferred).
- Resume
- A 750-word essay on one of two prompts: technical analysis problem or human resource problem (details of each problem are included in the essay tab of the online application).
- International students must submit an Internet-based TOEFL (IBT = score of 100 or higher).

At least five years of relevant professional work experience are recommended, but not required.

Continuing master's students pursuing other technical disciplines may also complete the certificate courses as electives with approval from their advisor (i.e. electrical engineering master's students may complete these four courses to satisfy four of their five elective requirements).

This certificate is awarded to students who successfully complete the following four graduate-level courses from the master's in engineering management (http://www.drexel.edu/egmt/resources/current/catalog) curriculum:

Requirements

EGMT 501	Engineering Management I	3.0
EGMT 504	Communications	3.0
EGMT 531	Economics for Engineering Management	3.0
EGMT 535	Financial Management I	3.0
Total Credits		12.0

The program is administered through Drexel Online. Applications to the certificate program are managed by Drexel Online. For the most current admission information, please visit www.drexel.com (http://www.drexel.com/online-degrees/engineering-degrees/cert-egmt).

Master of Engineering

Master of Engineering (ME): 48.0 quarter credits

About the Program

Intense global competition has created a demand in industry for engineering professionals with expertise in modern manufacturing technology, including management and the practical aspects of manufacturing.This career-focused program is designed for working professionals and those seeking employment in a manufacturing-related industry, and may not be the best choice for those who wish to earn a PhD in engineering.

The Master of Engineering (ME) with a practice-oriented manufacturing option, a multidisciplinary program, draws on the strengths of all the departments in the College of Engineering, as well as on the offerings of related areas within the University. Intense global competition has

created a demand in American industry for engineering professionals with expertise in modern manufacturing technology, including both the management and physical aspects of manufacturing. The ME degree program with a practice-oriented manufacturing option is designed for working professionals and those seeking employment in a manufacturing-related industry.

The ME program offers wide flexibility for those students who wish to combine technical and nontechnical study with hands-on experience in industry. It is a career-focused program and may not be appropriate for those whose ultimate goal is a PhD in engineering.

Admission Requirements

In addition to meeting requirements for graduate admission, which include at least a 3.0 GPA for the last two years of undergraduate study and for any graduate study, applicants must hold a bachelor's degree in engineering from an accredited institution or an equivalent. Students whose background is in science or mathematics may be accepted to the program, but they will be required to take undergraduate engineering courses. Although the Graduate Record Examination (GRE) is not required for admission, it may be required of students interested in a teaching or research assistantship. Applicants whose native language is not English and who do not have previous degrees from a U.S. institution are required to submit scores of at least 550 on the Test of English as a Foreign Language (TOEFL).

Degree Requirements

All students enrolled in the program receive the ME degree from the College of Engineering. Students take a series of manufacturing core courses, a set of discipline-oriented engineering courses, business core electives, and a mathematics/quantitative methods course. A six-month period of career-related employment through Drexel's Graduate Co-op program is a requirement for full-time students. Students who are already employed as practicing engineers may apply to pursue the program on a part-time basis. A thesis is not required. The average time required to complete the master's degree is two years of full-time study or three years of part-time study.

Degree Requirements

The degree requires a total of 48 credits, including at least 18 credits from an engineering discipline core. This core may be from any engineering department: Civil and Architectural, Chemical, Electrical and Computer, Materials, or Mechanical Engineering and Mechanics. (Please refer to the appropriate departmental description in this catalog for more information about each department.) Students also complete 15 credits from the manufacturing core, which includes 6 credits in manufacturing and 9 credits of departmental manufacturing electives. Three credits of either engineering analysis or probability and statistics, 6 credits from either engineering management or the Bennett S. LeBow College of Business, and 6 credits of GCP round out the program.Curriculum

Manufacturing Core Courses

MEM 687	Manufacturing Processes I	3.0
MEM 689	Computer-Aided Manufacturing	3.0
Departmental Manufacturing Electives (see below)		9.0
Departmental Engineering Core		18.0
Engineering Management/Business Requirements (see below)		6.0

Engineering Analysis/Probability and Statistics Requirement		3.0
Graduate Co-Op Program		6.0
Departmental Manufacturing Elective Courses		
Select three of the following:		
Chemical Engineering		
CHE 525	Transport Phenomena I	
CHE 554	Process Systems Engineering	
CHE 560	Transport Phenomena in Biological Systems	
CHE 562	Bioreactor Engineering	
CHE 564	Unit Operations in Bioprocess Systems	
Electrical and Computer Engineering		
ECEC 541	Robotic Computer Interface Controls I	
ECEC 542	Robotic Computer Interface Controls II	
Materials Science and Engineering		
MATE 570	Materials Processing I	
MATE 651	Advanced Polymer Processing	
Mechanical Engineering and Mechanics		
MEM 688	Manufacturing Processes II	
MEM 717	Heat Transfer in Manufacturing	
MEM 727	Fluid Dynamics in Manufacturing Processes	
MEM 800	Special Topics Mechanical Engineering	
Business Core		
Select two of the following courses:		
LeBow College of Business		
POM 620	Management of Manufacturing Firms	
POM 624	Management of Service Firms	
Engineering Management		
EGMT 531	Economics for Engineering Management	
EGMT 607	Marketing for Engineers	
EGMT 652	Engineering Law	
EGMT 680	Special Topics in Engineering Management	
Total Credits		48.0

Environmental Engineering

Master of Science in Environmental Engineering (MSENE): 45.0 quarter credits
Doctor of Philosophy: 90.0 quarter credits

About the Program

Programs in environmental engineering are available with specializations in air pollution, hazardous and solid waste, subsurface contaminant hydrology, water resources, water and wastewater, and sustainability treatment.

Environmental engineering is concerned with protecting human, animal, and plant populations from the effects of adverse environmental factors, including toxic chemicals and wastes, pathogenic bacteria, and global warming.

Environmental engineers also try to minimize the effect of human activities on the physical and living environment so that we can all live more healthy and sustainable lives.This field builds on other branches of engineering, especially civil, chemical, and mechanical engineering. It also builds on information from many of the sciences, such as chemistry, physics,

hydrology, geology, atmospheric science, and several specializations of biology (ecology, microbiology) and public health. Students who elect to study environmental engineering will become familiar with many of these areas because maintaining and improving the environment requires that problems be evaluated and solutions found using a multidisciplinary approach.

For more information about this program, visit the MS in Environmental Engineering (http://www.drexel.edu/grad/programs/coe/environmental-engineering) web page.

Admission Requirements

In addition to the general entrance requirements for all environmental engineering applicants, entrance to the MS in Environmental Engineering program requires an undergraduate engineering degree from an ABET-approved institution. Students lacking this credential will be required to complete additional undergraduate courses to incorporate related elements of the functional equivalent of the ABET engineering BS degree. Typically, courses must be taken in computer programming, differential equations, linear algebra and fluid mechanics.

For additional information on how to apply, visit Drexel's Admissions page for Environmental Engineering (http://www.drexel.edu/grad/programs/coe/apply/requirements/p_enve).

Degree Requirements: MS in Environmental Engineering

The MS in Environmental Engineering program requires 45.0 credits of coursework. Both a theses and a non-thesis option are available. It is possible to finish the MS degree on either a part-time or full-basis. The degree consists of a set of core courses, a sequence in one of several areas of emphasis (treatment process, human risks, water resources, environmental modeling, and air quality) and completion of cognate and elective sequences. After the first term of study, a detailed plan of study is developed with the student's graduate advisor.

Degree Requirements: PhD in Environmental Engineering

Applicants to the doctoral program are judged on the basis of academic excellence and the alignment of their research interests with those of the faculty in the School. To be awarded the PhD, students must complete a major research project publishable in peer-reviewed journals. The degree requires a total of 90 credits; credits earned toward a master's degree may apply toward the 90. There is no prescribed coursework—students must take courses needed to complete their research under guidance of an academic advisor. There is a one-year residency requirement. Students must successfully pass the candidacy examination, the proposal defense, and a PhD dissertation and oral defense.

Prospective PhD student are welcome to contact the Department (http://www.drexel.edu/cae) to discuss their research interests.

Dual Degree

Dual MS Degree

The university encourages students with broad interest to consider a dual-master's option. Students can simultaneously work on two master's degree, applying to both programs a limited number of credits (a maximum of 15 to each). Applicants interested in a dual degree should apply for just one program; once enrolled at Drexel, the student may then request admission to the second program. The graduate advisors from both degree programs must approve the student's enrollment, and they must approve the transfer of credits from one program to another. Applicants considering two degrees are encouraged to contact the appropriate academic departments.

Bachelor's/Master's Dual Degree Program

The BS/MS dual degree is an accelerated program providing the academically qualified student an opportunity to simultaneously earn both BS and MS degrees (two diplomas are awarded) in program areas of his/her choice in five years, the time normally required to finish a bachelor's degree alone. Because both degrees are completed in the time usually required for the bachelor's degree, both degrees may be completed at the undergraduate tuition rate.

The five-year completion period is possible because fewer undergraduate credits are required for the combined degrees (180 instead of 192). Also, co-op experience may be adjusted (two co-op periods instead of three) giving the BS/MS student two additional quarters to take courses. If needed, students may also take evening courses while on co-op.

The program combines the practical work experience of Drexel undergraduate cooperative education with the graduate credentials of an advanced degree. Students may earn both degrees in the same major, or may complete their master's degree in a different field. With both an undergraduate and graduate degree and practical work experience, BS/MS graduates enter the work force with specialized knowledge and training.

Students interested in the Environmental Engineering BS/MS program, may contact Dr. Charles N. Haas at haas@drexel.edu for more information.

Facilities

The Department of Civil, Architectural, and Environmental Engineering is well equipped with state-of-the-art facilities:

- A $4.5-million instruction and research lab renovation — funded by the National Science Foundation, alumni, and corporations — was opened in 1999.
- The department computer labs are in operation: a computer-assisted design (CAD) and computerized instructional lab; and a graduate-level lab (advanced undergraduates can become involved in graduate-level work).
- External labs are used for surveying, building diagnostics, and surface and ground-water measurements.
- A renovated environmental engineering research lab was completed in 2006.

Materials Science and Engineering

Master of Science in Materials Science and Engineering (MSMSE): 45.0 quarter credits
Doctor of Philosophy: 90.0 quarter credits

About the Program

The graduate program in Materials Science and Engineering aims to provide an education which encompasses both the breadth and depth of the most recent knowledge base in the materials science and engineering fields in a format suitable for individuals seeking careers in academia and/or industry.

In addition, the program provides students with research training through their courses and thesis research at the MS and PhD levels.

The graduate student body reflects a broad spectrum of undergraduate backgrounds. Because of the expansion into interdisciplinary areas, qualified physical and biological science graduates may also join the program. Non-engineering graduates are required to take MATE 503-Introduction to Materials Engineering.

Graduate work in materials science and engineering is offered both on a regular full-time and on a part-time basis. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study.

Career Opportunities

Graduates go on to careers in engineering firms, consulting firms, law firms, private industry, business, research laboratories, academia, and national laboratories. Materials scientists and materials engineers find employment in such organizations as Hewlett-Packard, Intel, IBM, 3M, DuPont, Lockheed-Martin, Johnson and Johnson, Merck, AstraZeneca, Arkema, Army Research Laboratory, Los Alamos National Laboratory, Air Products, Micron, Xerox, Motorola, Monsanto, Corning, and Eastman Kodak.

For more information about Materials Science and Engineering, visit the Department of Materials Science and Engineering (http://www.materials.drexel.edu) web page.

Admission Requirements

Applicants must meet the graduate requirements for admission to Drexel University. The graduate student body reflects a broad spectrum of undergraduate backgrounds. Because of the expansion into interdisciplinary areas, qualified non-MSE engineering, physical and biological science graduates may also join the program.

For specific information on how to apply to this program, visit Drexel University's Materials Science and Engineering Graduate Admissions (http://www.drexel.edu/grad/programs/coe/materials-science-engineering) page.

Master of Science in Materials Science and Engineering

The 45.0 quarter credits required for the MS degree include two required core courses on MATE 510-Thermodynamics of Solids and MATE 512-

Introduction to Solid State Materials. Students choose four additional core courses.

Thesis Options

All full-time students are required to undertake a 9.0 credit thesis on a topic of materials research supervised by a faculty member. MS students can select the Non-thesis Option if carrying out research is not possible, in which case, the thesis may be replaced by either (a) a 6.0 credit Thesis Proposal and 3.0 credit coursework, or (b) 9.0 credits of coursework.

All students are required, during their first year, to propose an advisor supported research thesis topic or literature survey for approval by the department. Students are urged to make a choice of topic as early as possible and to choose appropriate graduate courses in consultation with their advisor.

The program is organized so that part-time students may complete the degree requirements in two to four years. Full-time students may complete the program in two years.

MS to PhD Program

There is no general exam required for MS students. If an MS student wishes to continue for a PhD then: (a) the student must be admitted to the PhD program (there is no guarantee that an MS student will be admitted to the PhD program), and (b) the student must take the Candidacy Exam during the first term after being admitted to the PhD program.-

Materials Science and Engineering (MSMSE) Core Courses [*]

Required core courses:		
MATE 510	Thermodynamics of Solids	3.0
MATE 512	Introduction to Solid State Materials	3.0
Select four additional core courses from the following:		12.0
MATE 501	Structure and Properties of Polymers	
MATE 507	Kinetics	
MATE 515	Experimental Technique in Materials	
MATE 535	Numerical Engineering Methods	
MATE 610	Mechanical Behavior of Solids	
MATE 661	Biomedical Materials I	
Any additional related courses if approved by the graduate advisor/ thesis advisor (such as MATE 514 and MATE 573)		
Optional Core Courses [**]		18.0
Thesis and Alternatives		9.0
9.0 credits MS thesis OR 6.0 credits of thesis proposal (literature review) + 3.0 credit course OR 9.0 credits of electives		
Total Credits		45.0

[*]   PhD candidates must achieve a minimum B- grade in each of the core courses. Waiver of any of the 6 core courses must be approved by the MSE Department Graduate Advisor and the student's Thesis Advisor in Advance.

[**]   Of the 18 technical elective credits, at least 9 credits must be taken as Materials Science and Engineering (MATE) courses, while the rest may be taken within the College of Engineering, College of Arts and Sciences, or at other colleges if consistent with the student's plan of study (and given advance written approval by his/her advisor). At least 9 of these 18 technical electives must be exclusive of independent study courses or research credits.

PhD in Materials Science and Engineering

Requirements

The graduate school requires at least 90.0 credits for the PhD degree in Materials Science and Engineering. An MS degree is not a prerequisite for the Ph.D. degree, but does count as 45 credits toward the 90-credit requirement. Students entering the department at the BS level must satisfy the course requirements for the MS degree.

Students choose a doctoral thesis topic after consultation with the faculty. Students are urged to consider and select topics early in their program of study. An oral thesis presentation and defense are scheduled at the completion of the thesis work.

Doctoral program students must pass a candidacy examination within the first eighteen months. The candidacy exam consists of a seminar presentation by the student, followed by an oral examination covering the materials found in the core courses as well as the subject matter presented in the seminar. Six months later, doctoral candidates present a thesis proposal outlining their research study. Approximately six months before the full defense of their Ph.D. thesis, doctoral candidates should prepare and present a pre-defense seminar.

For more information, visit the Department of Materials Science and Engineering (http://www.materials.drexel.edu) web page.

Facilities

Biomaterials and Biosurfaces Laboratory
This laboratory contains 10 kN biaxial and 5 kN uniaxial servo-hydraulic mechanical testing machines, a Fluoroscan X-ray system, a microscopic imaging system, a spectra fluorometer, a table autoclave, centrifuge, vacuum oven, CO_2 incubators, biological safety cabinet, thermostatic water baths, precision balance and ultrasonic sterilizer.

Nanobiomaterials and Cell Engineering Laboratory
This laboratory contains fume hood with vacuum/gas dual manifold, vacuum pump and rotary evaporator for general organic/polymer synthesis; gel electrophoresis and electroblotting for protein characterization; bath sonicator, glass homogenizer and mini-extruder for nanoparticle preparation; centrifuge; ultrapure water conditioning system; precision balance; pH meter and shaker.

Ceramics Processing Laboratory
This laboratory contains a photo-resist spinner, impedance analyzer, Zeta potential meter, spectrofluorometer, piezoelectric d33 meter, wire-bonder, and laser displacement meter.

Dynamic Characterization Laboratory
This laboratory contains metallographic sample preparation (sectioning, mounting and polishing) facilities; inverted metallograph; microhardness tester; automated electropolishing for bulk and TEM sample preparation; SEM tensile stage for EBSD; magneto-optical Kerr effect (MOKE) magnetometer.

MAX Phase Ceramics Processing Laboratory
This laboratory contains a vacuum hot-press; cold isostatic press (CIP) and hot isostatic press (HIP) for materials consolidation and synthesis; precision dilatometer; laser scattering particle size analyzer; impedance analyzer, creep testers, and assorted high temperature furnaces.

Mechanical Testing Laboratory
This laboratory contains mechanical and closed-loop servo-hydraulic testing machines, hardness testers, impact testers, equipment for fatigue

testing, metallographic preparation facilities and a rolling mill with twin 6" diameter rolls.

Mesoscale Materials Laboratory

This laboratory contains instrumentation for growth, characterization, device fabrication, and design and simulation of electronic, dielectric, ferroelectric and photonic materials. Resources include physical and chemical vapor deposition and thermal and plasma processing of thin films, including oxides and metals, and semiconductor nanowire growth. Facilities include pulsed laser deposition, atomic layer deposition, chemical vapor deposition, sublimation growth, and resistive thermal evaporation. Variable-temperature high-vacuum probe station and optical cryostats including high magnetic field, fixed and tunable-wavelength laser sources, several monochromators for luminescence and Raman scattering spectroscopies, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

Nanomaterials Laboratory

This laboratory contains instrumentation for testing and manipulation of materials under microscope, high-temperature autoclaves, Sievert's apparatus; glove-box; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; electro-spinning system for producing nano-fibers.

Oxide Films and Interfaces Laboratory

This laboratory contains an oxide molecular beam epitaxy (MBE) thin film deposition system; physical properties measurement system for electronic transport and magnetometry measurements from 2 – 400K, up to 9 T fields; 2 tube furnaces.

Powder Processing Laboratory

This laboratory contains vee blenders, ball-mills, sieve shaker + sieves for powder classification, several furnaces (including one with controlled atmosphere capability); and a 60-ton Baldwin press for powder compaction.

Soft Matter Research and Polymer Processing Laboratories

These laboratories contain computerized thermal analysis facilities including differential scanning calorimeters (DSC), dynamic mechanical analyzer (DMA) and thermo-gravimetric analyzer (TGA); single-fiber tensile tester; strip biaxial tensile tester; vacuum evaporator; spincoater; centrifuge; optical microscope with hot stage; liquid crystal tester; microbalance; ultrasonic cleaner; laser holographic fabrication system; polymer injection molder and single screw extruder.

Natural Polymers and Photonics Laboratory

This laboratory contains a spectroscopic ellipsometer for film characterization; high purity liquid chromatography (HPLC) system; lyophilizer; centrifuge; refractometer; electro-spinning system for producing nano-fibers.

X-ray Tomography Laboratory

This laboratory contains a high resolution X-ray tomography instrument and a cluster of computers for 3D microstructure reconstruction; mechanical stage, a positioning stage and a cryostage for in-situ testing. For more information on departmental facilities, please visit the Department's Facilities page at http://www.materials.drexel.edu/research/facilities/

Centralized Research Facilities

The Department of Materials Science & Engineering relies on Core Facilities within the University for materials characterization and micro- and nano-fabrication. These facilities contain state-of-the-art materials characterization instruments, including environmental and variable pressure field-emission scanning electron microscopes with Energy

Dispersive Spectroscopy (EDS) for elemental analysis, and Orientation Image Microscopy (OIM) for texture analysis; a Transmission Electron Microscope (TEM) with STEM capability and TEM sample preparation equipment; a dual beam focused ion beam (FIB) system for nano-characterization and nano fabrication; a femtosecond/ terahertz laser Raman spectrometer; visible and ultraviolet Raman micro spectrometers with a total of 7 excitation wavelengths for non-destructive chemical and structural analysis and Surface Enhanced Raman (SERS); a Fourier Transform Infrared (FTIR) spectrometer with a microscope and full array of accessories; a Nanoindenter; an X-ray Photoelectron Spectrometer (XPS)/Electron Spectroscopy for Chemical Analysis (ESCA) system; and X-Ray Diffractometers (XRD), including small angle/wide angle X-Ray scattering (SAX/WAX).

More details of these instruments, information how to access them and instrument usage rates can be found at http://crf.coe.drexel.edu/

Mechanical Engineering and Mechanics

Master of Science in Mechanical Engineering and Mechanics (MSME): 45:0 quarter credits
Doctor of Philosophy: 90.0 quarter credits

About the Program

The Mechanical Engineering and Mechanics (MEM) Department (http://www.drexel.edu/coe/departments/mech_eng) offers MS and PhD degrees, with four optional areas of specialization: design and manufacturing, mechanics, systems and control, and thermal and fluid sciences. The field is rapidly changing due to advances in materials, manufacturing, and communication. Mechanical engineers must possess diverse interdisciplinary skills, including an understanding of the global, entrepreneurial and managerial abilities, and teamwork skills. Graduate work is offered on both a full-time and a part-time basis. The majority of courses are scheduled in the late afternoon and evening, so part-time students can take courses together with full-time students. The General (Aptitude) Test of the Graduate Record Examination (GRE) is required for applicants pursuing full-time study. The department has adopted the Graduate Co-op program at the master's level.

Admission Requirements

Applicants must meet the graduate requirements for admission to Drexel University. Students holding a bachelor's degree in a science or engineering discipline other than mechanical engineering are advised to take several undergraduate courses as preparation for graduate studies. Though these courses are not counted toward the required credits for the degree, they also must be listed in the student's plan of study. Outstanding students with a GPA of at least 3.5 in their master's program will be considered for admission to the program leading to the doctor of philosophy degree in mechanical engineering.

Master of Science in Mechanical Engineering and Mechanics

Requirements

The MS program has a two-fold mission: to prepare some students for continuation of their graduate studies and research toward a PhD degree and to provide other students with a terminal professional degree to better prepare them for a career in industry.

The MS program is structured so that students have the opportunity to specialize in an area of interest while obtaining the broadest education possible. MS candidates are required to take two core-course sequences (two terms each) from any two core areas. Candidates may choose either the thesis or nonthesis option; all MS students are strongly recommended to follow the thesis option.

Typical MS Program

Two Core-Course Sequences (required)	12.0
Three Mathematics Courses (required) [*]	9.0
Eight Technical Electives (including 9 credits for thesis option)	24.0
Total Credits	45.0

[*]   Mathematics courses: MEM 591, MEM 592, MEM 593.

Core Areas

All students take core courses in the department's areas of specialization as part of a comprehensive and flexible program. Further details can be obtained from the department's Graduate Programs Manual (http://www.mem.drexel.edu/current/graduate/manual.php).

The core courses in each area are listed below:

Mechanics Area

Theory of Elasticity

MEM 660	Theory of Elasticity I	3.0
MEM 661	Theory of Elasticity II	3.0

Solid Mechanics

MEM 663	Continuum Mechanics	3.0
MEM 664	Introduction to Plasticity	3.0

Advanced Dynamics

MEM 666	Advanced Dynamics I	3.0
MEM 667	Advanced Dynamics II	3.0

Systems and Control Area

Robust Control Systems

MEM 633	Robust Control Systems I	3.0
MEM 634	Robust Control Systems II	3.0

Non-Linear Control Theory

MEM 636	Theory of Nonlinear Control I	3.0
MEM 637	Theory of Nonlinear Control II	3.0

Real-Time Microcomputer Control

MEM 639	Real Time Microcomputer Control I	3.0
MEM 640	Real Time Microcomputer Control II	3.0

Thermal and Fluid Sciences Area

Advanced Thermodynamics [*]

MEM 601	Statistical Thermodynamics I	3.0
MEM 602	Statistical Thermodynamics II	3.0

Heat transfer

MEM 611	Conduction Heat Transfer	3.0
MEM 612	Convection Heat Transfer	3.0
or MEM 613	Radiation Heat Transfer	

Fluid Mechanics [*]

MEM 621	Foundations of Fluid Mechanics	3.0
MEM 622	Boundry Layers-Laminar & Turbulent	3.0

[*]   Consult the Thermal and Fluid Sciences area advisor for other options.

PhD in Mechanical Engineering

Outstanding students with a GPA of at least 3.5 in their master's program will be considered for admission to the program leading to the Doctor of Philosophy degree in mechanical engineering.

PhD Course Requirements
At least 90.0 credits are required for the PhD degree. The master's degree is not a prerequisite for the PhD, but does count as 45.0 credits toward the 90.0-credit requirement.

For students entering the PhD program with an MS degree:

- 45.0 credits of graduate courses out of which 18.0 credits are graduate courses exclusive of independent study and dissertation. If the MS degree was not from Drexel's Mechanical Engineering and Mechanics department, 12.0 of these 18.0 credits must be MEM graduate courses (600-level or above). The remaining 27.0 credits consist of a combination of dissertation, independent study, and additional advanced coursework consistent with the approved plan of study. All PhD students are expected to participate in the department's seminar program, course instruction, and other academic activities.

For students entering the PhD program with a BS degree (i.e. without a master's degree):

- 90.0 credits of graduate courses. 45.0 of these 90.0 credits must satisfy the MS in Mechanical Engineering (http://www.drexel.edu/catalog/masters/mech.htm) degree requirements. The remaining 45.0 credits must satisfy the requirements above.

PhD Candidacy Examination
Students who hold a BS degree and are currently enrolled in the MEM graduate program can take the PhD candidacy examination after the completion of at least one year of graduate study at Drexel University with a minimum GPA of 3.5 in all engineering and science graduate courses. A student holding an MS degree that has not been granted by the MEM

Department can take the PhD candidacy examination after completing at least two terms of graduate study at Drexel University with a minimum GPA of 3.5 in all engineering and science graduate courses taken while in the MEM Department.

The PhD candidacy examination consists of two parts, a written part and an oral part. The written part consists of one examination in applied mathematics and one examination in a major area established by the applicant and his or her advisor. Following successful completion of the written examinations, an oral examination is administered. This examination emphasizes, but is not restricted to, the student's major area.

The PhD candidacy examination is given twice each year, at the beginning of the fall and spring terms. Additional details are given in the Mechanical Engineering and Mechanics Graduate Program Manual.

Thesis Proposal
At least one year prior to graduation, candidates must give a presentation to the dissertation committee. The committee must approve the thesis topic and the general method of attack. A final examination consisting of a presentation and defense of the research dissertation is required, before the PhD degree is granted.

Furthermore, PhD students may be required to take technical writing courses in fulfillment of their PhD requirements. Foreign PhD students are subject to the same ESL requirements as MS students.

PhD students must comply with the University's one-year residency requirement.

Further details can be obtained from the department's Graduate Programs Manual (http://www.drexel.edu/mem/programs/graduate/GradPgmManual).

Facilities

Advanced Design and Manufacturing Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=6)
This laboratory provides research opportunities in design ethodology,computer-aided design, analysis and manufacturing, and materials processing and manufacturing. Facilities include various computers and software, I-DEAS, Pro/E,ANSYS, MasterCAM, Mechanical DeskTop, SurfCAM, Euclid, Strim, ABQUS, and more.The machines include two Sanders Model Maker rapid prototyping machines, a BridgePort CNC Machining Center, a BOY 220 injection molding machine, an Electra high-temperature furnace for metal sintering, infiltration, and other heat treatment.

Biofluid Mechanics Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=5)
The biofluid mechanics laboratory conducts computational and experimental research on the dynamics of flow in the cardiovascular and respiratory system, and the effects of flow on biological processes, particularly hemostasis and thrombosis. Lab resources include high-performance engineering workstations, commercial computational fluid dynamics (CFD) software, and basic experimental facilities including Laser Doppler Velocimetry (LDV), pressure and flow transducers, pumps, and microscopes.

Biological Systems Analysis Laboratory
The research in the Laboratory for Biological Systems Analysis involves the integration of biology with systems level engineering analysis and design, with an emphasis on: (1) the development of robotic systems that borrow from nature's designs and use novel technologies to achieve superior performance and function; and (2) the use of system identification techniques to evaluate the functional performance of animal physiological systems under natural, behavioral conditions. Facilities include rapid prototyping machines, compliant material manufacturing, mold making facilities, and a traditional machine shop and electronics workshop.

Biomechanics Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=2)
Emphasis in this laboratory is placed on understanding the mechanical properties of human joints, characterization of the mechanical properties of biological materials, studies of human movements, and design and development of artificial limbs. Facilities include a 3-D kinematic measuring system, Instron testing machine, and microcomputers for data acquisition and processing. Additional biomechanical laboratory facilities are available at Moss Rehab Hospital.

Combustion and Fuels Chemistry Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=1)
Emphasis in this laboratory is placed on developing an understanding of both the chemical and physical factors that control and, hence, can be used to tailor combustion processes for engineering applications. Facilities include continuous spectroscopic reaction monitoring systems, static reactors, combustion bombs, flat flame burner systems, flow reactors, and complete analytical and monitoring instrumentation.

Combustion and Thermal-Science Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=9)
Research is conducted in the areas of (1) low temperature hydrocarbon oxidation, (2) cool flames, (3) auto-ignition, (4) flame instabilities, (5) flame structure, (6) flame ignition, and (7) flame extinction (quenching). Cooperative research projects in microgravity combustion are ongoing with NASA's Glenn Research Center in Cleveland, Ohio, to ascertain the effects of natural convection on the structure and stability of cool and premixed flames. New ways to improve fuel efficiency in practical combustors and recover waste energy in the transportation sector are also being explored.

Combustion Emissions/Engine Laboratory
In this laboratory the effects of engine operating variables, fuel type, ambient conditions, and control devices on engine performance and emissions are studied. The laboratory contains both diesel and spark ignition engines, as well as extensive engine and emissions monitoring instrumentation, including dynamometers and continuous gaseous emission analyzers. The laboratory has a high-pressure flow reactor for detailed kinetic studies of hydrocarbon oxidation processes in engines.

Composite Mechanics Laboratory
Emphasis in this laboratory is placed on the characterization of performance of composite materials. Current interest includes damage mechanisms, failure processes, and time-dependent behavior in resin-, metal-, and ceramic-matrix composites. Major equipment includes servo-hydraulic and electromechanical Instron testing machines, strain/displacement monitoring systems, environmental chambers, microcomputers for data acquisition and processing, composites fabrication facility, interferometric displacement gauge, X-radiography, and acoustic emission systems.

Drexel Plasma Institute (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=11)
The Drexel Plasma Institute (DPI) was formed in 2002 to stimulate and coordinate research projects related to plasma and other modern

high energy engineering techniques. Today the DPI is an active multidisciplinary organization involving 23 faculty members from 6 engineering departments working in close collaboration with School of Biomedical Engineering, College of Arts and Sciences and College of Nursing and Health Professions.

Heat Transfer Laboratory
The heat transfer laboratory is outfitted with an array of instrumentation and equipment for conducting single- and multiphase heat transfer experiments in controlled environments. Facilities include computer-controlled data acquisition (LabVIEW) systems, a Newport holographic interferometric system with associated lasers and optics, image enlargers, power amplifiers, precision voltmeters, slip-ring assemblies, and an IBM RISC/6000 workstation for large-scale computing and simulation. A draft-free room is available with independent temperature control for carrying out natural convection experiments. An experimental test-rig is available for studying heat transfer from rotating surfaces. A bubble column has been recently built to study multiphase flow and heat transfer problems. Facilities are also available for measuring thermal conductivities of thin films using a thermal comparator.

Microcomputer Controls Laboratory
This laboratory provides an environment conducive to appreciating aspects of systems and control through hands-on experiments. They range from data acquisition and processing to modeling of dynamical systems and implementing a variety of controllers to control systems, such as DC motors and the inverted pendulum. Facilities also include microcontrollers such as Basic Stamp and the Motorola 68HCl 1. Active research is being conducted on control reconfiguration in the event of actuator failures in aircrafts.

Non-Newtonian Fluid and Heat Transfer Laboratory
Emphasis in this laboratory is placed on the study of hydrodynamic and thermal performance of various non-Newtonian viscoelastic fluids in complex flow geometries. Facilities and equipment include a 20-foot-long recirculating flow loop with a 500-gallon reservoir tank and a thermal conductivity measurement cell. A complete data acquisition system provides fully automated experimental operation and data reduction. A state-of-the-art finite element code FIDAP running on a CDC 180 computer provides three-dimensional flow and heat transfer simulations of flows in complex geometrics, with a complete post-processing graphic capability backed by template.

Precision Instrumentation and Metrology Laboratory (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=7)
This laboratory is focused on activities related to precision measurement, computer-aided inspection, and precision instrument design. Facilities include 3D Coordinate Measuring Machine (Brown & Sharpe) with Micro Measurement and Reverse engineering software, Surface Profilometer, and Laser Displacement Measuring System.

Rheology Laboratory
Emphasis in this laboratory is placed on developing tools for rheological property measurement of various non-Newtonian fluids, including friction-reducing viscoelastic fluids, molten polymers, coal-water slurries, ceramic slurries, and bonding cements for biomedical applications. A capillary tube viscometer, falling ball and needle viscometers, and Brookfield rotating viscometer are available. In particular, the capillary tube viscometer is designed to allow fully automated operation, thus avoiding time-consuming data collection procedures. A high-temperature and high-pressure capillary tube viscometer is under development, so that viscosities of advanced polymer materials can be measured at relatively high temperatures and shear rates.

Rapid Product Development Center (http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=4)
This center provides fundamental research, educational instruction, and engineering services in product design and manufacturing, solid freeform fabrication, and computer-aided tissue engineering.The center is equipped with state-of-the-art CAD/CAE/CAM, medical imaging processing, and 3D reconstruction software, and a rapid prototyping system.

Master of Science in Software Engineering

Master of Science in Software Engineering (MSSE): 45.0 quarter credits

About the Program

Drexel University's Master of Science in Software Engineering program was created in response to the growing importance of software to the national infrastructure and the rapid rise in demand for professional software engineers.

The MS in Software Engineering is a multidisciplinary degree sponsored by the College of Engineering and the College of Information Science and Technology. The program, drawing on the strengths of existing Drexel programs in computer science, engineering, and information science and technology, provides a curriculum that encompasses behavioral, managerial, and technical aspects of software engineering and attempts to synthesize—rather than differentiate—disciplinary paradigms and themes. The program is appropriate for students interested in a wide range of application domains.

All students in the program take a core curriculum that spans the scope of disciplinary areas relevant to the degree, thereby providing a common foundation for all students in the program. Students also elect an area of concentration, or track — a cohesive, more specialized set of courses that builds on the core to support each student's particular career interest. Three tracks are available: information science and technology, computer science, and engineering. The average time to complete this master's degree is three years of part-time study.

Admission Requirements

In addition to satisfying the general admission requirements of the University, all applicants to the program must satisfy the following entrance requirements:

- Applicants must have a bachelor's degree from an accredited institution of higher education with an appropriate undergraduate major. Appropriate undergraduate majors include, but are not limited to, computer science, engineering, information systems, management science, and mathematics. Applicants may also have master's degrees in similar fields.
- After consultation with an academic advisor, students found to be deficient in one or more of the areas below will be required to take foundation courses (these will not count toward the degree) to prepare them for admission to the MSSE program. These foundation courses, to be determined by the advisor, will provide students with the requisite knowledge and skill necessary to begin the master's program. Foundation courses must be taken at Drexel or another approved university.

- In addition to the prerequisite (http://www.drexel.edu/cs/academics/ grad/admissions/prerequisites) courses listed in the Computer Science website, applicants should possess the following knowledge and/or experience:
  - Advanced capability to program in a block-structured programming language such as Pascal, C, or Ada, or an object-oriented language such as C++ or Smalltalk.
  - A grade of B or better in an undergraduate course in systems analysis and design or software engineering.
  - A grade of B or better in an undergraduate course in data structures and algorithms.
  - A grade of B or better in an undergraduate course in discrete mathematics.
  - Applicants must demonstrate evidence of an understanding of the development of industrial-strength software applications. This requirement may be met by at least two years of experience working directly with software system development, or (with permission of an advisor) by extensive software-intensive coursework. Students may also be required to have or develop proficiency in particular technologies, operating systems, or programming languages.

How to Apply

Additional details on how to apply to the MS in Software Engineering program depends on the chosen track. Visit the Drexel University Admissions web site to learn more about the Information Science and Technology Track (http://www.drexel.edu/grad/programs/ischool/apply/ requirements/p_se)

Students interested in the College of Engineering track should complete the requirements for the College of Engineering application (http:// www.drexel.edu/grad/programs/coe/apply).

Degree Requirements

Degree requirements vary by track. All students take the required six core courses (18.0 quarter credits).

Core Courses

Core courses cover topics that are essential for the practicing software engineer.

Degree Requirements

Degree requirements vary by track. All students take the required six core courses (18.0 quarter credits).

Core Courses

Core courses cover topics that are essential for the practicing software engineer.

Computer Science Courses		
CS 575	Software Design	3.0
CS 576	Dependable Software Systems	3.0
Electrical and Computer Engineering Courses		
ECEC 500	Fundamentals Of Computer Hardware [*]	3.0
ECEC 600	Fundamentals of Computer Networks [*]	3.0
Information Science and Technology Courses		
INFO 627	Requirements Engineering and Management	3.0
INFO 638	Software Project Management	3.0
Total Credits		18.0

[*] For students enrolled in the online program, INFO 631 Information Technology Integration may be substituted for ECEC 500, and CS 544 Computer Networks may be substituted for ECEC 600.

Tracks

Students in each track follow the policies determined by the respective College.

Information Science and Technology Track

This track supports students interested in applying software engineering to information systems problems in commercial organizations and other settings. The principal focus is the process by which user and system requirements are converted into cost-effective, maintainable software systems. This is complemented by a concern for defining, creating, understanding, and evaluating the full range of software life-cycle products. The track places particular emphasis on information systems methodologies such as human-computer interaction, requirements analysis, modeling, and validation, along with the use of off-the-shelf tools and components to assist in software processes.

Students in the information science and technology track take a total of nine track courses: four required track courses, three courses selected from the track distribution courses, and two courses selected from the distribution courses or other approved electives. This track requires a total of 45 credits, 18 of which are from the required core.

Required Courses		12.0
INFO 608	Human-Computer Interaction	
INFO 630	Evaluation of Information Systems	
INFO 636	Software Engineering Process I	
INFO 637	Software Engineering Process II	
Distribution Courses		9.0
Select three of the following:		
INFO 606	Advanced Database Management	
INFO 607	Applied Database Technologies	
INFO 610	Analysis of Interactive Systems	
INFO 611	Design of Interactive Systems	
INFO 620	Information Systems Analysis and Design	
INFO 631	Information Technology Integration	
INFO 646	Information Systems Management	
Two Elective Courses		6.0
Select two of the following:		
INFO 612	Knowledge Base Systems	
INFO 613	XML and Databases	
INFO 616	Social and Collaborative Computing	
INFO 617	Introduction to System Dynamics	
INFO 634	Data Mining	
Total Credits		27.0

Computer Science Track

Track Coordinator: Dr. Spiros Mancoridis, 215-895-6824, spiros@drexel.edu

The computer science track welcomes students who are interested in a variety of technical topics pertaining to the development of software systems such as databases, networks, operating systems, graphics and animation systems, compilers, expert systems, and systems for scientific computing. Students will use languages and apply techniques to specify, design, implement, test, and maintain software systems.

Students in the computer science track take nine courses in addition to the six core courses listed above (for a total of 15 courses). Of the nine additional courses, four courses must be from one of the five concentration areas, plus five electives must be graduate level CS courses and two may be fulfilled by any graduate level CS or INFO courses, except for INFO 605 and INFO 530.

Students in their final 3 quarters of study who have a 3.5 GPA or better may take a 9-credit project instead of 3 elective courses. To register for a project, the student must select a project advisor (a member of the CS faculty who is willing to supervise). The project is a large-scale software development effort in which students specify, design, implement, and test a significant software system.

Concentration Courses		12.0
Select four of the following:		
Computing Systems Concentration		
CS 500	Database Theory	
CS 540	High Performance Computing	
CS 543	Operating Systems	
CS 544	Computer Networks	
CS 643	Advanced Operating Systems	
CS 645	Network Security	
CS 647	Distributed Systems Software	
CS 675	Reverse Software Engineering	
CS 676	Parallel Programming	
CS 741	Computer Networks II	
CS 680	Special Topics in Computer Science (Computer Systems)	
Programming Languages Concentration		
CS 525	Theory of Computation	
CS 550	Programming Languages	
CS 551	Compiler Construction I	
CS 552	Compiler Construction II	
CS 650	Program Generation and Optimization	
CS 675	Reverse Software Engineering	
CS 676	Parallel Programming	
CS 680	Special Topics in Computer Science (Programming Languages)	
User Interface Software Concentration		
CS 530	Developing User Interfaces	
CS 536	Computer Graphics	
CS 630	Cognitive Systems	
CS 636	Advanced Computer Graphics	
CS 680	Special Topics in Computer Science (User Interface Software)	
Artificial Intelligence Concentration		
CS 510	Introduction to Artificial Intelligence	
CS 511	Robot Laboratory	
CS 610	Advanced Artificial Intelligence	
CS 612	Knowledge-based Agents	
CS 613	Machine Learning	
CS 680	Special Topics in Computer Science (Artificial Intelligence)	
Theory and Scientific Computation Concentration		
CS 520	Computer Science Foundations	
CS 521	Data Structures and Algorithms I	
CS 522	Data Structures and Algorithms II	
CS 540	High Performance Computing	
CS 567	Applied Symbolic Computation	
CS 668	Computer Algebra I	
CS 669	Computer Algebra II	
CS 676	Parallel Programming	
CS 680	Special Topics in Computer Science (Theory & Scientific Computation)	
Total Credits		12.0

For additional information on the Computer Science Track, as well as an FAQ, visit the Department of Computer Science's Master of Science in Software Engineering (https://www.cs.drexel.edu/graduate/msse) web page.

Engineering Track

Track Coordinator: Dr. Kapil Dandekar, 215-571-3579, dandekar@ece.drexel.edu

Students in this track pursue techniques to model engineering problems and offer software solutions. The courses in this track emphasize problems facing engineering industries including electrical, mechanical, environmental, chemical, and others. Systems modeling and simulation techniques will be used to solve these problems.

Students in this track take 27 or more credits of track courses in addition to the 18 credits of required core courses. Three computer engineering courses are required; the other courses are from one of five concentrations. A total of 45 approved graduate credits are required for the MSSE, including the 18 credits of core courses. Students opting for the Graduate Co-op Program (GCP) option are required to complete 51 approved credits, including 6 GCP credits.

For more information on curriculum requirements, visit the Department of Electrical and Computer Engineering's Graduate Student Guide (http://www.ece.drexel.edu/MSSE.html).

Sample Track Courses		27.0
Select nine of the following:		
Chemical Engineering Concentration		
CHE 554	Process Systems Engineering	
CHE 658	Advanced Process Design	
Civil and Architectural Engineering Concentration		
CIVE 501	Model Analysis of Structures	
CIVE 605	Advanced Mechanics Of Material	
CIVE 701	Structural Analysis I	
CIVE 702	Structural Analysis II	
CIVE 703	Structural Analysis III	
CIVE 704	Behavior and Stability of Structural Members I	
Electrical and Computer Engineering Concentration [*]		

ECEC 511	Combinational Circuit Design
ECEC 512	Sequential Circuit Design
ECEC 513	Design for Testability
ECEC 621	High Performance Computer Architecture
ECEC 622	Parallel Computer Architecture
ECEC 623	Advanced Topics in Computer Architecture
Total Credits	27.0

*   Any other ECE 500-level or above course may be eligible for credit for the Electrical and Computer Engineering concentration.

Dual MS Degree Opportunities

MS in Software Engineering (Computer Science Track) Dual Degree Program

Graduate students already enrolled in a master's degree program at Drexel have the opportunity, through the dual master's program, to work simultaneously on two master's degrees and to receive both upon graduation. To be eligible, graduate students must be currently working on their first degree when requesting admission to the second. They must obtain approval from the graduate advisors of both programs and work out a plan of study encompassing coursework and/or research (thesis) credits for both degrees.

To satisfy dual degree requirements for MSSE-CS the plan of study must include the following: the core and 4 concentration courses for a total of 30.0 credits. To obtain a dual degree you must have a minimum of 60 credits, thesis (MSSE-CS has a 9-credit project in place of thesis) and research credits will be in excess of the 30.0 credits required by MSSE-CS

The dual master's student must complete the Graduate Dual Degree Form (http://www.drexel.edu/provost/graduatestudies/forms/Graduate_Dual_Degree_Form.pdf) and obtain approvals from both graduate advisors. Final approval is granted by the Office of Graduate Studies. The student is then registered in both majors simultaneously. Upon graduation, the student must file two Application for Degree (http://www.drexel.edu/SRC/application_for_degree.asp) forms.

Electrical Engineering/Telecommunications Engineering

Master of Science in Electrical/Telecommunications Engineering (MSEET): 45.0 - 48.0 quarter credits
Doctor of Philosophy: 90.0 quarter credits

About the Program

Fueled by the rapid spread of technologies such as electronic mail, cellular and mobile phone systems, interactive cable television, and the information superhighway, Drexel's program in Telecommunications Engineering responds to the growing demand for engineers with telecommunications expertise. The program combines a strong foundation in telecommunications engineering with training in other important issues such as global concerns, business, and information transfer and processing.

Drexel University's program in Telecommunications Engineering combines the expertise of its faculty in electrical and computer

engineering, business, information systems, and humanities. Through its interdisciplinary approach, Drexel's Telecommunications Engineering program trains and nurtures the complete telecommunications engineer. The MS in Electrical Engineering/Telecommunications Engineering degree is awarded to students who demonstrate in-depth knowledge of the field. The average time required to complete the master's degree is two year of full-time or three years of part-time study.

For more information, visit the Department of Electrical and Computer Engineering' (http://www.ece.drexel.edu)s web site.

Admission Requirements

Applicants must meet the general requirements for graduate admission, which include at least a 3.0 GPA for the last two years of undergraduate study and for any graduate level study undertaken, and are required to hold a bachelor of science degree in electrical engineering or a related field. Applicants whose undergraduate degrees are not in the field of electrical engineering may be required to take a number of undergraduate courses. The GRE General Test is required of applicants for full-time MS and PhD programs. Applicants whose native language is not English and who do not have a previous degree from a U.S. institution are required to take the Test of English as a Foreign Language (TOEFL).

For additional information on how to apply, visit Drexel's Admissions page for Electrical-Telecommunications Engineering (http://www.drexel.edu/grad/programs/coe/electrical-telecommunications).

MS in Electrical and Telecommunications Engineering

The Master of Science in Electrical and Telecommunications Engineering curriculum encompasses 45.0 or 48.0 (with the Graduate Co-Op) approved credit hours, chosen in accordance with the following requirements and a plan of study arranged with the departmental graduate advisor in consultation with the student's research advisor (if applicable). Before the end of the first quarter in the Department of Electrical and Computer Engineering, for a full-time student, or by the end of the first year for a part-time student, this lan of study must be filed and approved with the departmental graduate advisor.

Degree Requirements

A total of at least 30.0 credit hours must be taken from among the graduate course offerings of the Department of Electrical and Computer Engineering. These credits must be taken at Drexel University. No transfer credit may be used to fulfill these requirements, regardless of content equivalency.

Electrical and Computer Engineering Courses		30.0
Select ten of the following:		
ECEC 631	Principles of Computer Networking	
ECEC 632	Performance Analysis of Computer Networks	
ECEC 633	Advanced Topics in Computer Networking	
ECES 511	Fundamentals of Systems I	
ECES 512	Fundamentals of Systems II	
ECES 513	Fundamentals of Systems III	
ECES 521	Probability & Random Variables	
ECES 522	Random Process & Spectral Analysis	

ECES 523	Detection & Estimation Theory	
ECES 631	Fundamentals of Deterministic Digital Signal Processing	
ECES 632	Fundamentals of Statistical Digital Signal Processing	
ECES 682	Fundamentals of Image Processing	
ECET 501	Fundamentals of Communications Engineering	
ECET 511	Physical Foundations of Telecommunications Networks	
ECET 512	Wireless Systems	
Total Credits		30.0

With the remaining required 15.0 credit hours, students may take graduate coursework, subject to the approval of the departmental graduate advisor, in electrical and computer engineering, mathematics, physics or other engineering disciplines.

In addition, students pursuing an MS in Electrical and Telecommunications Engineering are allowed and strongly encouraged to take the following course as part of their required 15.0 credit hours:

| COM 650 | Telecommunications Policy in the Information Age | 3.0 |

Although not required, students are encouraged to complete a Master's Thesis as part of the MS studies. Those students who choose the thesis option may count up to 9.0 research/thesis credits as part of their required credit hour requirements.

Graduate Co-Op Program

Students may choose to participate in the Graduate Co-Op Program, where 6.0 credit hours can be earned for a six month co-operative education experience in industry, working on curriculum related projects. The total number of required credit hours is increased to 48 for those students who choose to pursue the Graduate Co-Op option. This change represents an increase in non-departmental required credit hours to a total of 18.0 credit hours, 6.0 of which are earned from the co-operative education experience.

Please note that ECEC 500 (Fundamentals of Computer Hardware) and ECEC 600(Fundamentals of Computer Networks) do **not** count toward the credit requirements to complete the MS in Electrical Engineering degree program.

For more information on curricular requirements, visit the Department of Electrical and Computer Engineering (http://www.ece.drexel.edu)'s web site.

PhD in Electrical Engineering

General Requirements
The following general requirements must be satisfied in order to complete the PhD in Electrical Engineering:

- 90.0 credit hours total
- candidacy examination
- research proposal
- dissertation defense

Students entering with a master's degree in electrical or computer engineering or a related field will be considered a post-masters PhD student and will only be required to complete a total of 45.0 credit hours, in accordance with University policy.

Curriculum
Appropriate coursework is chosen in consultation with the student's research advisor. A plan of study must be developed by the student to encompass the total number of required credit hours. Both the departmental graduate advisor and the student's research advisor must approve this plan.

Candidacy Examination
The candidacy examination explores the depth of understanding of the student in his/her specialty area. The student is expected to be familiar with, and be able to use, the contemporary tools and techniques of the field and to demonstrate familiarity with the principal results and key findings.

The student, in consultation with his/her research advisor, will declare a principal technical area for the examination. The examination includes the following three parts:

- A self-study of three papers from the archival literature in the student's stated technical area, chosen by the committee in consultation with the student.
- A written report (15 pages or less) on the papers, describing their objectives, key questions and hypotheses, methodology, main results and conclusions. Moreover, the student must show in an appendix independent work he/she has done on at least one of the papers – such as providing a full derivation of a result or showing meaningful examples, simulations or applications.
- An oral examination which takes the following format:
  - A short description of the student's principal area of interest (5 minutes, by student).
  - A review of the self-study papers and report appendix (25-30 minutes, by students).
  - Questions and answers on the report, the appendix and directly related background (40-100 minutes, student and committee).

In most cases, the work produced during the candidacy examination will be a principal reference for the student's PhD dissertation; however, this is not a requirement.

Research Proposal
Each student, after having attained the status of PhD Candidate, must present a research proposal to a committee of faculty and industry members, chosen with his/her research advisor, who are knowledgeable in the specific area of research. This proposal should outline the specific intended subject of study, i.e., it should present a problem statement, pertinent background, methods of study to be employed, expected difficulties and uncertainties and the anticipated form, substance and significance of the results.

The purpose of this presentation is to verify suitability of the dissertation topic and the candidate's approach, and to obtain the advice and guidance of oversight of mature, experienced investigators. It is not to be construed as an examination, though approval by the committee

is required before extensive work is undertaken. The thesis proposal presentation must be open to all; announcements regarding the proposal presentation must be made in advance.

The thesis advisory committee will have the sole responsibility of making any recommendations regarding the research proposal. It is strongly recommended that the proposal presentation be given as soon as possible after the successful completion of the candidacy examination. The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.

Dissertation Defense

Dissertation Defense procedures are described in the Office of Graduate Studies policies regarding Doctor of Philosophy Program Requirements (http://www.drexel.edu/provost/graduatestudies). The student must be a PhD candidate for at least one year before he/she can defend his/her doctoral thesis.

Dual Degree

The ECE Department offers outstanding students the opportunity to receive two diplomas (BS and MS) at the same time. The program requires five (5) years to complete. Participants, who are chosen from the best undergraduates students, work with a faculty member on a research project and follow a study plan that includes selected graduate classes. This program prepares individuals for careers in research and development; many of its past graduates continued their studies toward a PhD.

For more information on eligibility, academic requirements, and tuition policy visit the Engineering Combined BS/MS (http://www.ece.drexel.edu/undergrad/bsms.html) page.

Facilities

Drexel University and the Electrical and Computer Engineering Department are nationally recognized for a strong history of developing innovative research. Research programs in the ECE Department prepare students for careers in research and development, and aim to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. The ECE Department is well equipped with state-of-the-art facilities in each of the following ECE Research laboratories:

Research Laboratories at the ECE Department

- **Adaptive Signal Processing and Information Theory Research Group** (http://www.ece.drexel.edu/aspitrg.html)
- **Applied Communications and Information Networking Center** (http://www.ece.drexel.edu/acinc.html)
- **Applied Networking Research Laboratory** (http://www.ece.drexel.edu/anrl.html)
- **Biochemical Signal Processing Laboratory** (http://www.ece.drexel.edu/bspl.html)
- **Cleanroom Microfabrication Facility** (http://www.ece.drexel.edu/cmf.html)
- **Data Fusion Laboratory** (http://www.ece.drexel.edu/dfl.html)
- **Drexel Network Modeling Laboratory** (http://www.ece.drexel.edu/dnml.html)

- **Drexel Wireless Systems Laboratory** (http://www.ece.drexel.edu/dwsl.html)
- **Electric Power Engineering Center** (http://www.ece.drexel.edu/epec.html)
- **Electronic Design Automation (EDA) Facility** (http://www.ece.drexel.edu/edaf.html)
- **Microwave Photonics Center** (http://www.ece.drexel.edu/mpc.html)
- **Microwave-Photonics Device Laboratories** (http://www.ece.drexel.edu/mpdl.html)
- **Music and Entertainment Technology Laboratory** (http://www.ece.drexel.edu/metl.html)
- **NanoPhotonics Laboratory** (http://www.ece.drexel.edu/npl.html)
- **Opto-Electro-Mechanical Laboratory** (http://www.ece.drexel.edu/oeml.html)
- **Plasma and Magnetics Laboratory** (http://www.ece.drexel.edu/pml.html)
- **Power Electronics Research Laboratory** (http://www.ece.drexel.edu/perl.html)
- **Supervisory Control Laboratory** (http://www.ece.drexel.edu/scl.html)
- **Testbed for Power/Performance Management of Enterprise Computing Systems** (http://www.ece.drexel.edu/tppm.html)

Certificate in Infrastructure Engineering Management

The graduate certificate in infrastructure engineering management is designed to prepare engineers to manage large-scale infrastructure projects and key personal interactions with external stakeholders. The program builds upon the College of Engineering's excellence in areas such as engineering management, civil engineering, and environmental risk analysis. Courses focus on decision making, planning and management and explore the impact of regulations on work with public funding and how contractual relationships dominate its execution. Upon successful completion of the program, graduates will be skilled at managing the flow of public resources, integrating an array of projects into a long-term program, and incorporating public values and participation in infrastructure decisions. The six-course sequence is an 18-credit graduate certificate students can utilize either as a professional development credential or to apply as electives toward the completion of a Master's in Engineering Management.

Required Courses

EGMT 501	Engineering Management	3.0
EGMT 515	Infrastructure Systems & Performance Evaluation	3.0
EGMT 516	Infrastructure Project & Program Planning	3.0
EGMT 517	Public Value & Participation in Infrastructure Decision	3.0
EGMT 520	Infrastructure Capstone	3.0
Elective chosen from either the MS in Engineering Management or MS in Construction Management programs		3.0
Total Credits		18.0

Certificate in Power Engineering Management

The certificate in power engineering management is oriented toward engineers in power utilities, utility associations, or infrastructure firms interested in power distribution systems. The scope of this graduate-level program includes both program management and enhancement of technical knowledge beyond a bachelor's degree.

Admission to this graduate certificate program requires an undergraduate degree in engineering. Completed credits from the certificate completion can apply toward either a master's in engineering management or a master's in electrical engineering.

Required Courses

ECEP 501	Power System Analysis	3.0
ECEP 502	Computer Analysis of Power Systems	3.0
ECEP 503	Synchronous Machine Modeling	3.0
ECEP 612	Economic Operation of Power Systems	3.0
EGMT 501	Engineering Management	3.0
EGMT 516	Infrastructure Project & Program Planning	3.0
Total Credits		18.0

Architectural Engineering

Courses

AE 220 Introduction to HVAC 3.5 Credits
This course includes a review of thermodynamics, moist air properties and processes, basic heat transfer, solar radiation, heating and cooling losses and load calculation, types of air conditioning systems, infiltration and ventilation, air motion and distribution.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CAEE 201 [Min Grade: D] and (ENGR 210 [Min Grade: D] or TDEC 202 [Min Grade: D])

AE 340 Architectural Illumination and Electrical Systems 3.0 Credits
This course covers building electrical systems, including power demand, distribution and control; building illumination techniques, including lighting demand, layout and energy analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CAEE 201 [Min Grade: D] and (PHYS 102 [Min Grade: D] or TDEC 115 [Min Grade: D])

AE 380 Special Topics in Architectural Engineering 0.5-12.0 Credits
Various topics of interest in the field of architectural engineering. See program director for details on topics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

AE 390 Architectural Engineering Design I 4.0 Credits
Establishes a base of building systems design concepts, knowledge and performance criteria, with emphasis on the thermal, electrical, illumination and structural aspects of buildings.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: AE 220 [Min Grade: D] and AE 340 [Min Grade: D] and ARCH 192 [Min Grade: D] and MEM 202 [Min Grade: D]

AE 391 Architectural Engineering Design II 4.0 Credits
Emphasizes the development of insight into the solution of building system design problems, development of in-depth understanding of building systems design synthesis, and integration in a single building of modest scale and complexity.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: AE 390 [Min Grade: D]

AE 399 Independent Study in Architectural Engineering 12.0 Credits
Independent study on a topic selected by the student. Independent study is supervised by a faculty member and guided by a plan of study.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

AE 430 Control Systems for HVAC 3.0 Credits
This course introduces basic control concepts with applications to HVAC systems; direct digital control, control loops; system modeling; transfer functions; selecting and locating sensors and actuators; design and tuning control algorithms; design and programming of HVAC control systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: AE 220 [Min Grade: D] or MEM 413 [Min Grade: D]

Civil & Arch Engineering

Courses

CAE 491 [WI] Senior Design Project I 3.0 Credits
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CIVE 330 [Min Grade: D] and (CIVE 301 [Min Grade: D] or CIVE 371 [Min Grade: D]) and (AE 391 [Min Grade: D] or CIVE 310 [Min Grade: D])

CAE 492 [WI] Senior Design Project II 3.0 Credits
Continues CAE 491. Requires written and oral progress reports. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CAE 491 [Min Grade: D]

CAE 493 [WI] Senior Design Project III 3.0 Credits
Continues CAE 492. Requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CAE 492 [Min Grade: D]

Civil, Arch & Envr Engr

Courses

CAEE 201 Introduction to Infrastructure Engineering 3.0 Credits
This course presents case studies to introduce the design, construction, operation and maintenance of infrastructure projects. Key engineering elements within civil, architectural and environmental engineering are presented. The concept of an "infrastructure system" along with interrelationships among three disciplines are illustrated using specific case studies which changes annually as various local infrastructure projects move from design through construction. On or two field trips are part of the course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CAEE 210 Measurements in Civil, Architectural and Environmental Engineering I 3.0 Credits
This course introduces student to various technical specialties within Civil, Architectural and Environmental engineering through hands-on experience of conducting field and laboratory measurements that are typical to three engineering fields. The course emphasizes graphical presentation of data using EXCEL, SKETCHUP and other software. Students collect data from lab or field sites.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CAEE 201 [Min Grade: D]

CAEE 211 Measurements in Civil, Architectural and Environmental Engineering II 4.0 Credits
This course is a continuation of CAEE 210. There are two main modules in the course: fundamental geological principles and relationships to engineering properties and fundamental surveying principles and measurements using modern surveying equipment including GPS.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CAEE 210 [Min Grade: D]

Chemical Engineering

Courses

CHE 201 Process Material Balances 3.0 Credits
Covers elementary principles of chemical engineering, use of stoichiometry and material balances to analyze chemical processing operations, and application to specific commercial processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 121 [Min Grade: D] or CHEM 102 [Min Grade: D] or CHEM 162 [Min Grade: D]

CHE 202 Process Energy Balances 3.0 Credits
Covers use of first law to analyze chemical processing operations, energy balances for non-reactive and reactive processes, chemical reaction equilibria, and application to specific commercial processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 201 [Min Grade: D]
Corequisite: CHE 206

CHE 206 Basic Chemical Engineering Thermodynamics 3.0 Credits
First and second laws of thermodynamics, use of state functions to solve macroscopic problems, distinction between solving ideal gas and real fluid problems. An introduction to phase equilibrium and mixtures. Concepts of fugacity and activity as measures of nonideality.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CHE.
Prerequisites: CHE 201 [Min Grade: D] and MATH 200 [Min Grade: D]
Corequisite: CHE 202

CHE 250 Chemical Engineering Process Principles 3.0 Credits
Applies heuristics to the art process synthesis and analysis. Identify key parameters in reaction and separation in processes. Examine common and divergent elements of major chemical processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CHE 201 [Min Grade: D]
Corequisite: CHE 202

CHE 301 Process Thermodynamics 3.0 Credits
Within the context of processes previously introduced, covers application of first and second laws to engineering processes, thermodynamic analysis of processes, and behavior of reacting and non-reacting homogeneous and heterogeneous mixtures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 202 [Min Grade: D] or MEM 210 [Min Grade: D] or CHE 206 [Min Grade: D]

CHE 302 Process Fluid Mechanics 4.0 Credits
Within the context of processes previously introduced, introduces fluid flow of gases, liquids, and particulates; momentum transport; skin friction; drag; piping networks; filtration; and fluidization.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 221 [Min Grade: D] or MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or ENGR 232 [Min Grade: D]

CHE 303 Process Heat Transfer 3.0 Credits
Covers, within the context of processes previously introduced, transfer of energy by conduction, convection, and radiation; continuation of transport phenomena; design of heat exchangers; and applications in industry and in nature.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 302 [Min Grade: D]

CHE 304 Process Mass Transfer 4.0 Credits
Covers, within the context of processes previously introduced, mass transfer in mixtures; diffusion, convection, and continuation of transport phenomena; component separation in continuous contractors; gas absorption; liquid-liquid extraction; and simultaneous heat and mass transfer.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 303 [Min Grade: D]

CHE 305 Process Separations 4.0 Credits
Covers, within the context of processes previously introduced, the application of thermodynamics and equilibrium stage concepts to the unit operations involved in chemical processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 301 [Min Grade: D] and CHE 307 [Min Grade: D]

CHE 307 Process Modeling I 4.0 Credits
Models simple chemical and biochemical processes such as heating, cooling, and separation systems. Covers analytical and numerical methods for solving algebraic and ordinary differential equations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 221 [Min Grade: D] or MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or ENGR 232 [Min Grade: D]

CHE 308 Process Modeling II 4.0 Credits
Covers mathematical modeling of chemical and biochemical processes such as chemical and biochemical reactors and heating and cooling systems, analytical methods for solving algebraic and ordinary-differential equations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 305 [Min Grade: D] and CHE 307 [Min Grade: D]
Corequisite: CHE 304

CHE 310 Transport Phenomena 4.0 Credits
Non-chemical engineering students only. Examines mass, momentum, and energy transport in processes applied to electrical and materials engineering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is CHE or classification is Freshman
Prerequisites: TDEC 202 [Min Grade: D] or MEM 210 [Min Grade: D] or ENGR 210 [Min Grade: D]

CHE 311 Fluid Flow and Transport 3.0 Credits
Non-chemical engineering students only. Examines fluid flow and heat and mass transfer in processes associated with civil, environmental, and materials engineering disciplines.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is CHE or classification is Freshman
Prerequisites: TDEC 202 [Min Grade: D] or MEM 210 [Min Grade: D]

CHE 332 [WI] Chemical Engineering Laboratory 2.0 Credits
Requires students to perform experiments illustrating the fundamentals of chemical engineering process analysis. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 302 [Min Grade: D] (Can be taken Concurrently)CHE 301 [Min Grade: D]

CHE 333 [WI] Chemical Engineering Laboratory II 2.0 Credits
Offers laboratory experiments illustrating the fundamentals of chemical engineering process analysis. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 303 [Min Grade: D] (Can be taken Concurrently)CHE 302 [Min Grade: D]

CHE 334 [WI] Chemical Engineering Laboratory III 2.0 Credits
Offers laboratory experiments illustrating the fundamentals of chemical engineering process analysis. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 304 [Min Grade: D] (Can be taken Concurrently)CHE 303 [Min Grade: D]

CHE 335 Statistics and Design of Experiments 3.0 Credits
Provides statistical treatment of engineering data, including application of statistical techniques to process model formulation, statistical designs of engineering experiments, and analysis of probabilistic systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or TDEC 221 [Min Grade: D] or ENGR 232 [Min Grade: D]

CHE 360 BioProcess Principles 3.0 Credits
This course is concerned with manufacturing processes involving biological substances. Students gain detailed knowledge in the design and operation of bioreactors and learn about biomolecules produces therein. Specific topics covered include: Cells (type, organization, function and growth); Protein and Enzymes; Bioreactor Process Principles (active vs. passive immobilization, fermentation and scale-up, recovery and purification); Special consideration for animal and plant cell cultures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CHE 250 [Min Grade: D] and BIO 214 [Min Grade: D] and BIO 215 [Min Grade: D]

CHE 399 Special Problems in Chemical Engineering 1.0-12.0 Credit
Covers individual research problems of a non-routine nature. Requires report.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

CHE 400 Special Topics in Chemical Engineering 3.0 Credits
Special courses offered in response to particular student and/or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

CHE 420 Process Systems Engineering 3.0 Credits
Covers the application of automatic control theory to chemical processes within the context of processes previously introduced.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 221 [Min Grade: D] or MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or ENGR 232 [Min Grade: D]

CHE 424 Chemical Kinetics and Reactor Design 4.0 Credits
Covers isothermal and non-isothermal reactor design, series and parallel reactions, and heterogeneous catalysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 304 [Min Grade: D]

CHE 450 Chemical Process Industries 3.0 Credits
Chemical engineering juniors and seniors. Combines process heuristics and design strategies with case studies of the industrial manufacture of a variety of materials, including petrochemicals, polymers, and ammonia. Discusses operational and design problems as well as the interactions of process principles.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Pre-Junior or Sophomore

CHE 451 Safety Engineering 3.0 Credits
Covers selected topics such as safeguarding systems, fault trees, risk analysis, explosions, fires, and building safety.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CHE 482 [Min Grade: D]

CHE 452 Polymer Process Technology 3.0 Credits
Covers chemistry of chain and stepwise polymerization, industrial reactor systems, polymer melt rheology, processing of thermoplastic resins, and plastics properties.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

CHE 460 Biochemical Engineering 3.0 Credits
Introduces underlying biological and engineering principles in an integrate fashion for biopharmaceutical production systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is BME or major is CHE and classification is Junior or Senior.

CHE 481 Process Design I 3.0 Credits
Within the context of previously introduced processes, covers economic feasibility of projects and optimization of equipment and production in the design of process plants.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CHE and classification is Senior.
Prerequisites: CHE 304 [Min Grade: D] and CHE 308 [Min Grade: D]
Corequisite: CHE 424

CHE 482 [WI] Process Design II 3.0 Credits
Within the context of previously introduced processes, covers execution of feasibility study and preliminary design of process plants. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CHE 481 [Min Grade: D]

CHE 483 [WI] Process Design III 3.0 Credits
Within the context of previously introduced processes, covers completion of feasibility study and preliminary design of process plants. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CHE 482 [Min Grade: D]

Civil Engineering

Courses

CIVE 240 [WI] Engineering Economic Analysis 3.0 Credits
Techniques for project decisions: benefit cost and present worth analysis, rate of return, capital budgeting, risk analysis, environmental impact, and depreciation. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

CIVE 250 Construction Materials 4.0 Credits
Construction Materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 202 [Min Grade: D]

CIVE 251 Engineering Surveying 3.0 Credits
Covers the theory and use of surveying instruments and principles of plane and topographic surveying. Introduces computer programs for surveying computations and plotting.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

CIVE 261 Materials and Structural Behavior I 3.0 Credits
Introduces the basic materials of construction (timber, masonry, steel, and concrete). Covers their behavior as ingredients of the structural system. Required for architecture and construction management students. Fall.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is AE or major is CIVE or classification is Freshman
Prerequisites: PHYS 182 [Min Grade: D]

CIVE 262 Materials and Structural Behavior II 3.0 Credits
Continues CIVE 261. Required for architecture and construction
management students. Winter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is AE or major is CIVE or
classification is Freshman
Prerequisites: CIVE 261 [Min Grade: D]

CIVE 263 Materials and Structural Behavior III 3.0 Credits
Continues CIVE 262. Required for architecture and construction
management students. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is AE or major is CIVE or
classification is Freshman
Prerequisites: CIVE 262 [Min Grade: D]

CIVE 300 Theory of Structures I 3.0 Credits
Covers analysis of statically determinate structures: equilibrium,
compatibility, boundary conditions, complimentary and virtual work,
energy theorems, reactions, member forces and deflection of trusses,
beams and frames, and influence lines.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 250 [Min Grade: D] and MEM 230 [Min Grade: C]

CIVE 301 Theory of Structures II 4.0 Credits
Covers analysis of statically indeterminate structures: force methods for
trusses, beams and frames, slope-deflection and equilibrium methods,
moment distribution, stiffness matrices of truss and beam elements, and
stiffness matrix method of analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 300 [Min Grade: D]

CIVE 310 Soil Mechanics I 4.0 Credits
Gives an overview of types of problems encountered in geotechnical
engineering: index, mechanical, hydraulic and environmental properties
of soils; earth mass stability, deformation, and groundwater seepage;
laboratory measurements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: (EGEO 220 [Min Grade: D] or CAEE 211 [Min Grade: D])
and CIVE 250 [Min Grade: D]

CIVE 320 Introduction to Fluid Flow 3.0 Credits
Covers fundamentals of fluid flow, fluid properties, hydrostatic forces,
kinematics of flow, the Bernoulli equation, linear momentum, dimensional
analysis, Froude and Reynolds similarity and hydraulic models and an
introduction to pipe flows and friction.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: TDEC 202 [Min Grade: D] or ENGR 210 [Min Grade: D]

CIVE 330 Hydraulics 4.0 Credits
Covers pipe flow, friction losses, multiple pipe systems, water demand
and distribution network design, pumps and pumping systems, air flow
in ducts and fans, open channel flows, hydraulic jumps and energy
dissipation, gravity pipe networks and the design of storm and sanitary
sewer systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 320 [Min Grade: D]

CIVE 341 Municipal Water Facilities 3.0 Credits
Covers analysis and design of municipal water supply systems,
including collection, transmission and distribution facilities; public health
considerations in water supply; and maintenance of water supply
infrastructure.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 330 [Min Grade: D] and CIVE 430 [Min Grade: D]

CIVE 370 Introduction to Structural Analysis 3.0 Credits
Covers equilibrium, virtual work, reactions, and member forces in trusses,
beams, and frames. Introduces analysis of statically indeterminate
structures and the stiffness matrix method of analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 230 [Min Grade: D] and CIVE 250 [Min Grade: D]

CIVE 371 Introduction to Structural Design 3.0 Credits
Covers the design process, with topics including structural systems, loads
and load path, structural safety, and design methods. Offers introduction
to steel, reinforced concrete, wood, and masonry design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 370 [Min Grade: D]

CIVE 372 Structural Laboratory 1.0 Credit
Course use of structural analysis computer programs to construct
analytical models of various structural systems. Calculate reactions and
deflections of statically determinate and determinate structures and check
reliability of results.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore
Corequisite: CIVE 371

CIVE 375 Structural Material Behavior 3.0 Credits
Study of deformation, fracture and fatigue of structural materials used
in infrastructure. Includes basic failure modes, yielding and plasticity,
and fracture mechanics. Emphasis on analytical and predictive methods
that designers use to avoid failure. Metals, ceramic and composites are
considered, as is time-dependent behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 230 [Min Grade: D] and CIVE 250 [Min Grade: D]
and (MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR
231 [Min Grade: D])

CIVE 380 Special Topics in Civil Engineering 12.0 Credits
Covers selected topics in civil engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

CIVE 399 Independent Study in Civil Engineering 12.0 Credits
Independent study on a topic selected by the student. Independent study is supervised by a faculty member and guided by a plan of study.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CIVE 400 Structural Design I 3.0 Credits
Covers principles of design of structural members and systems, including loads on structures, structural safety, and structural members and their behavior. Introduces elastic and limit design procedures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CIVE 301 [Min Grade: D]

CIVE 401 Structural Design II 3.0 Credits
Covers principles of design of reinforced concrete structural systems, including beams, slabs, columns, and footings.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 400 [Min Grade: D]

CIVE 402 Structural Design III 3.0 Credits
Covers elastic and plastic design of structural steel members, including beams, columns, tension members, beam columns, and plate girders; design of welded and high-strength bolted connections; and design of steel trusses, bridges, and buildings.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 401 [Min Grade: D]

CIVE 410 Foundation Engineering 3.0 Credits
Covers shear strength, bearing capacity, and lateral earth pressure; design of shallow foundations (footings, mats) and deep foundations (piles, drilled shafts); and excavation and slope stability.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 310 [Min Grade: D]

CIVE 420 Water and Waste Treatment I 3.0 Credits
Covers water supply chemistry, including corrosion in water distribution systems, microbiology of water and wastes, biodegradation of toxic materials, and growth and metabolism in wastewater treatment processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CIVE 330 [Min Grade: D] and CIVE 340 [Min Grade: D]

CIVE 430 Hydrology 3.0 Credits
Covers the relationship between precipitation and runoff, unit hydrographs, flood routing, and water supply principles and applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CAEE 211 [Min Grade: D]

CIVE 431 Hydrology-Ground Water 3.0 Credits
Covers geologic and hydrologic occurrence of groundwater, underground flow, and groundwater supply. Winter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 330 [Min Grade: D]

CIVE 432 Water Resources Design 3.0 Credits
Covers planning and design of basin and developments for requirements of various water use purposes. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 430 [Min Grade: D]

CIVE 477 [WI] Seminar 2.0 Credits
Covers professional development and ethics. Requires preparation of a technical paper. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

CIVE 478 [WI] Seminar 1.0 Credit
Requires preparation and presentation of a technical paper. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

Computer Science

Courses

CS 121 Computation Laboratory I 1.0 Credit
Introduces computation and programming through the use of a symbolic mathematical computation system. Programming techniques and algorithmic problem solving are introduced in the context of the differential calculus. Illustrates the power and limitations of the computer in solving mathematical, engineering and scientific problems. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 110 [Min Grade: D], MATH 121 [Min Grade: D] (Can be taken Concurrently)

CS 122 Computation Laboratory II 1.0 Credit
Introduces computation and programming through the use of a symbolic mathematical computation system. Programming techniques and algorithmic problem solving are introduced in the context of the integral calculus. Illustrates the power and limitations of the computer in solving mathematical, engineering and scientific problems. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 121 [Min Grade: D] (Can be taken Concurrently)CS 121 [Min Grade: D] and (MATH 110 [Min Grade: D]

CS 123 Computation Laboratory III 1.0 Credit
Introduces computation and programming through the use of a symbolic mathematical computation system. Programming techniques and algorithmic problem solving are introduced in the context of the multivariate calculus and series. Illustrates the power and limitations of the computer in solving mathematical, engineering and scientific problems. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 121 [Min Grade: D], MATH 122 [Min Grade: D] (Can be taken Concurrently)CS 122 [Min Grade: D]

CS 132 Computer Programming B 3.0 Credits
Introduction to structured computer programming in the language of instruction (e.g. C++). Topics include: random numbers, recursion, vectors, searching and sorting, classes, information hiding principles. Stresses good programming style, documentation, debugging, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 131 [Min Grade: D] or CS 171 [Min Grade: D]
Corequisite: EXAM 080

CS 133 Computer Programming C 3.0 Credits
Advanced principles of computer programming in the language of instruction (e.g. C++). Classes, inheritance, information hiding principles, recursion, quicksort, multidimensional arrays, pointers, and dynamic memory. Stresses good programming style, documentation, debugging, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 132 [Min Grade: D]
Corequisite: EXAM 080

CS 140 Introduction to Multimedia Programming 3.0 Credits
Introduction to structured computer programming in a language designed for working with media (images, sound, video), e.g. Python/Jython. Topics include: variables, input and output, expressions, assignment statements, conditionals and branching, files, repetition, functions and parameter passing, one-dimensional and two-dimensional arrays, and media manipulation. Stresses good programming style, documentation, debugging, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 143 Computer Programming Fundamentals 3.0 Credits
Introduction to structured computer programming in language of instruction (e.g. C++). Topics include: variables, input and output, expressions, assignment statements, conditionals and branching, files, repetition, functions and parameter passing, arrays, and string manipulation. Stresses good programming style, documentation, debugging and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 161 Introduction to Computing 3.0 Credits
Introduction to the computer as a tool for productivity and communications. Provides fluency in the use of industry-standard software for professional communications and presentations, data analysis, and telecommunication. Introduce automation and programming to enhance the effective use of computers and computer applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Corequisite: EXAM 080

CS 164 Introduction to Computer Science 3.0 Credits
An introduction to the field of computer science. Exposure to core areas (selected from algorithms, artificial intelligence, computer architecture, databases, graphics, human-computer interaction, programming languages, scientific computation, software engineering) while introducing and reinforcing the importance of programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CS or major is MATH and classification is Freshman.
Corequisite: EXAM 080

CS 171 Computer Programming I 3.0 Credits
Covers fundamentals of structured computer programming in the language of instruction (e.g., C++): variables, input and output, expressions, assignment statements, conditionals and branching, subprograms, parameter passing, repetition, arrays, top-down design, testing, and debugging.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Corequisite: EXAM 080

CS 172 Computer Programming II 3.0 Credits
Covers object-oriented design, inheritance hierarchies, information hiding principles, string processing, recursion, good programming style, documentation, debugging, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 171 [Min Grade: C] or CS 132 [Min Grade: C]
Corequisite: EXAM 080

CS 175 Computer Programming I-II 3.0 Credits
Advanced programming in language of instruction at an accelerated pace: object-oriented design, inheritance hierarchies, information hiding principles, recursion, quick sort, multidimensional arrays, classes, pointers, dynamic memory, good programming style, documentation, debugging, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 190 Selected Computer Language 3.0 Credits
Focuses on programming in a selected language of interest. Course content, language, and prerequisites may vary according to instructor, with emphasis on applications for which the language is designed. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CS 203 Programming for Engineers 3.0 Credits
Fundamentals of computer organization; rudiments of programming including data types, arithmetic and logical expressions, conditional statements, control structures; problem solving techniques for engineers using programming; object-oriented programming; arrays; simulation of engineering systems; principles of good programming practice.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

CS 204 Advanced Programming for Engineers 3.0 Credits
An advanced introduction to classes and objects; inheritance and polymorphism; abstract classes and interfaces; exception handling; files and streams; garbage collection and dynamic memory allocation; recursion; using linked lists, stacks, queues, and trees; search and sorting algorithms; generic methods and classes; a comparative introduction to dominant programming languages; engineering examples.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 203 [Min Grade: D] or CS 203 [Min Grade: D]

CS 260 Data Structures 3.0 Credits
Covers stacks, queues, linked allocation, binary trees, internal searching and sorting, hashing, and applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 265 [Min Grade: D]

CS 265 Advanced Programming Tools and Techniques 3.0 Credits
Introduction to the basic principles of programming practice: testing, debugging, portability, performance, design alternatives, and style. Application in a variety of programming languages, programming environments, and operating systems. Introduction to tools used in the software development process for improving program functionality, performance, and robustness.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 172 [Min Grade: D] or CS 133 [Min Grade: D] or SE 103 [Min Grade: D] or ECEC 301 [Min Grade: D]

CS 270 Mathematical Foundations of Computer Science 3.0 Credits
Emphasizes analytic problem-solving and introduction of mathematical material necessary for later courses in algorithms, compiler theory, and artificial intelligence. Includes topics such as logic, theorem-proving, language operations, context-free grammars and languages, recurrence relations, and analysis of algorithms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 172 [Min Grade: D] or CS 265 [Min Grade: D] or SE 103 [Min Grade: D]

CS 275 Web and Mobile App Development 3.0 Credits
This course introduces students to web-based and mobile development technologies and practices, including tiered application development, Service-Oriented Architectures and associated exchange protocols, and web-database programming. This course explores development and integration of web services from well-known providers as well as services created by the student, using a mobile platform as a vehicle for interactions with the services.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 265 [Min Grade: D]

CS 280 Special Topics in Computer Science 12.0 Credits
Covers topics in modern computer science. Different topics may be considered in different quarters.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

CS 281 Systems Architecture 4.0 Credits
Covers internal function and organization of digital computers, including instruction sets, addressing methods, input-output architectures, central processor organization, machine language, and assembly language.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: (ECE 200 [Min Grade: D] or CS 270 [Min Grade: D]) and (CS 172 [Min Grade: D] or SE 103 [Min Grade: D])

CS 283 Systems Programming 3.0 Credits
This course introduces computer systems, including interaction of hardware and software through the operating system, from the programmer's perspective. Three fundamental abstractions are emphasized: processes, virtual memory, and files. These abstractions provide programmers a common interface to a wide variety of hardware devices. Topics covered include linking, system level I/O, concurrent programming, and network programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 265 [Min Grade: D]

CS 300 Applied Symbolic Computation 3.0 Credits
This course covers the fundamentals of symbolic mathematical methods as embodied in symbolic mathematics software systems, including: fundamental techniques, simplification of expressions, solution of applications problems, intermediate expressions swell, basic economics of symbolic manipulation, efficient solution methods for large problems, hybrid symbolic/numeric techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 270 [Min Grade: D] and MATH 200 [Min Grade: D] and MATH 201 [Min Grade: D]

CS 303 Algorithmic Number Theory and Cryptography 3.0 Credits
Covers fundamental algorithms for integer arithmetic, greatest common
divisor calculation, modular arithmetic, and other number theoretic
computations. Algorithms are derived, implemented and analyzed for
primality testing and integer factorization. Applications to cryptography
are explored including symmetric and public-key cryptosystems. A
cryptosystem will be implemented and methods of attack investigated.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and MATH 221 [Min Grade: D] and
(MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231
[Min Grade: D])

CS 337 The Psychology of Human-Computer Interaction 3.0 Credits
Applies cognitive and experimental psychology to the understanding of
human-computer interaction.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: PSY 101 [Min Grade: D] and CS 171 [Min Grade: D]

CS 338 Graphical User Interfaces 3.0 Credits
This course covers the design and implementation of graphical user
interfaces. Topics include: event-driven programming, application
programmer interfaces, widgets, callback functions, windowing systems
and desktops, rapid prototyping languages, multithreaded GUI's. A
term project involving implementation of a complex application will be
undertaken.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 350 [Min Grade: D] or SE 310 [Min Grade: D]

CS 345 Computer Game Design and Development 3.0 Credits
This course introduces students to the computer game design process.
Students also learn how the individual skills of modeling, animation,
scripting, interface design and story telling are coordinated to produce
interactive media experiences for various markets, devices and purposes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (DIGM 260 [Min Grade: D] or GMAP 260 [Min Grade: D])
and (CS 265 [Min Grade: D] or DIGM 141 [Min Grade: D])

CS 347 Experimental Game Development 3.0 Credits
The goal of this course is to develop new ideas and innovations in games
through the design, development, and implementation of games using
short development cycles and creative thematic constraints.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 345 [Min Grade: D], GMAP 345 [Min Grade: D] (Can
be taken Concurrently)

CS 348 Serious Game Development 3.0 Credits
The goal of this course is to learn more about serious games, that is
games used in a non-entertainment context, such as games for health,
education, and persuasion, through readings and through the design,
development, and implementation of serious games.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 345 [Min Grade: D], GMAP 345 [Min Grade: D] (Can
be taken Concurrently)

CS 350 [WI] Software Design 3.0 Credits
Covers software design methods and implementation. Good design and
implementation approaches will be motivated through software examples
and reinforced through programming projects. Topics include architectural
styles, code reuse, modularity and information hiding principles, object-
oriented design patterns, design specification and formal methods, good
coding and documentation practices. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore
Prerequisites: CS 260 [Min Grade: D] and CS 265 [Min Grade: D]

CS 352 Processor Architecture & Analysis 3.0 Credits
This course covers performance evaluation and benchmarking, pipelining,
superscalar processors, multiprocessors, and interfacing processors and
peripherals. The memory hierarchy, including cache and virtual memory,
are also explored from a programmer's perspective with high-performance
computing techniques in mind.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 281 [Min Grade: D] or ECEC 355 [Min Grade: D]

CS 360 Programming Language Concepts 3.0 Credits
Introduces the design and implementation of modern programming
languages: formal theory underlying language implementation;
concerns in naming, binding, storage allocation and typing; semantics of
expressions and operators, control flow, and subprograms; procedural
and data abstraction; functional, logic, and object-oriented languages.
Students will construct an interpreter for a nontrivial language.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 265 [Min Grade: D] and
CS 270 [Min Grade: D]

CS 361 Concurrent Programming 3.0 Credits
Covers programming of concurrent, cooperating sequential processes.
Studies race conditions, critical sections, mutual exclusion, process
synchronization, semaphores, monitors, message passing, the
rendezvous, deadlock, and starvation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 260 [Min Grade: D] and CS 281 [Min Grade: D]

CS 365 System Administration 3.0 Credits
Fundamentals of system administration featuring hands-on practice
with an industry standard operating system. Focus on installation,
maintenance and management of several systems for multi-user
environments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 265 [Min Grade: D]

CS 370 Operating Systems 3.0 Credits
Explores the internal algorithms and structures of operating systems: CPU scheduling, memory management, file systems, and device management. Considers the operating system as a collection of cooperating sequential processes (servers) providing an extended or virtual machine that is easier to program than the underlying hardware. Topics include virtual memory, input/output devices, disk request scheduling, deadlocks, file allocation, and security and protection.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 283 [Min Grade: D] or CS 361 [Min Grade: D]

CS 380 Artificial Intelligence 3.0 Credits
Explores the foundations of artificial intelligence: production systems, heuristic programming, knowledge representation, and search algorithms. Also covers programming in an AI language. Additional topics chosen from game theory, decision support systems, pattern matching and recognition, image understanding, natural language, fuzzy and non-monotonic logic, machine learning, theorem proving, and common sense reasoning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 260 [Min Grade: D] and CS 270 [Min Grade: D]

CS 383 Machine Learning 3.0 Credits
This course covers the fundamentals of modern statistical machine learning. Lectures will cover the theoretical foundation and algorithmic details of representative topics including probabilities and decision theory, regression, classification, graphical models, mixture models, clustering, expectation maximization, hidden Markov models, and weak learning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 380 [Min Grade: D]

CS 385 Evolutionary Computing 3.0 Credits
This course covers computational intelligence approaches to problem solving for classification, adaptation, optimization, and automated control. Methods covered will include evolutionary programming/genetic algorithms, genetic programming, neural networks, swarm optimization, and fuzzy logic.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 380 [Min Grade: D]

CS 387 Game AI Development 3.0 Credits
This course focuses on artificial intelligence (AI) techniques for computer games. Students will learn both basic and advanced AI techniques that are used in a variety of game genres including first-person shooters, driving games, strategy games, platformers, etc. The course will emphasize the difference between traditional AI and game AI, the latter having a strong design component, focusing on creating games that are "fun to play." Topics include path-finding, decision-making, strategy and machine learning in games.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 380 [Min Grade: D]

CS 430 Computer Graphics 3.0 Credits
The course presents the fundamental geometric representations and drawing algorithms of computer graphics through lectures and programming assignments. The representations include lines, curves, splines, polygons, meshes, parametric surfaces and solids. The algorithms include line drawing, curve and surface evaluation, polygon filling, clipping, 3D-to-2D projection and hidden surface removal.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 200 [Min Grade: D] and MATH 201 [Min Grade: D] and (CS 350 [Min Grade: D] or SE 310 [Min Grade: D])

CS 431 Advanced Rendering Techniques 3.0 Credits
The creation of realistic images from 3D models is central to the development of computer graphics. The ray tracing algorithm has become one of the most popular and powerful techniques for creating photo-realistic images. This class explores the algorithmic components of ray tracing. Students implement many of these components in their class programming projects.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 430 [Min Grade: D]

CS 432 Interactive Computer Graphics 3.0 Credits
This is a project-oriented class that covers the concepts and programming details of interactive computer graphics. These include graphics primitives, display lists, picking, shading, rendering buffers and transformations. Students will learn an industry-standard graphics system by implementing weekly programming assignments. The course culminates with a student-defined project.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and (MATH 200 [Min Grade: D] or MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231 [Min Grade: D])

CS 435 Computational Photography 3.0 Credits
Fundamentals of computational photography, an interdisciplinary field at the intersection of computer vision, graphics, and photography. Covered topics include fundamentals of cameras, novel camera designs, image manipulation, single-view modeling, and image-based rendering with an emphasis on learning the computational methods and their underlying mathematical concepts through hands-on assignments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (MATH 123 [Min Grade: D] or MATH 200 [Min Grade: D]) and (MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231 [Min Grade: D]) and CS 260 [Min Grade: D]

CS 440 Theory of Computation 3.0 Credits
Finite automata, regular sets, and regular expressions; pushdown automata, context-free languages, and normal forms for grammars; Turing machines and recursively enumerable sets; Chomsky hierarchy; computability theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore
Prerequisites: CS 270 [Min Grade: D] and MATH 221 [Min Grade: D]

CS 441 Compiler Workshop I 3.0 Credits
Design and implementation of compiler for specified language. Practical application and in-depth study of parsing, scanning, run-time storage management, type analysis, code generation, and error recovery.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore
Prerequisites: CS 270 [Min Grade: D] and CS 283 [Min Grade: D] and CS 360 [Min Grade: D] and CS 440 [Min Grade: D]

CS 442 Compiler Workshop II 3.0 Credits
Continuation of CS 441. Advanced topics in compilation, code generation, and optimization for various programming languages and paradigms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore
Prerequisites: CS 441 [Min Grade: D]

CS 445 Topics in Computer Gaming 3.0 Credits
Contemporary topics in the design and implementation of computer games. Topics may include game genres, psychological and sociological aspects of games, software tools and game development engines, character and behavior modeling, physical models and realism, virtual reality, graphics and animation, network-based games, performance analysis and efficiency.
College/Department: College of Engineering
Repeat Status: Can be repeated 3 times for 9 credits
Prerequisites: CS 345 [Min Grade: D] or DIGM 345 [Min Grade: D]

CS 451 Software Engineering 3.0 Credits
Covers requirements specification, system modeling, formal methods, architectural design, object-oriented design, programming for reliability, user interface design, functional and structural testing, software reuse, and configuration management.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 270 [Min Grade: D] and MATH 221 [Min Grade: D] and (CS 350 [Min Grade: D] or SE 310 [Min Grade: D])

CS 457 Data Structures and Algorithms I 3.0 Credits
This course covers techniques for analyzing algorithms, including: elementary combinatorics, recurrence relations, and asymptotic analysis; data structures such as hash tables, red-black trees, B-trees, binomial and Fibonacci heaps, union-find trees; sorting algorithms and elementary graph algorithms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D] and CS 270 [Min Grade: D] and MATH 221 [Min Grade: D]

CS 458 Data Structures and Algorithms II 3.0 Credits
This course presents algorithm design techniques such as dynamic programming, greedy methods, divide and conquer, amortized algorithms; more graph algorithms for minimum spanning trees, shortest paths, and network flows; string matching algorithms; algorithms for finding the convex hull of a discrete set of points; NP-Completeness and approximation algorithms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 457 [Min Grade: D]

CS 461 Database Systems 3.0 Credits
Covers topics including structure and function of database systems, normal form theory, data models (relational, network, and hierarchical), query processing (ISBL), relational algebra and calculus, and file structures. Includes programming project using DBMS.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 260 [Min Grade: D]

CS 470 Operating Systems Workshop 3.0 Credits
Studies a modern multitasking operating system in detail, including device drivers, CPU scheduling, memory management, and file systems. Includes programming assignments that modify or enhance the operating system.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 370 [Min Grade: D]

CS 472 Computer Networks: Theory, Applications and Programming 3.0 Credits
Introduction to computer networking theory, applications and programming, focusing on large heterogeneous networks. Broad topdown introductions to computer networking concepts including distributed applications, socket programming, operation system and router support, router algorithms, and sending bits over congested, noisy and unreliable communication links.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 361 [Min Grade: D] or CS 283 [Min Grade: D]

CS 475 Computer and Network Security 3.0 Credits
The key objective of this course is to provide a thorough understanding of technologies and methodologies with which computer networks can be protected. Topics that are covered include: key management and credentials, steganography and watermarking, networking security (VPNs, firewalls, intrusion detection) and system security policies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 472 [Min Grade: D] or CS 283 [Min Grade: D]

CS 476 High Performance Computing 3.0 Credits
This course is an introduction to high performance computing, including concepts and applications. Course contents will include discussions of different types of high performance computer architectures (multi-core/multi-threaded processors, parallel computers, etc), the design, implementation, optimization and analysis of efficient algorithms for uni-processors, multi-threaded processors, parallel computers, and high performance programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (CS 281 [Min Grade: D] and CS 283 [Min Grade: D]) or (ECEC 353 [Min Grade: D] and ECEC 355 [Min Grade: D])

CS 480 Special Topics in Computer Science 12.0 Credits
Covers topics in computer science of interest to students or faculty. Different topics may be considered during different quarters.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CS 481 Advanced Artificial Intelligence 3.0 Credits
This course covers topics in representation, reasoning, and decision-making under uncertainty; learning; solving problems with time-varying properties. Assignments applying AI techniques toward building intelligent machines that interact with dynamic, uncertain worlds will be given.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 380 [Min Grade: D] and (MATH 311 [Min Grade: D] or MATH 410 [Min Grade: D])

CS 485 Special Topics in Artificial Intelligence 3.0 Credits
A variety of special topics are offered in artificial intelligence (AI) including: intelligent time-critical reasoning, knowledge-based agents, machine learning, natural language processing, and geometric reasoning. This course may be repeated for credit as topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Prerequisites: CS 260 [Min Grade: D] and CS 380 [Min Grade: D]

CS 491 [WI] Software Engineering Workshop 3.0 Credits
Offers in-depth study and application of software engineering practice. Students work in teams to develop a significant software system. Course is intended to serve as a capstone experience for students in the senior year. The project involves the specification and review of software requirements and designs, implementation and code inspections, functional testing, and documentation. This course is writing intensive.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 451 [Min Grade: D]

CS 492 [WI] Software Engineering Workshop II 3.0 Credits
Continues CS 491 team project. This course is writing intensive.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 491 [Min Grade: D]

CS 493 [WI] Software Engineering Workshop III 3.0 Credits
Continues CS 492 team project. This course is writing intensive.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 492 [Min Grade: D]

CS 498 Independent Study in Computer Science 12.0 Credits
Provides supervised study of selected topics in computer science.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

Electrical & Computer Engineering

Courses

ECE 101 Electrical and Computer Engineering in the Real World 1.0 Credit
This seminar introduces students to highly visible and compelling applications of ECE through the use of familiar real-world applications. The course will highlight some of the high-impact advances of ECE and the importance of ECE in our daily lives. Fundamental concepts, such as electricity, light, computing, networking, and signal processing will be introduced in this context and explained at an introductory level. This course is intended to inspire students to pursue ECE and will lead them directly into ECE 102.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 102 Applications of Electrical and Computer Engineering 2.0 Credits
Introduces the basic fundamentals of ECE through the use of real-world applications. The course will introduce Signals and Systems, Analog electronic basics, as well as Digital numbers and systems. The course will introduce students to basic ECE material, preparing the students for ECE 200 and ECE 201.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 121 Introduction to Entertainment Engineering 3.0 Credits
This introductory survey course will focus on the four prevailing entertainment media: music, images, video, and games. We will explore how each medium is represented digitally and reveal the technologies used to capture, manipulate and display such content. Technical standards used in everyday entertainment devices (mp3, H.264, JPEG 1080p, HDMI) will be explained in layman's terms. The goal is to provide students with technical literacy for using digital media.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 190 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECE 200 Digital Logic Design 3.0 Credits
Number systems and representation, two's complement arithmetic, digital logic devices, switching algebra, truth tables, minimization of Boolean functions, combinational logic design and analysis, sequential circuit analysis and design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 170 [Min Grade: D] or TDEC 132 [Min Grade: D] or CS 171 [Min Grade: D] or ENGR 103 [Min Grade: D] or ENGR 104 [Min Grade: D]

ECE 201 Foundations of Electric Circuits 3.0 Credits
Covers basic electric circuit concepts and laws; circuit theorems; mesh and node methods; analysis of first-and second-order electric circuits; force and natural response; sinusoidal steady state analysis; complex frequency.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is CAE or classification is Freshman
Prerequisites: PHYS 211 [Min Grade: D] or TDEC 115 [Min Grade: D] or PHYS 281 [Min Grade: D] or PHYS 102 [Min Grade: D]

ECE 203 Programming for Engineers 3.0 Credits
Fundamentals of computer organization; rudiments of programming including data types, arithmetic and logical expressions, conditional statements, control structures; problem solving techniques for engineers using programming; object-oriented programming; arrays; simulation of engineering systems; principles of good programming practice.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ECE 211 Electrical Engineering Principles 3.0 Credits
Not open to electrical or mechanical engineering students. Covers basic techniques of electric circuit analysis, electronic devices, amplifiers, operational amplifier, and fundamentals of instrumentation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is EE or major is MECH or classification is Freshman
Prerequisites: (MATH 201 [Min Grade: D] or ENGR 231 [Min Grade: D] or MATH 261 [Min Grade: D]) and (PHYS 211 [Min Grade: D] or PHYS 281 [Min Grade: D] or PHYS 102 [Min Grade: D])
Corequisite: ECE 212

ECE 212 Electrical Engineering Principles Laboratory 1.0 Credit
Not open to electrical or mechanical engineering students. Includes experiments involving concepts discussed in ECE 211.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if major is EE or major is MECH or classification is Freshman
Corequisite: ECE 211

ECE 290 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECE 361 Probability for Engineers 3.0 Credits
This course will cover topics related to probability and statistics. Probability topics include sample space and probability, discrete and continuous random variables, expectation, variance, covariance, correlation, conditional expectation, conditional variance, the weak and strong law of large numbers and the central limit theorem. Statistics topics include properties of a random sample, principles of data reduction, and point estimation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENGR 202 [Min Grade: D] and (ENGR 231 [Min Grade: D] or MATH 261 [Min Grade: D])

ECE 362 Engineering Statistics 3.0 Credits
This course will cover topics related to statistics and probability. Probability topics include sample space and probability; discrete and continuous random variables, expectation, variance, the law of large numbers and the central limit theorem. Statistics topics include properties of a random sample, principles of data reduction, point estimation, hypothesis testing, interval estimation, and linear regression.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ENGR 202 [Min Grade: D] and ENGR 231 [Min Grade: D]) or (ENGR 202 [Min Grade: D] and MATH 261 [Min Grade: D])

ECE 390 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECE 391 Introduction to Engineering Design Methods 1.0 Credit
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 491 [WI] Senior Design Project I 2.0 Credits
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

ECE 492 [WI] Senior Design Project II 2.0 Credits
Continues ECE 491. Requires written and oral progress reports. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECE 491 [Min Grade: D]

ECE 493 Senior Design Project III 4.0 Credits
Continues ECE 492. Requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECE 492 [Min Grade: D]

Electrical & Computer Engineering - Computers

Courses

ECEC 301 Advanced Programming for Engineers 3.0 Credits
An advanced introduction to classes and objects; inheritance and polymorphism; abstract classes and interfaces; exception handling; files and streams; garbage collection and dynamic memory allocation; recursion; using linked lists, stacks, queues, and trees; search and sorting algorithms; generic methods and classes; a comparative introduction to dominant programming languages; engineering examples.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 203 [Min Grade: D] or CS 203 [Min Grade: D]

ECEC 302 Digital Systems Projects 4.0 Credits
Offers hands-on experiences in digital system design with automation tools. Uses field programmable gate arrays in the projects. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CS 171 [Min Grade: D] (Can be taken Concurrently) or ECE 203 [Min Grade: D] or CS 203 [Min Grade: D]) and ECE 200 [Min Grade: D]

ECEC 304 Design with Microcontrollers 4.0 Credits
Offers hands-on experience in the design of controllers that incorporate microcontrollers as an embedded component in a larger system. The microcomputer topics to be studied will include architecture, software, programming and interfaces.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECE 200 [Min Grade: D] and (CS 171 [Min Grade: D] or ECE 203 [Min Grade: D] or CS 203 [Min Grade: D])

ECEC 352 Secure Computer Systems: Design Concepts 4.0 Credits
Covers concepts of secure computation, including economics vs. faults, errors, and hidden messages; mathematical foundations of secure computing; design issues in fault-tolerant computing; and testability and cryptography.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEC 302 [Min Grade: D] and MATH 221 [Min Grade: D]

ECEC 353 Systems Programming 3.0 Credits
This course introduces computer systems, including interaction of hardware and software through the operating system, from the programmer's perspective. Three fundamental abstractions are emphasized: processes, virtual memory, and files. These abstractions provide programmers a common interface to a wide variety of hardware devices. Topics covered include linking, system level I/O, concurrent programming, and network programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 265 [Min Grade: D]

ECEC 355 Computer Organization & Architecture 4.0 Credits
This course will cover the principles of designing microprocessors using solid engineering fundamentals and quantitative cost/performance trade-offs. Topics will cover instruction set architectures, arithmetic for computers, assessing and understanding processor performance, processor datapath and control, pipelining, cache design, and virtual-memory design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECE 200 [Min Grade: D] or CS 270 [Min Grade: D]) and ECEC 302 [Min Grade: D]

ECEC 356 Embedded Systems 4.0 Credits
Lectures will cover theoretical concepts of embedded and cyber#physical systems including discrete and continuous dynamics, hybrid systems, state machines, concurrent computation, embedded systems architecture and scheduling. Lab involves programming embedded applications for the decentralized software services architecture using C# and the Microsoft Robotics Software Development Kit (SDK) together with the hardware image processing and tracking capabilities of the Kinect sensor.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 304 [Min Grade: D]

ECEC 357 Introduction to Computer Networks 4.0 Credits
History of the Internet; introduction to packet switching, circuit switching and virtual circuit switching; statistical multiplexing; protocol layering; metrics of network performance including bandwidth, delay and loss; medium access protocols and Ethernet; routing algorithms; end-to-end issues; flow and congestion control; an overview of application layer protocols.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 203 [Min Grade: D] or CS 171 [Min Grade: D]

ECEC 390 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 411 Computer Hardware 3.0 Credits
Covers the design and performance of computer hardware devices, including direct memory access, priority arbitration, double buffering, and bus standards. Fall.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECEC 355 [Min Grade: D]

ECEC 412 Modern Processor Design 3.0 Credits
This course introduces modern processor design in a systematic manner. It discusses dynamically scheduled superscalar techniques including multi-issue, dynamic instruction scheduling, speculative execution, and branch prediction; advanced cache designs, and new techniques including SMT and VLIW. The course provides a comprehensive coverage of modern processor architectures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D] or CS 281 [Min Grade: D]

ECEC 413 Introduction to Parallel Computer Architecture 3.0 Credits
This course provides an introduction to the fundamental principles and engineering trade-offs involved in designing modern parallel computers (multi-processors). Topics covered include, but are not limited to, shared-memory and message-passing programming, cache-coherence, synchronization, scalable distributed memory multi-processors, and interconnection techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D] or CS 281 [Min Grade: D]

ECEC 414 High Performance Computing 3.0 Credits
This course is an introduction to high performance computing, including both concepts and applications. Course contents will include discussions of different types of high performance computer architectures (multi-core/multi-threaded processors, parallel computers, etc.), the design, implementation, optimization and analysis of efficient algorithms for uni-processors, multi-threaded processors, and parallel computers, and high performance programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D] or (CS 281 [Min Grade: D] and CS 282 [Min Grade: D])

ECEC 421 Introduction to Operating Systems I 3.0 Credits
Covers basic concepts of computer operating systems, including multiprocessing and multiprogramming systems, lock operations, synchronization, and file structures. Winter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECEC 355 [Min Grade: D] and CS 260 [Min Grade: D]

ECEC 422 Introduction to Operating Systems I 3.0 Credits
Further develops the topics of ECEC 421. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEC 421 [Min Grade: D]

ECEC 431 Introduction to Computer Networks 3.0 Credits
Covers topics in computer and telecommunications network design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECE 200 [Min Grade: D] and CS 260 [Min Grade: D]

ECEC 432 Internet Architecture and Protocols 3.0 Credits
Covers architecture, protocols, and services of the Internet with an analytical approach focused on design principles; Internet architecture and topology; architecture of web and mail servers; router architectures; routing protocols; multicasting; multimedia over IP and associated protocols; Quality-of-Service issues in the Internet.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 357 [Min Grade: D] or CS 472 [Min Grade: D]

ECEC 433 Network Programming 3.0 Credits
Covers application layer protocol and how applications use the transport layer; principles and practice of network programming; the client-server model; concurrent processing; introduction to sockets and related functions client and server software design with examples; principles, issues and challenges in e-mail and web application protocols; security protocols; and network life system concepts.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 357 [Min Grade: D]

ECEC 441 Robotic Computer Interface & Control I 3.0 Credits
Covers fundamentals of robotics systems, including mechanics, actuators, sensors, kinematics, and inverse kinematics. Fall.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECES 356 [Min Grade: D]

ECEC 442 Robotic Computer Interface & Control II 3.0 Credits
Covers robot dynamics, Lagrangian and Newton Euler methods, linear control of robots, path planning, and computer implementation. Winter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEC 441 [Min Grade: D]

ECEC 443 Robotic Computer Interface & Control III 3.0 Credits
Covers robot-computer interface methods, including redundancy, optimal control, robustness, nonlinear control, adaptive control, and multiprocessor control. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEC 442 [Min Grade: D]

ECEC 451 Computer Arithmetic 3.0 Credits
This course provides an introduction to number representations used in computer arithmetic, issues of complexity in arithmetic operations, fixed point arithmetic, floating point arithmetic, and residue number systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 200 [Min Grade: D] and ECEC 355 [Min Grade: D]

ECEC 453 Image Processing Architecture 3.0 Credits
This course covers applications of computing techniques and hardware in image (still and video) processing. Methods of compression (lossless, lossy), video compression, JPEG standards, MPEG standards, processing requirements, and implementations for multimedia.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 200 [Min Grade: D] and ECES 302 [Min Grade: D]

ECEC 455 Intelligent System Architectures 3.0 Credits
This course outlines the principles of designing the architectures for intelligent systems. Methods of knowledge representation are compared for a variety of engineering problems. Methods of sensing and behavior generation are demonstrated for applications in large engineering and information systems including autonomous robots. Principles of goal-oriented computers are discussed, and modules of intelligent systems architectures are described. Theoretical fundamentals and practical techniques for learning are also covered.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: MATH 221 [Min Grade: D] and ECEC 355 [Min Grade: D]

ECEC 457 Security in Computing 3.0 Credits
The course introduces ideas from Cryptography and Fault Tolerant Computing. Cryptography studies how to artificially create distortions that being interwoven with computations mask them from eavesdropping. Fault Tolerance studies techniques of suppressing effects of natural noises that operate in computation channels. The course deals with both some introductory issues in Public Key Cryptography and some important aspects of designing Fault Tolerant Systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D]

ECEC 459 Testing of Hardware 3.0 Credits
Testing has become the largest expense item in the semiconductor industry. There is rapidly being developed new techniques in testing, design for test and built-in self-test because no existing set of techniques can satisfy the existing and future needs. The course reviews, in a unified way, important issues in testing and diagnosis of hardware. Together with the "Security in Computing" course, it brings a design engineer student to the state of the art level in the field.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D]

ECEC 471 Introduction to VLSI Design 3.0 Credits
This is an introductory course where systematic understanding, design and analysis of digital VLSI integrated circuits will be covered. The course will begin with a review of CMOS transistor operation and semiconductor processes. Logic design with CMOS transistor and circuit families will be described. Specifically, layout, design rules, and circuit simulation will be addressed. Performance metrics will be analyzed in design and simulation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECE 200 [Min Grade: D] or CS 270 [Min Grade: D]) and (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D])

ECEC 472 VLSI Design & Automation 3.0 Credits
Design and analysis of VLSI integrated circuits will be covered from circuits and systems design perspectives. First, system timing and arithmetic building blocks will be presented. Then, design automation will be presented by hierarchical design examples using hardware description languages (HDL) and physical design with VLSI CAD tools.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 355 [Min Grade: D] and (ECE 200 [Min Grade: D] or CS 270 [Min Grade: D])

ECEC 473 Modern VLSI IC Design 3.0 Credits
This is a project-oriented course where a high-complexity VLSI design project will be assigned to student teams. Team-work, task assignment and team communication will be mediated in an industry setting. Design tasks will cover the entire IC design flow range, from system specification to TRL description to timing and power analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 472 [Min Grade: D]

ECEC 474 ASIC Design I 3.0 Credits
This course will focus exclusively on digital CMOS Application Specific Integrated Circuit (ASIC) systems design and automation. The ASIC physical design flow, including logic synthesis, floorplanning, placement, clock tree synthesis, routing and verification will be presented. These back-end physical design flow steps will also be covered through hands-on practice using industrial VLSI CAD tools. Contemporary design practices will be reviewed and presented in experiments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 200 [Min Grade: D] and ECEC 355 [Min Grade: D]

ECEC 475 ASIC Design II 3.0 Credits
Design and analysis of Application Specific Integrated Circuits (ASICs) will be covered from a systems design perspective. System timing, arithmetic building block and memory block design processes will be presented. Design tasks in a quarter-long, small-complexity processor design project will cover the back-end of the IC design flow range, from RTL synthesis to timing and power analysis. Projects will be performed in a hierarchical group, similar to an industrial setting, with other graduate and undergraduate students.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 474 [Min Grade: D]

ECEC 490 Special Topics in Computer Engineering 12.0 Credits
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

ECEC 497 Research In Computer Engineering 0.5-12.0 Credits
Computer engineering students only. Requires independent research in a field approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if major is CE.

ECEC 499 Independent Study in Computer Engineering 0.5-12.0 Credits
Computer engineering students only. Requires independent study or research in a field approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if major is CE.
Cannot enroll if classification is Freshman or Sophomore

Electrical & Computer Engineering - Electroph

Courses

ECEE 302 Electronic Devices 4.0 Credits
Covers principles of operation of semiconductor devices, including PN diodes, bipolar transistors, and field effect transistors (JFET, MOSFET, MESFET). Applications of PN junctions, including solar cells, led, laser diodes. Laboratories reinforce lecture material by allowing students to build, measure and analyze data from simple devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: TDEC 211 [Min Grade: D] or ENGR 220 [Min Grade: D]

ECEE 304 Electromagnetic Fields & Waves 4.0 Credits
Covers vector calculus, Coulomb's Law, Gauss' Law, Ampere's Law, Maxwell's equations, Electromagnetic (EM) fields in devices, EM fields in circuits, EM fields in machinery, EM waves, biological effects.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATH 291 [Min Grade: D]

ECEE 352 Analog Electronics 4.0 Credits
Teaches the fundamentals of electronic circuit analysis and design by means of practical projects, such as a dc power supply and an audio amplifier. Covers design with discrete components as well as integrated circuit design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 302 [Min Grade: D] and ECES 302 [Min Grade: D]

ECEE 354 Wireless and Optical Electronics 4.0 Credits
Covers propagation of waves in various media as it relates to wireless communications: reflection, transmission, polarization, wave packets, dispersion, radiation and antennas, microwave electronic devices, optical wave guides, and fiber optics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 302 [Min Grade: D] and ECEE 304 [Min Grade: D]

ECEE 390 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 421 Advanced Electronics I 4.0 Credits
Application-and design-focused course. Analyzes feedback in electronic circuits such as operational amplifiers. Covers design and applications of active filters and other typical electronic circuitry. Includes experiments in the design of multistage transistor circuits, feedback loops, operational amplifiers, and active filters.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 352 [Min Grade: D]

ECEE 422 Advanced Electronic Circuits I 3.0 Credits
Application-and design-focused course. Covers analysis and design of communication circuits and non-linear active circuits; oscillators, mixers, IF and RF amplifiers; and AM and FM modulators.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 421 [Min Grade: D]

ECEE 423 Advanced Electronics Circuits II 3.0 Credits
Application-and design-focused course. Covers non-linear circuits; function and wave form generators; log-amp, multipliers, dividers, power amp, and phase-lock loops; and design of electronics needed to implement different logic circuit families.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 421 [Min Grade: D]

ECEE 434 Digital Electronics 4.0 Credits
Covers basic digital integrated circuit building blocks (inverters, nor and nand logic), CMOS logic gates (dc and transient behavior), drivers, and digital circuits and systems (PLA, gate array, memory). Experiments in semiconductor material characterization, device characterization, circuit and device simulations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 302 [Min Grade: D]

ECEE 441 Lightwave Engineering I 3.0 Credits
Covers fundamentals of wave propagation, including propagation in various fiber wave guides and field distributions, diffraction, attenuation, dispersion, information capacity, and other analytic and design considerations in fiber systems. Fall.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 304 [Min Grade: D]

ECEE 442 Lightwave Engineering II 3.0 Credits
Covers operating principles, construction, and characteristics of sources, couplers, and detectors used in optical systems. Includes equivalent circuit models and principles of generation, transmission, and reception. Winter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 441 [Min Grade: D]

ECEE 443 Lightwave Engineering III 3.0 Credits
Covers applications of devices and systems in such areas as data, voice, and image trans-mission; industrial automation; process control; medicine; and computers. Includes basic measurement systems. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 442 [Min Grade: D]

ECEE 451 Electroacoustics 3.0 Credits
Applications-oriented course. Covers fundamentals of vibrating systems; equations of motion; acoustical, electrical, and mechanical analogs; properties of waves in fluids; acoustic impedance and plane wave transmission; application to design of transducers; and application of acoustic waves in medical imaging, non-destructive testing, and the biomedical field.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Junior or Pre-Junior or Sophomore

ECEE 471 RF Components and Techniques 4.0 Credits
This course covers microwave networks (Z, Y, S, T ABCD Parameters), signal flowgraph, impedance matching techniques (lumped and distributed, quarter wave transformers), circulators and isolators, directional couplers (branch line, Wilkinson, Lange, slot waveguide), and filters (lowpass, bandpass, bandstop, highpass). CAD laboratory and design projects are an integral part of this course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 354 [Min Grade: D]

ECEE 472 RF Electronics 4.0 Credits
This course covers static and dynamic characteristics of transistors, unipolar (MOSFET, MESFET, HEMT), bipolar (BJT, HBT), LNA design and realization, power amplifiers, distributed amplifiers, switches, limiters, phase shifters, detectors, mixers, oscillators (Colpitts, YIG turned, reflection, transmission, DRO). CAD laboratory and design projects are an integral part of this course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 471 [Min Grade: D]

ECEE 473 Antennas and Radiating Systems 4.0 Credits
This course covers short and magnetic dipole, radiation pattern, radiation resistance, directivity and gain, line antennas (dipoles, monopoles, V and inverted V antennas), helix, Yagi-Uda, log-periodic, aperture antennas (slot, horn and reflector), printed circuit antennas (patch and spiral), and phased antennas. CAD laboratory and design projects are an integral part of this course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 471 [Min Grade: D]

ECEE 490 Special Topics in Electrophysics 12.0 Credits
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

ECEE 497 Research in Electrophysics 0.5-12.0 Credits
Requires independent research in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 499 Independent Study In Electrophysics 0.5-12.0 Credits
Requires independent study in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

Electrical Engineering Lab

Courses

ECEL 301 [WI] Electrical Engineering Laboratory 2.0 Credits
Offers laboratory experiences in each of the five ECE tracks: computers, controls/robotics, electronics, power and energy, and telecommunications. Each lab consists of a stand-alone module containing: lecture material providing basic theory, references, and laboratory experiments. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECE 200 [Min Grade: D] and ECE 201 [Min Grade: D] and (TDEC 132 [Min Grade: D] or TDEC 133 [Min Grade: D] or ENGR 104 [Min Grade: D] or ENGR 103 [Min Grade: D])

ECEL 302 ECE Laboratory II 2.0 Credits
Offers laboratory experiences in each of the five ECE tracks: computers, controls/robotics, electronics, power and energy, and telecommunications. Each lab consists of a stand-alone module containing: lecture material providing basic theory, references, and laboratory experiments. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 302 [Min Grade: D] (Can be taken Concurrently)ECEL 301 [Min Grade: D]

ECEL 303 ECE Laboratory III 2.0 Credits
Covers basic digital signal processing concepts, an introduction to analog-to-digital and digital-to-analog converters, and power supply design using analog IC devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEL 301 [Min Grade: D]

ECEL 304 ECE Laboratory IV 2.0 Credits
This course offers laboratory experience, using both modeling software and digital and analog hardware relevant to both electrical and computer engineers. Multi-week design projects and design teams are used to prepare students for Senior Design work.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEL 303 [Min Grade: D]

ECEL 311 ECE Laboratory Methods I 3.0 Credits
Introduces students to MATLAB and PSpice, industry standard CAD software for electronics (analog and digital) and systems engineers. Solve DC bias, DC sweep, AC sweep, and transient problems in PSpice and MATLAB. Build and design simple digital circuits.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECE 200 [Min Grade: D] and ECE 201 [Min Grade: D] and ENGR 103 [Min Grade: D]

ECEL 312 ECE Laboratory Methods II 3.0 Credits
Covers introduction to transistor circuits, PSpice simulations of active devices, transfer function analysis, Bode analysis, active filter analysis and design. Programming and use of Microprocessors and/or FPGA. Perform measurements on devices and circuits.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEL 301 [Min Grade: D] or ECEL 311 [Min Grade: D]

ECEL 401 Lightwave Engineering Laboratory 3.0 Credits
Teaches fundamentals of interaction of light with matter. Waves and photons. nterference and diffraction. Optical fibers and free-space optics. Introduces students to optical communication and imaging.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECEE 302 [Min Grade: D]) or (ECEL 311 [Min Grade: D] and ECEL 312 [Min Grade: D] and ECEE 304 [Min Grade: D])

ECEL 402 Nano-Photonics Laboratory 3.0 Credits
Teaches a fundamental knowledge of nanophotonic materials, devices, and applications in a hands-on laboratory setting. Introduces students to photonic bandgaps, photonic crystals, optical sensing methods, holography methods and materials, concepts of surface plasmons and Plasmon resonance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECEE 304 [Min Grade: D]) or (ECEL 311 [Min Grade: D] and ECEL 312 [Min Grade: D] and ECEE 304 [Min Grade: D])

ECEL 403 Bio-Photonics Laboratory 3.0 Credits
Teaches the fundamentals of the interaction of light with matter. Introduces students to different types of optical detection for biomedical applications,Quantized states of matter, Energy levels of atoms and molecules, Absorption, Scattering, Fluorescence, Imaging of cells and molecules, Spectroscopy, and Cancer precursors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECEE 304 [Min Grade: D]) or (ECEL 311 [Min Grade: D] or ECEL 312 [Min Grade: D] or ECEE 304 [Min Grade: D])

ECEL 404 Software Defined Radio Laboratory 3.0 Credits
This course introduces students to the concept of software defined radio using the USRP hardware platform and GNU Radio software. Functional blocks of wireless communications systems will be discussed, programmed in Python, and tested on hardware.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECES 302 [Min Grade: D]) or (ECEL 311 [Min Grade: D] and ECEL 312 [Min Grade: D] and ECES 302 [Min Grade: D])

ECEL 405 Digital Systems Laboratory 3.0 Credits
Students will gain practical knowledge of digital systems and signal processing by designing, simulating, constructing, testing and refining a digital audio recording system.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECES 302 [Min Grade: D]) or (ECEL 311 [Min Grade: D] and ECEL 312 [Min Grade: D] and ECES 302 [Min Grade: D])

ECEL 407 General Purpose GPU Programming 3.0 Credits
This course will teach students how to develop parallel algorithms for the GPU and implement them using the CUDA progamming interface.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (ECEL 301 [Min Grade: D] and ECEL 302 [Min Grade: D] and ECEC 301 [Min Grade: D] and ECEC 355 [Min Grade: D]) or (ECEL 311 [Min Grade: D] and ECEL 312 [Min Grade: D] and ECEC 301 [Min Grade: D] and ECEC 355 [Min Grade: D])

ECEL 490 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Electrical & Computer Engineering - Power Engineering

Courses

ECEP 352 Electric Motor Control Principles 4.0 Credits
Introduces machinery principles, magnetic circuits, three-phase circuits, the electrical and economic structure of the power industry, ac and dc machine fundamentals, and power electronic converters and their interfaces with electric motors. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 302 [Min Grade: D] (Can be taken Concurrently) (ECE 201 [Min Grade: D] or ECES 211 [Min Grade: D])

ECEP 354 Energy Management Principles 4.0 Credits
Covers principles of power engineering, including the electrical and economic structure of the power industry (distribution, subtransmission, and bulk transmission levels; environmental issues; the electrical system analysis; the thermal system analysis; links between electromechanics and thermodynamics; and safety issues). Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 302 [Min Grade: D] (Can be taken Concurrently) (ECE 201 [Min Grade: D] or ECES 211 [Min Grade: D])

ECEP 372 Radiation Detection and Measurement 3.0 Credits
Introduces students to the fundamentals of radiation detection, and applications of radiation detection equipment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 371 [Min Grade: D] or ECEP 404 [Min Grade: D] or MEM 371 [Min Grade: D]

ECEP 380 Introduction to Renewable Energy 3.0 Credits
Introduction to Renewable Energy is an undergraduate survey course for engineers, scientists and others interested in energy systems and applications. The course introduces students to the mix of current major electric power sources and the pressures that are forcing a transition to renewable sources. Wind and solar energy will be studied in detail, with others as time allows. Course culminates with an integrating off-grid energy system design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATH 122 [Min Grade: D] and (PHYS 102 [Min Grade: D] or PHYS 115 [Min Grade: D] or PHYS 154 [Min Grade: D])

ECEP 390 Special Topics 1.0-4.0 Credit
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 402 Theory of Nuclear Reactors 4.0 Credits
Introduces students to atomic and nuclear physics, radiation interaction with matter, components of nuclear reactors, neutron diffusion and moderation, nuclear reactor theory, and heat removal from nuclear reactors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENGR 210 [Min Grade: D]

ECEP 403 Nuclear Power Plant Design & Operation 3.0 Credits
Introduces students to the design of nuclear power plants. Topics covered include electrical transmission, non-nuclear related equipment, fluid flow, heat transfer, thermodynamics, heat exchangers, pump, valves, piping and nuclear reactor design. Course includes a final project which is the design of a nuclear power plant.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 404 Introduction to Nuclear Engineering 2.0 Credits
Introduces the fundamental scientific, technical, social and ethical issues in nuclear engineering; nuclear reactions and readiation, radiation protection and control, nuclear energy production and utilization, nuclear fuel cycle, nuclear fuel cycle, nuclear materials, controlled fusion and thermonuclear plasma systems, basics of plasma physics and plasma chemistry, nuclear waste management, nuclear reactor safety, analysis of severe nuclear accidents, risk assessment and related issues of engineering ethics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: PHYS 201 [Min Grade: D] and (ENGR 210 [Min Grade: D] or CHE 206 [Min Grade: D])

ECEP 406 Introduction to Radiation Health Principles 3.0 Credits
This course is intended to impart radiation safety knowledge to the nuclear engineering student. A fundamental knowledge of radiation safety is critical for all nuclear engineers.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 371 [Min Grade: D] or ECEP 404 [Min Grade: D]

ECEP 411 Power Systems I 3.0 Credits
Covers steady state generator, transformer and transmission line modeling used for balanced steady state power system analysis including three-phase to single-phase model conversion, per-unit analysis, generator and line loadability, transformer and transmission line voltage regulation and reactive compensation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 352 [Min Grade: D]

ECEP 412 Power Systems II 4.0 Credits
Covers y-bus based analysis of power systems including steady-state power-flow models and algorithms, economic dispatch of power generation, load-frequency control and introduction to transient stability analysis including time-domain simulation and equal area criterion.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 411 [Min Grade: D]

ECEP 413 Power Systems III 3.0 Credits
Covers Z-bus-based analysis of power systems including symmetrical component networks of generators, transformers, transmission lines and loads, symmetrical and unbalanced three-phase bus and line faults, and an introduction to power system protection.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 412 [Min Grade: D]

ECEP 421 Modeling and Analysis of Electric Power Distribution Systems 3.0 Credits
Introduction to power distribution systems; balanced and unbalanced systems, component and load modeling, radial and weekly meshed topologies; algorithms for unbalanced power studies including radial and general structure solver.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Corequisite: ECEP 411

ECEP 422 Power Distribution Automation and Control 3.0 Credits
Focuses on distribution management systems and their application: including optimizing network operation - capacitor placement and control, network reconfiguration, service restoration. Modern solution technologies are addressed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 421 [Min Grade: C]

ECEP 423 Service and Power Quality Distribution Systems 3.0 Credits
Focus on power distribution systems: service and power quality assessment including stat estimation, voltage quality, trouble call analysis, service restoration, component and system reliability assessment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 422 [Min Grade: C]

ECEP 431 Advanced Electromagnetic Energy Conversion I 4.0 Credits
Covers theory and operation of alternating current machinery, with emphasis on design alternatives and the effects of design on performance. Includes construction of machine models from laboratory measurements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 352 [Min Grade: D]

ECEP 432 Advanced Electromagnetic Energy Conversion II 4.0 Credits
Covers dynamic behavior and transient phenomena of rotating machines and the mathematical models used to describe them, generalized machine theory, measurement of parameters for the mathematical models, and measurement of dynamic and transient behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 431 [Min Grade: D]

ECEP 441 Protective Relaying 3.0 Credits
Covers operating principles of electromechanical and static relays, fault clearance, and protection of individual parts of a power system. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 411 [Min Grade: D] (Can be taken Concurrently)ECEP 352 [Min Grade: D]

ECEP 451 Power Electronic Converter Fundamentals 3.0 Credits
Fundamentals of power electronics that include waveforms, basic power switch properties and magnetic circuits. Introduction to basic power electronic converter circuits: diode and phase-controlled rectifies and inverters; switch-mode converters. Applications to DC and AC power supply systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 352 [Min Grade: D]

ECEP 452 Experimental Study of Power Electronic Converters 3.0 Credits
Experimental study of common power electronic converters: diode rectifiers, phase-controlled rectifies, switch-mode inverters. Both hardware and software studies. Additional lectures on: Study of DC-DC switch-mode converters.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 451 [Min Grade: D]

ECEP 453 Applications of Power Electronic Converters 3.0 Credits
Provides a first look at various power electronic applications in residential, commercial and industrial sites. Examples include utility application such as static var compensators (SVC), thyristor switch capacitors (TSC), high voltage direct-current (HVDC) transmission systems among others. In addition, fundamentals of motor drives and their controls are covered. Examples include induction, DC synchronous and specialized motors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 451 [Min Grade: D]

ECEP 461 High Voltage Laboratory 1.0 Credit
Requires students to perform four basic experiments to become familiar with high-voltage techniques and then do a high-voltage design project of their own choosing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEP 352 [Min Grade: D]

ECEP 471 Power Seminar I 0.5 Credits
Discusses current developments in power system operation and research, concentrating on current and future energy sources.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ECEP 472 Power Seminar II 0.5 Credits
Discusses current developments in power system operation and research, concentrating on generating stations, transmission lines, and substations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ECEP 473 Power Seminar III 0.5 Credits
Discusses current developments in power system operation and research, concentrating on distribution, security, and economics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ECEP 480 Solar Energy Engineering 3.0 Credits
Covers design of grid-connected and battery backup grid-connected photovoltaic systems. Both electrical and mechanical aspects are included. Topics include system components (solar cells, charge controllers, maximum power point trackers, inverters, etc.), system economics, computer and web-based design aids, electrical codes and standards, externalities of PV systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECEE 302 [Min Grade: D] or ECEE 352 [Min Grade: D] or CHE 431 [Min Grade: D] or ECEP 380 [Min Grade: D]

ECEP 490 Special Topics in Power Engineering 12.0 Credits
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

ECEP 497 Research in Power Systems 0.5-12.0 Credits
Requires independent study in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 499 Independent Study In Power Engineering 0.5-12.0 Credits
Requires independent study in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

Electrical & Computer Engineering - Systems

Courses

ECES 201 Introduction to Audio-Visual Signals 4.0 Credits
This introductory engineering course will focus on the digital signal representations commonly used in prevailing entertainment media: audio, images, and video. It will explore how each medium is represented digitally and convey the signal processing concepts used in storing, manipulating, transmitting, and rendering such content. The goal of the course is to provide non-engineering students with a fundamental understanding of core digital signal processing methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 122 [Min Grade: D]

ECES 302 Transform Methods and Filtering 4.0 Credits
Covers the Fourier series and the Fourier transform, sinusoidal steady-state analysis and filtering, discrete-time systems and the Z-transform, discrete Fourier transform, network functions and stability, magnitude, phase, poles and zeroes, Nyquist criterion, the Nyquist plot and root loci, stability of one-ports, sensitivity, worst-case design and failure-tolerance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: (TDEC 221 [Min Grade: D] or ENGR 232 [Min Grade: D] or MATH 262 [Min Grade: D] or MATH 210 [Min Grade: D]) and ECE 201 [Min Grade: D]

ECES 304 Dynamic Systems and Stability 4.0 Credits
Covers linear time-invariant circuits and systems; two-and multi-terminal resistors, operational-amplifier circuits, first-order circuits, linear and nonlinear second-order systems, state equation and state variables, eigenvalues and eigenvectors, zero-input response, qualitative behavior of x'=Ax (stability and equilibria), qualitative behavior of x'=f(x), phase portraits, equilibrium states.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 302 [Min Grade: D]

ECES 306 Analog & Digital Communication 4.0 Credits
Covers signal sampling and reconstruction; modulation, angle modulation; digital communications systems, digital transmission.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 302 [Min Grade: D]

ECES 352 Introduction to Digital Signal Process 4.0 Credits
Covers discrete-time signals, analog-digital conversion, time and frequency domain analysis of discrete-time systems, analysis using Z-transform, introduction to digital filters, discrete-time Fourier transform, Discrete Fourier Transform (DFT), and Fast Fourier Transform (FFT).
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 302 [Min Grade: D]

ECES 354 Wireless, Mobile & Cellular Communications 4.0 Credits
Covers concepts of wireless systems; propagation effects, including loss, dispersion, fading, transmission, and reception; mobile systems, including design of base units and mobile units; micro cells and pico cells; cell division, including frequency use and reuse; concepts of FDMA, TDMA, and CDMA; error rates and outage probability; and circuits and components for wireless and mobile systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 306 [Min Grade: D]

ECES 356 Theory of Control 4.0 Credits
Covers the foundations of control theory. Includes experiments and demonstrations during lectures and labs that may be jointly held, taking advantage of multimedia and computer-controlled apparatus.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 304 [Min Grade: D]

ECES 358 Computer Control Systems 4.0 Credits
Reviews principles of applications of computer control systems to a variety of industries and technologies, including manufacturing processes, robotic cells, machine cells, chemical processes, network control, investment portfolio control, and real-time expert and learning systems for diagnostics and quality control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 356 [Min Grade: D]

ECES 390 Special Topics 4.0 Credits
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 411 Convex Optimization in Engineering Systems 3.0 Credits
Covers fundamental of convex optimization including convex sets, convex functions, linear and nonlinear constraints, complementary slackness, Lagrange multipliers, Lagrangian duality, and quadralic programming. Focuses on applications (e.g., signal processing, communications, computer networking, and portfolio management). Focuses on use of Matlab or equivalent software.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECES 302 [Min Grade: D] and ENGR 361 [Min Grade: D]

ECES 412 Simulation of Stochastic Engineering Systems 3.0 Credits
Covers algorithms for generation of pseudo-random numbers, generation of random variates using the inverse transform, acceptance rejection techniques, Monte Carlo simulation, basics of point and interval estimation and hypothesis testing. Coverage of Markov chains, Markov chain Monte Carlo, Metropolis algorithm, simulated annealing, as time permits. Applications include computer networks, statistical physics, derivative pricing. Focus on use of Matlab or equivalent software.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECES 302 [Min Grade: D] and ENGR 361 [Min Grade: D]

ECES 413 Strategies for Repeated Games 3.0 Credits
Covers the gambler's ruin problem, optimality of bold play for subfair games, the Martingale betting system, Kelly betting and the maximum growth rate in superfair games, the multi-armed bandit and it generalizations, Parrondo's paradox for coupled subfair games, basics of auction theory. Focus on use of Matlab or equivalent software.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ECES 302 [Min Grade: D] and ENGR 361 [Min Grade: D]

ECES 421 Communications I 3.0 Credits
Covers analog communications, including linear modulation methods (AM, DSB, SSB), exponential modulation (FM, PM), and noise effects on analog communication systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 306 [Min Grade: D]

ECES 422 Communications II 3.0 Credits
Covers analog (PAM, PPM) and digital (PCM, DM) pulse modulation systems, entropy, source coding, and channel coding.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 421 [Min Grade: D]

ECES 423 Communications III 3.0 Credits
Covers digital transmission systems, baseband and passband, spread-spectrum communications, and basics of wireless and mobile systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ECES 422 [Min Grade: D]

ECES 434 Applied Digital Signal Processing 4.0 Credits
This course explores digital signal processing (DSP) concepts through the context of current applications, which range from video encoding to human genome analysis. Topics such as sampling, aliasing, and quantization, are considered in terms of the constraints of particular applications. Discrete-time linear systems, frequency-domain analysis, and digital filtering using Discrete Fourier Transform are examined in-depth and realized through application-specific lab projects.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 352 [Min Grade: D]

ECES 435 Recent Advances in Digital Signal Processing 4.0 Credits
Digital signal processing algorithms once thought to be impractical are now implemented in devices, such as household appliances & mobile phones. This course explores the computationally-intensive DSP methods including short-time linear prediction, cepstral analysis, and complex phase reconstruction as well as alternative signal representations and transforms, including the Hilbert, Chirp, and Discrete Cosine Transforms. Laboratory projects will focus on the implementation of these methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 352 [Min Grade: D]

ECES 436 Multi-disciplinary Digital Signal Processing 4.0 Credits
The applications of digital signal processing (DSP) span a wide range of problem domains and disciplines. This course explores the multi-disciplinary aspects of DSP by focusing on a core set of common methods applicable to problems in many fields, such as periodicity detection, signal and power spectrum estimation, and data modeling. Laboratory projects will utilize experiments drawn from a diversity of fields, including medicine, music analysis, image processing,voice/data communications and robotics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 352 [Min Grade: D]

ECES 444 Systems and Control I 4.0 Credits
This course reviews classical control: analysis and design, state space approach to systems analysis and control; Eigenvalue/Eigenvector analysis, model decomposition, state space solutions and Cayley-Hamilton technique and applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 356 [Min Grade: D]

ECES 445 Systems and Control II 4.0 Credits
This course covers Eigenvector single-value decomposition and modal decomposition; controllability, observability and Kalman canonical forms; state controllers and observers and the separation principle.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 444 [Min Grade: D]

ECES 446 Systems and Control III 4.0 Credits
This course covers linear quadratic control, non-linear stability and analysis. Current topics in control include Robust, H-infinity, and Fuzzy Control concepts.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 445 [Min Grade: D]

ECES 490 Special Topics in Systems Engineering 12.0 Credits
Provides special courses offered because of particular student or faculty interest.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

ECES 497 Research in Systems Engineering 0.5-12.0 Credits
Electrical engineering students only. Requires independent research in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

ECES 499 Supervised Study in Systems Engineering 0.5-20.0 Credits
Requires independent study in a topic approved by the faculty.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

Engineering Management

Courses

EGMT 462 Introduction to Engineering Management 3.0 Credits
Introduces the general theory of management, including the processes of planning, organizing, assembling resources, supervising, and controlling. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.
Prerequisites: CS 240 [Min Grade: D]

EGMT 465 Introduction to Systems Engineering 3.0 Credits
Determining technical requirements for engineering systems and planning technical product design and requirements. Analyzing the functionality, interoperability, and sustainability of new engineering systems. Integrating disparate engineering components for overall system optimization. Planning for testing and evaluation of engineering systems to evaluate conformance with technical requirements. Planning optimized organizational structure for execution of complex engineering programs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.
Prerequisites: EGMT 462 [Min Grade: D] or MEM 462 [Min Grade: D]

Engineering, General

Courses

ENGR 100 Beginning Computer Aided Drafting for Design 1.0 Credit
Introduces students to computer-aided graphics techniques and the use of a state-of-the-art, computer-aided design/drafting package. Students will learn 2-D and 3-D modeling techniques to support the design process. All students will be required to take a competency quiz on 4 of 6 available AutoCAD labs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 101 Engineering Design Laboratory I 2.0 Credits
This course introduces students to engineering design and practice. Emphasis is placed on the synthesis of knowledge, skills and the methodologies that are the heart of the profession. The course is designed to integrate core scientific foundations into an engineering perspective through the use of team-based projects, computer tools and technical writing. This is the first part of the three term freshman design experience.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 102 Engineering Design Laboratory II 2.0 Credits
This course introduces students to engineering design and practice. Emphasis is placed on the synthesis of knowledge, skills and the methodologies that are the heart of the profession. The course is designed to integrate core scientific foundations into an engineering perspective through the use of team-based projects, computer tools and technical writing.This is the second part of the three term freshman design experience.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 103 Engineering Design Laboratory III 2.0 Credits
This course introduces students to engineering design and practice. Emphasis is placed on the synthesis of knowledge, skills and the methodologies that are the heart of the profession. The course is designed to integrate core scientific foundations into an engineering perspective through the use of team-based projects, computer tools and technical writing.This is the third part of the three term freshman design experience.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 104 Engineering Design Laboratory for Transfers 4.0 Credits
Individualized course specially designed for transfer students. Provides selected educational experiences in engineering design, experimental techniques, and computer skills to round out the student's previous course of study.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 180 Special Topics in Engineering 12.0 Credits
Topics of special interest to students and faculty in Engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ENGR 199 Preparation for the Engineering Studies 6.0 Credits
Preparation for the Engineering Core Curriculum through intensive, coordinated work in three areas: pre-calculus mathematics, effective study methods, and career evaluation and selection. Topics include: algebra, trigonometry, geometry, note-taking, exam preparation, time management, evaluation of engineering and other career paths. (This course does not count toward graduation requirements).
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ENGR 201 Evaluation & Presentation of Experimental Data I 3.0 Credits
Provide a comprehensive introduction to analysis, presentation, and communication of data collected by the engineer. Requires students to conduct experiments on engineering systems, then process and evaluate the collected data. Required presentation of research, results, conclusions, and conjectures from a technical and ethical viewpoint.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: (MATH 122 [Min Grade: D] and PHYS 101 [Min Grade: D] and ENGR 103 [Min Grade: D]) or (TDEC 112 [Min Grade: D] and TDEC 113 [Min Grade: D] and TDEC 132 [Min Grade: D])
Corequisite: EXAM 081

ENGR 202 Evaluation & Presentation of Experimental Data II 3.0 Credits
A continuation of ENGR 201.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ENGR 201 [Min Grade: D] or TDEC 231 [Min Grade: D]
Corequisite: EXAM 081

ENGR 210 Introduction to Thermodynamics 3.0 Credits
Introduces thermodynamics from a classical point of view. Covers work, heat, entropy, thermodynamic properties, equations of state, and first and second law analysis of closed systems, control volumes, and selected thermodynamic cycles.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATH 122 [Min Grade: D] and PHYS 101 [Min Grade: D]
Corequisite: EXAM 081

ENGR 220 Fundamentals of Materials 4.0 Credits
Introduces materials and their properties; atomic view and architecture of solids; atomic motion in solids, mechanical, magnetic, electrical and optical properties of materials. Corrosion and degradation of solids.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (CHEM 102 [Min Grade: D] and MATH 122 [Min Grade: D] and PHYS 101 [Min Grade: D]) or (TDEC 121 [Min Grade: D] and TDEC 112 [Min Grade: D] and TDEC 112 [Min Grade: D] and TDEC 113 [Min Grade: D])
Corequisite: EXAM 081

ENGR 231 Linear Engineering Systems 3.0 Credits
Provides an overview of systems and modeling; specifically using linear algebra as the model. Specific emphasis will be placed on developing models of engineering systems and the use of computational tools for solutions of the problems. The focus of the lab will be the use of MATLAB for solution of contemporary engineering problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATH 122 [Min Grade: D] or TDEC 112 [Min Grade: D]
Corequisite: EXAM 081

ENGR 232 Dynamic Engineering Systems 3.0 Credits
Provides an overview of dynamic systems and modeling; specifically using differential equations as a model. Specific emphasis will be placed on developing models of dynamic systems and the use of computational tools for solutions of the problems. The focus of the lab will be the use of MATLAB for solution of contemporary engineering problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ENGR 231 [Min Grade: D] or MATH 261 [Min Grade: D] or MATH 201 [Min Grade: D]
Corequisite: EXAM 081

ENGR 280 Introduction to Global Engineering 2.0 Credits
Introduces students to a broad range of contemporary issues (economic, political, and cultural) engineers face in meeting the challenges of globalization. In addition to responding to weekly presentations, students will engage in and report on an in-depth case study.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 361 Statistical Analysis of Engineering Systems 3.0 Credits
Probability, random variables, reliability, quality control, design of experiments, regression/correlation, ANOVA and related topics, hypothesis testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Sophomore

ENGR 491 Senior Project Design I 2.0 Credits
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ENGR 492 Senior Project Design II 2.0 Credits
Continues ENGR 491. Requires written and oral progress reports.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CIVE 491 [Min Grade: D]

ENGR 493 Senior Project Design III 4.0 Credits
Continues ENGR 492. Requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

Environmental Engineering

Courses

ENVE 300 Introduction to Environmental Engineering 3.0 Credits
Overview of environmental engineering practice: water resources, water and waste control, solid waste, air pollution, risk management and environmental health. Population and resource demand forecasting, chemistry and microbiology necessary to solve basic problems is included.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CAEE 201 [Min Grade: D]

ENVE 302 Environmental Transport and Kinetics 3.0 Credits
Covers applications of mass balances to describing transport environmental systems, diffusive and dispersive processes, and coupling of transport and kinetic models.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: CHE 201 [Min Grade: D]

ENVE 335 Industrial Safety 3.0 Credits
Examines safety in the workplace, loss prevention principles, Occupational Safety and Health Act implementation, accident investigation techniques, and basics of loss control and risk management.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ENVE 410 Solid and Hazardous Waste 3.0 Credits
Provides an overview of municipal and industrial waste management, including design and economic analysis. Discusses options such as landfilling and incineration from engineering, social, and regulatory perspectives. Reviews physical, chemical, and biological treatment of hazardous waste.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ENVE 421 Water and Waste Treatment II 3.0 Credits
Covers processes used for water purification and waste treatment, containment and immobilization of hazardous wastes, and ultimate disposal of residues and hazardous materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

ENVE 422 Water and Waste Treatment Design 3.0 Credits
Covers integration of processes into a complete treatment system. Includes detailed design procedures to control wastes, prevent environmental contamination, and protect drinking water quality.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ENVE 421 [Min Grade: D]

ENVE 435 Groundwater Remediation 3.0 Credits
Reviews physical, chemical, and biological remediation technologies for contaminated sites and groundwater by in-site and ex-site applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

ENVE 450 Data-based Engineering Modeling 3.0 Credits
This course covers empirical methods to understand and model engineering systems. Students will learn to develop evaluate statistical models and use three common statistical software packages, Excel, SPSS, and R.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Junior or Pre-Junior or Sophomore
Prerequisites: ENGR 361 [Min Grade: D] or CHE 335 [Min Grade: D] or MEM 361 [Min Grade: D] or MATH 311 [Min Grade: D]

ENVE 455 Geographic Information Systems 3.0 Credits
The course provides grounding in fundamental principles of GIS, and achieves understanding through hands on practical laboratories. Course topics include: spatial reference systems, geographic data theory and structures, structures, spatial analysis tools, functions and algorithms, GIS data sources, compilation and quality, and GIS project design and planning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

ENVE 460 Fundamentals of Air Pollution Control 3.0 Credits
Fundamental topics with regard to the formation and control of air pollutants are studied. This course provides strong foundation for engineers who will be involved in the development of engineering solutions for industrial air pollution prevention and design, development or selection of air pollution control devices and systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 465 Indoor Air Quality 3.0 Credits
Introduces basic concepts about indoor air quality, indoor air pollutants, including their sources and health effects, transport of pollutants, modeling of pollutant concentration in buildings, and ventilation as well as air cleaning systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVE 302 [Min Grade: D] or AE 220 [Min Grade: D]

ENVE 480 Topics in Environmental Engineering 0.5-12.0 Credits
Selected topics offered in the area of Environmental Engineering of interest to students or faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ENVE 485 Professional Environmental Engineering Practice 1.0 Credit
Professional and ethical considerations in environmental engineering practice. Career management and lifelong learning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is ENVE and classification is Senior.

ENVE 486 Environmental Engineering Processes Laboratory I 2.0 Credits
Laboratory experiments on common environmental engineering unit processes are performed. Students use data to draw conclusions relevant to design of full-scale systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is ENVE and classification is Senior.
Prerequisites: ENVE 302 [Min Grade: D] and ENVE 401 [Min Grade: D]

ENVE 487 Environmental Engineering Processes Laboratory II 2.0 Credits
Laboratory experiments on common environmental engineering unit processes are performed. Students use data to draw conclusions relevant to design of full-scale systems. Continuation of ENVE 486.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is ENVE and classification is Senior.
Prerequisites: ENVE 486 [Min Grade: D]

ENVE 491 [WI] Senior Project Design I 3.0 Credits
Introduces the design process. Covers information retrieval, problem definition, proposal writing, patents, and design notebooks. Explores problem areas through presentations by experts from industry, government, and education. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ENVE 302 [Min Grade: D]

ENVE 492 [WI] Senior Design Project II 3.0 Credits
Continues the work started in ENVE 491. Requires written and oral progress reports. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ENVE 491 [Min Grade: D]

ENVE 493 [WI] Senior Design Project III 4.0 Credits
This course is the final sequence in the design project. It requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: ENVE 492 [Min Grade: D]

Materials Engineering

Courses

MATE 100 Materials for Emerging Technologies 2.0 Credits
Evolution of materials engineering; education and the profession; concepts, tools, and techniques; selection and design using metals, ceramics, polymers, and composites; application of materials in a technological society; and materials of the future.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 101 Fundamentals of Materials 4.0 Credits
Examines principles underlying structure, properties, and behavior of engineering materials, including metals, ceramics, and polymers. Covers topics including bonding; crystal structure; defect structure; alloying; mechanical, electronic, and magnetic properties in relation to structure; phase equilibria; phase transformations; and oxidation and corrosion. All terms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (CHEM 103 [Min Grade: D] or CHEM 163 [Min Grade: D]) and (CHEM 102 [Min Grade: D] or CHEM 162 [Min Grade: D])

MATE 214 Introduction to Polymers 4.0 Credits
Covers polymer molecular structure, polymerization methods, semi-crystalline polymers, glass transition, polymer solution in blends, mechanical properties, and characterization methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 221 [Min Grade: D] and (MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231 [Min Grade: D]) and CHEM 241 [Min Grade: D]

MATE 221 Introduction to Mechanical Behavior of Materials 3.0 Credits
Covers mechanics of materials, materials under load, application to materials testing, rate-dependent response to materials, fracture materials, fatigue behavior, manufacturing, and materials processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: TDEC 211 [Min Grade: D] or ENGR 220 [Min Grade: D]

MATE 240 Thermodynamics of Materials 4.0 Credits
Covers the fundamental laws of thermodynamics, statistical meaning of entropy, thermodynamic functions, heat capacity, reactions in gases and condensed phases, phase diagrams, solutions, and reaction equilibria in condensed solutions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 221 [Min Grade: D] and (TDEC 202 [Min Grade: D] or ENGR 210 [Min Grade: D])

MATE 245 Kinetics of Materials 4.0 Credits
Covers chemical reaction kinetics, thermodynamics and structure of crystal defects, diffusion equations and numerical methods of solution, kinetics in interfacial phenomena, and diffusional transformations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 240 [Min Grade: D]

MATE 280 Advanced Materials Laboratory 4.0 Credits
The goal of the course is to introduce students to state-of-the-art experimental techniques for analysis of structure, composition and properties of materials. Electron microscopy, Raman spectroscopy, indentation and thermal analysis will be described.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (TDEC 212 [Min Grade: D] or ENGR 220 [Min Grade: D]) and (TDEC 232 [Min Grade: D] or ENGR 202 [Min Grade: D])

MATE 315 Processing Polymers 4.5 Credits
Covers polymer processing, viscous flow and melt rheology, injection molding, extrusion, mechanical behavior, and applications and design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 214 [Min Grade: D]

MATE 341 Defects in Solids 3.0 Credits
Main classes of crystalline defects: vacancies, dislocations, stacking faults, surfaces, grain boundaries, geometry, energy considerations, and movement of defects. Defects in specific crystallographic systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is MSE.
Prerequisites: MATE 355 [Min Grade: D]

MATE 345 Processing of Ceramics 4.5 Credits
Covers powder production, materials characterization, stability of powder suspensions, rheological and viscoelastic properties of slurries, green-body consolidation, drying, sintering, and structure-property relationships.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 355 [Min Grade: D] (Can be taken Concurrently)

MATE 351 Electronic and Photonic Properties of Materials 4.0 Credits
Electrons, principles of quantum mechanics, bonding, free electrons, and band theory solids; lattice vibrations, electronic and vibrational heat capacity; semiconductors and semiconductor devices; dielectrics, magnetic and optoelectronic materials and devices; superconductivity; applications and implications for energy-harvesting, conversion and storage.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 355 [Min Grade: D] (Can be taken Concurrently)

MATE 355 Structure and Characterization of Crystalline Materials 3.0 Credits
Bonding in solids; classification of metals, semiconductors, and insulators; crystal systems; crystallographic systems in specific engineering materials, relationships, X-ray generation, X-ray absorption and emission; reciprocal space; geometric representation of crystals, small and wide angle scattering, electron microscope imaging and diffraction.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is MSE.
Prerequisites: ENGR 220 [Min Grade: D] and MATE 221 [Min Grade: D]

MATE 366 [WI] Processing of Metallic Materials 4.5 Credits
Covers solidification processing, casting and welding, heat flow analysis, solid-state transformations, precipitation hardening, transformations in steels, martensite transformations, and industrial case studies. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 245 [Min Grade: D] and MATE 341 [Min Grade: D]

MATE 370 Mechanical Behavior of Solids 3.0 Credits
Covers continuum mechanics: three-dimensional stress and strain, hydrostatic and deviatoric components, and isotropic elasticity; Mises yield criterion; fracture criteria; linear elastic fracture mechanics; materials selection; defect-tolerant and defect-free fatigue design; notch effects; and statistics of variation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 221 [Min Grade: D] and ENGR 231 [Min Grade: D]

MATE 410 Case Studies in Materials 3.0 Credits
Covers interaction of materials processing and design, materials selection, the design-failure interface, cost and capacity in manufacturing. Taught via case studies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 221 [Min Grade: D]

MATE 450 The Nuclear Fuel Cycle & Materials 3.0 Credits
Nuclear fuel cycle, including extraction, enrichment, transmutation in a nuclear reactor, reprocessing, waste processing, repository performance. Materials for nuclear reactors, mechanical and thermal performance, radiation damage.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENGR 220 [Min Grade: D] and (MEM 371 [Min Grade: D] or ECEP 404 [Min Grade: D]) and ECEP 402 [Min Grade: D]

MATE 455 Biomedical Materials 3.0 Credits
Familiarizes students with natural tissues and the implants designed to replace them, treating both components as engineering materials. Includes a review of fundamental topics of materials structure and testing, and case studies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

MATE 458 Advanced Biomaterials 3.0 Credits
Tissue Engineering, matrices, cells, scaffold, engineering properties, constitutive relations, absorbable polymers, cell seeding, cellular isolation, cell-scaffold interaction. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if classification is Senior.

MATE 460 Engineering Computational Laboratory 4.0 Credits
Covers numerical techniques, finite differences and finite elements, convergence, and applications in engineering design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 221 [Min Grade: D] and (TDEC 222 [Min Grade: D] or ENGR 232 [Min Grade: D]) and (TDEC 114 [Min Grade: D] or MATH 200 [Min Grade: D])

MATE 473 Electronic, Magnetic and Optical Characterization of Energy Materials 3.0 Credits
This course will examine the selection criteria for component materials in each of these applications and cover how critical properties – electronic conductivity, mobility, ionic conductivity, magnetization, optical absorption, Seebeck coefficient – are measured.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 351 [Min Grade: D]

MATE 476 Recycling of Materials 3.0 Credits
This course will examine the selection criteria for recycling component materials. Recycling involves both reusing materials for energy applications and reprocessing materials into new products.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 240 [Min Grade: D] and MATE 245 [Min Grade: D]

MATE 482 Materials for Energy Storage 3.0 Credits
The course will address principles of operation of electrochemical energy storage devices and describe materials used in those devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENGR 220 [Min Grade: D]

MATE 483 Environmental Effects on Materials 3.0 Credits
Environmental degradation is explored with a focus on electrochemical corrosion reactions in metals and alloys due to atmospheric, aqueous, chemical or elevated temperature exposure. In addition, high temperature degradation of ceramics and degradation of polymers due to exposure to heat, light and chemicals will be addressed. The role of these environmental effects during service and the impact on performance and reliability will be explored.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 245 [Min Grade: D]

MATE 491 [WI] Senior Project Design I 2.0 Credits
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

MATE 492 Senior Project Design II 2.0 Credits
Continues MATE 491. Requires written and oral progress reports.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 491 [Min Grade: D]

MATE 493 [WI] Senior Project Design III 4.0 Credits
Continues MATE 492. Requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MATE 492 [Min Grade: D]

MATE 495 Special Topics in Materials 0.5-12.0 Credits
By arrangement. Covers selected topics of current interest in materials engineering. May be taken for multiple course credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

MATE 499 Independent Study 0.5-12.0 Credits
Provides independent study and/or research on a topic approved by the department.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

Mechanical Engineering & Mechanics

Courses

MEM 201 Foundations of Computer Aided Design 3.0 Credits
Covers application of modern, computer-aided graphics techniques and the use of state-of-the-art, computer-aided design/drafting package(s). Includes topics such as principles of computer-aided design/drafting and interactions with computer-aided manufacturing, rapid prototyping, and other modern manufacturing processes; engineering graphics and graphics languages in computer-aided design and/or drafting; creation of a drawing environment; database and file management, editing, modification, displaying, dimensioning, plotting and printing; special editing techniques; 3-D modeling, solid modeling, shading, and rendering; and file transfer. Students must have Sophomore class standing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman

MEM 202 Statics 3.0 Credits
Covers two-and three-dimensional vector representation of forces, moments and couples; static equilibrium of particles, rigid bodies, and engineering structures; analysis of external and internal forces in structures via methods of free body diagrams; and properties of cross-sectional areas.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: PHYS 185 [Min Grade: D] or PHYS 101 [Min Grade: D]

MEM 220 Basic Fluid Mechanics 4.0 Credits
Covers general physical properties of a fluid; kinetics of fluid motion; material derivative, vorticity, strain, and dynamics of fluids; and derivation of conservation laws in control volume form with applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: TDEC 114 [Min Grade: D] or MATH 189 [Min Grade: D] or MATH 200 [Min Grade: D]

MEM 230 Mechanics of Materials I 4.0 Credits
Covers definitions of stress and strain, uniaxial loading, torsion, bending moments and shear forces in beams, bending stresses and shear stress in beams, and stress transformation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 202 [Min Grade: D]

MEM 238 Dynamics 4.0 Credits
Covers kinematics and kinetics in two and three-dimensional space, force and acceleration, linear and angular momentum, and energy methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: (MATH 189 [Min Grade: D] or MATH 200 [Min Grade: D]) and (PHYS 111 [Min Grade: D] or PHYS 185 [Min Grade: D] or PHYS 101 [Min Grade: D])

MEM 255 Introduction to Controls 4.0 Credits
Introduces the concepts of modeling of mechanical, electrical, electromechanical, thermal, and hydraulic systems; linearization; state-space model; time-domain analysis; transfer functions; frequency-domain analysis; analysis of systems involving automatic control of position, speed, power, flow, pressure, temperature, and other physical quantities; basic concept of feedback; basic concept of stability; computer-aided analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 238 [Min Grade: D] and (MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231 [Min Grade: D]) and (MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or ENGR 232 [Min Grade: D])

MEM 304 Introduction to Biomechanical Engineering 3.0 Credits
An overview of the application of mechanical engineering to biological systems. Covers basic anatomy and physiology; tissue, joint, cell, and protein mechanics; joint kinematics; biofluid mechanics; biothermodynamics; biotransport; biomimetic controls; and biomanufacturing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATH 200 [Min Grade: D] and PHYS 101 [Min Grade: D] and CHEM 102 [Min Grade: D] and BIO 141 [Min Grade: D]

MEM 310 Thermodynamic Analysis I 4.0 Credits
Reviews first and second laws of thermodynamics as applied to closed systems, control volumes, and thermodynamic cycles; covers thermodynamic relations and properties of real fluids, mixtures, and solutions; introduces phase and chemical equilibrium, power and refrigeration cycles, and combustion.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ENGR 210 [Min Grade: D] or MEM 210 [Min Grade: D]

MEM 311 Thermal Fluid Science Laboratory 2.0 Credits
Introduces modern laboratory techniques, including statistical analysis of experimental data; thermodynamic properties and equations of state; and dynamic and static temperature measurements with potentiometers, bridge circuits, and oscilloscopes. Fall.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 220 [Min Grade: D] and MEM 310 [Min Grade: D]

MEM 320 Fluid Dynamics I 3.0 Credits
Covers equation of motion for compressible flow; static, total, and stagnation concepts; one-dimensional isentropic, normal shock, including Fanno and Rayleigh flows and choked flow; two-dimensional supersonic flow, including Prandtl-Meyer flow and oblique shocks; analysis and design of compressible flow devices, including supersonic nozzles, diffusers, wind tunnels, inlets, and combustors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 220 [Min Grade: D]

MEM 330 Mechanics of Materials II 4.0 Credits
Reviews mechanics of materials, beam theory, combined loading, stress transformation, shear center, asymmetrical bending, deflection of beams, statically indeterminate beams, energy methods, inelastic bending, and beam column instability.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 230 [Min Grade: D]

MEM 331 Experimental Mechanics I 2.0 Credits
Covers static testing methods, including strain gages, extensometers, photoelasticity, and model analysis; practical applications of experimental stress analysis; and verification of standard materials tests, including tensile, shear, and buckling. Winter. Some or all pre-requisites may be taken as either a pre-requisite or co-requisite. Please see the department for more information.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 238 [Min Grade: D] (Can be taken Concurrently)MEM 230 [Min Grade: D]

MEM 333 Mechanical Behavior of Materials 3.0 Credits
Introduces the deformation and failure of engineering materials; Emphasizes application of the fundamentals to engineering design to prevent failure; Covers material damage and failure under multi-axial stresses, yielding, fracture mechanics, fatigue crack growth, fatigue life estimation, and deformation and failure of composite materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Pre-Junior or Senior.
Prerequisites: MEM 230 [Min Grade: D]

MEM 345 Heat Transfer 4.0 Credits
Covers fundamentals of conduction, convection, and radiation; steady and unsteady heat conduction; fundamentals of boundary layer flows; introduction to forced and free convection for external and internal flows; blackbody radiation; and radiation and surface radiation properties.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: ENGR 210 [Min Grade: D] and (MEM 220 [Min Grade: D] or CIVE 320 [Min Grade: D]) and (MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D] or ENGR 232 [Min Grade: D])

MEM 351 Dynamic Systems Laboratory I 2.0 Credits
Includes experiments involving modeling and simulation of linear and non-linear dynamic systems, including feedback controls. Spring.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 255 [Min Grade: D]

MEM 355 Performance Enhancement of Dynamic Systems 4.0 Credits
This course introduces measures of performance of dynamical systems, means of computing/evaluation-of such measures, and how to design controllers to improve performance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 255 [Min Grade: D]

MEM 361 Engineering Reliability 3.0 Credits
Reviews probability concepts and modeling of random phenomena, including parameter estimation, empirical determination of distribution models, catastrophic failure models, material strength and fatigue life distribution, and reliability improvement.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.
Prerequisites: MATH 290 [Min Grade: D] or MATH 201 [Min Grade: D] or MATH 261 [Min Grade: D] or ENGR 231 [Min Grade: D]

MEM 371 Introduction to Nuclear Engineering I 2.0 Credits
Introduces the fundamental scientific, technical, social and ethical issues in nuclear engineering; nuclear reactions and readiation, radiation protection and control, nuclear energy production and utilization, nuclear fuel cycle, nuclear fuel cycle, nuclear materials, controlled fusion and thermonuclear plasma systems, basics of plasma physics and plasma chemistry, nuclear waste management, nuclear reactor safety, analysis of severe nuclear accidents, risk assessment and related issues of engineering ethics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: PHYS 201 [Min Grade: D] and (ENGR 210 [Min Grade: D] or CHE 206 [Min Grade: D])

MEM 373 Space Systems Engineering I 3.0 Credits
Introduction to space engineering through presentation of two topics that serve as the foundation of space systems analysis and design: rocket propulsion and orbital mechanics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 220 [Min Grade: D] and MEM 238 [Min Grade: D] and MEM 310 [Min Grade: D]

MEM 374 Space Systems Engineering II 3.0 Credits
Introduction to design principles and theory of satellite systems engineering, including design theories and parameters involved in satellite development, as well as real life conditions such as applications, product assurance, assembly, and testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 373 [Min Grade: D]

MEM 380 [WI] Special Topics in Mechanical Engineering 12.0 Credits
Selected topics that meet student interests and faculty capabilities. May be taken more than one time when the topics vary. Students may enroll in more than one section of this course in any one term when different topics are covered in each section. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MEM 395 Hess Undergraduate Scholars Research 0.5-3.0 Credits
A change for undergraduates to experience independent research as part of the MEM Hess Honors Program. Weekly group meetings to discuss the details of the research endeavor are coupled with independent student in a research laboratory. May be repeated five times for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated 5 times for 18 credits
Prerequisites: MEM 310 [Min Grade: D]

MEM 399 Independent Study in Mechanical Engineering 0.5-12.0 Credits
Provides independent study or research on a topic approved by the department.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Cannot enroll if classification is Freshman

MEM 400 Internal Combustion Engines 3.0 Credits
Covers engine types and trends, thermodynamics of engines and engine processes, ideal and actual engine processes and cycles, combustion and emissions, fuel chemistry and properties, detonation and knock, and engine testing and performance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 310 [Min Grade: D]

MEM 402 Power Plant Design 3.0 Credits
Covers heat cycle arrangement, equipment selection, analysis of cost demands, and diversity factors. Includes economic studies of plant and cycle arrangements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 310 [Min Grade: D]

MEM 403 Gas Turbines & Jet Propulsion 3.0 Credits
Covers fundamentals of thermodynamics and aerothermodynamics, and application to propulsion engines; thermodynamic cycles and performance analysis of gas turbines and air-breathing propulsion systems, turbojet, turboprop, ducted fan, ramjet, and ducted rocket; theory and design of ramjets, liquid and solid rockets, air-augmented rockets, and hybrid rockets; aerodynamics of flames, including the thermodynamics and kinetics of combustion reactions; supersonic combustion technology and zero-g propulsion problems; and propulsion systems comparison and evaluation for space missions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 220 [Min Grade: D] and MEM 310 [Min Grade: D]

MEM 405 Principles of Combustion I 3.0 Credits
Covers thermochemistry, the relationship between heats of formation and bond energies, heat capacity and heats of reaction, chemical equilibrium, calculation of flame temperature, and composition of burned gas.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 410 [Min Grade: D]

MEM 406 Principles of Combustion II 3.0 Credits
Covers laminar flame propagation in premixed gases, detonation and deflagration, burning of liquid and solid fuels, and diffusion flames.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 405 [Min Grade: D]

MEM 410 Thermodynamic Analysis II 3.0 Credits
Covers thermodynamic analysis of ideal and real mixtures and gas phase reacting systems. Introduces equilibrium analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 310 [Min Grade: D]

MEM 413 HVAC Loads 3.0 Credits
Human comfort and associated models; state-of-the-art methods of calculating building peak heating and cooling loads; analysis of different psychrometric processes; different types of secondary systems: description, operating principles, modeling, simulation and sizing of secondary systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 345 [Min Grade: D] and (MEM 310 [Min Grade: D] or AE 220 [Min Grade: D])

MEM 414 HVAC Equipment 3.0 Credits
Standard and real, single-stage multistage refrigeration cycles; vapor compression components (compressor, expansion devices, condensers, and evaporators); heat pumps; absorption systems; boilers; heat exchangers; cooling coils, cooling towers; part-load energy performance; annual energy; annual energy estimation methods (degree-day, bin method, modified degree-day).
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 345 [Min Grade: D] and (MEM 310 [Min Grade: D] or AE 220 [Min Grade: D])

MEM 415 Fuel Cell Engines 3.0 Credits
Introduces fundamental aspects and operating principles of fuel cell systems, including: basic electrochemical principles, thermodynamics required for understanding the operation, components including functions and materials, electrochemical performance characteristics, analysis of system losses and efficiency, various fuel cell types, current state of technology, application areas/implementation, and current technical challenges.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (MEM 220 [Min Grade: D] or CHE 302 [Min Grade: D] or CHE 311 [Min Grade: D] or CIVE 320 [Min Grade: D]) and MEM 310 [Min Grade: D]

MEM 417 Introduction to Microfabrication 3.0 Credits
This course focuses on the fundamentals of microfabrication technologies. The materials, principles, and applications of silicon-based microfabrication technologies such as photolithography, wet/dry etching, deposition techniques, surface micromachining, and polymer micromachining are covered. This course also includes two lab sessions through which students have hands-on experiences in microfabrication.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

MEM 419 Microfluidics and Lab-on-a-Chip 3.0 Credits
This course focuses on design, manufacturing, and application of lab-on-a-chip systems as well as understanding microfluidic phenomena. The lecture covers novel microfluidic phenomena, microsensors, microactuators, and case studies. This course also includes two lab sessions through which student have hands-on experiences in lab-on-a-chip technology.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.
Prerequisites: MEM 417 [Min Grade: D]

MEM 420 Aerodynamics 3.0 Credits
Covers steady and unsteady flow, flow around a body, wing theory, thin airfoil theory, fundamental equation of finite-wing theory, and aerodynamic characteristics of wings. Introduces potential theory and boundary layer phenomena.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 220 [Min Grade: D]

MEM 423 Mechanics of Vibration 4.0 Credits
Covers free and forced vibrations of one-, two-, and multiple-degree-of-freedom systems; continuous systems; and transient and random vibration problems. Includes use of digital computer for homework and special class problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 238 [Min Grade: D] and (TDEC 222 [Min Grade: D] or ENGR 232 [Min Grade: D] or MATH 210 [Min Grade: D] or MATH 262 [Min Grade: D])

MEM 424 Biomechanics 3.0 Credits
Introduces modeling of dynamics of biomechanical systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 202 [Min Grade: D] and MEM 238 [Min Grade: D]

MEM 425 Aircraft Design & Performance 3.0 Credits
Introduces aerodynamics and airfoils; steady flight; power required and power available curves; range and endurance; takeoff, glide, and landing; stick force and control-free stability; moment coefficients and derivatives; and designing to specification. Students must have Junior class standing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

MEM 426 Aerospace Structures 3.0 Credits
Covers properties of wing and fuselage sections, torsion of thin-walled and skin-stringer multiple-cell sections, non-symmetrical bending of wing and fuselage sections, shear in thin-walled and skin-stringer sections, and buckling. Introduces matrix methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 230 [Min Grade: D]

MEM 427 Finite Element Methods 3.0 Credits
Introduces the fundamental theory and formulations of finite element method and its application in structural mechanics and thermal/fluid science. Topics include formulation of 1-D and 2-D elements, isoparametric elements, static and dynamic analysis of trusses, beams, and frames, 2-D plane problems, and heat transfer problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 230 [Min Grade: D]

MEM 428 Introduction to Composites I 3.0 Credits
Introduces anisotropic elasticity, lamina stiffness and compliance, plane stress and strain, test methods, and failure criteria.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 330 [Min Grade: D]

MEM 429 Introduction to Composites II 3.0 Credits
Covers laminated plate theory, stiffness and compliance of laminated plates, effect of laminated configuration on elastic performance, and strength production.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 428 [Min Grade: D]

MEM 430 Advanced Stress Analysis 4.0 Credits
Examines three-dimensional representation of stress and strain, coordinate transformation, stress strain relationships for anisotropic and isotropic materials, equilibrium equations, boundary value problems, governing equations in plane strain and plane stress problems, Airy's stress function, two-dimensional problems in polar coordinates, and selected applications to stress analysis problems in mechanical engineering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 330 [Min Grade: D]

MEM 431 Machine Design I 3.0 Credits
Covers static strength and fatigue theories of failure, fasteners, welded joints, springs, roller bearings, and lubricated spur gears.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Junior or Pre-Junior or Sophomore
Prerequisites: MEM 202 [Min Grade: D] and MEM 230 [Min Grade: D] and MEM 238 [Min Grade: D]

MEM 435 Introduction to Computer-Aided Design and Manufacturing 4.0 Credits
Covers fundamental use of CAD/CAM systems for geometry definition, finite element applications, and introductory computer graphics concepts.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.
Prerequisites: MEM 201 [Min Grade: D]

MEM 436 Introduction to Computer-Aided Manufacturing 3.0 Credits
Examination of the basic elements that are used to integrate the design and manufacturing processes. Robotics computerized-numerical controlled machine, and CAD/CAM systems. Manufacturability considerations when integrating unit process elements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 201 [Min Grade: D] and MEM 435 [Min Grade: D]

MEM 437 Manufacturng Process I 3.0 Credits
Examines the basic elements used to integrate the design and manufacturing processes; robotics, computerized-numerical-controlled machines, and CAD/CAM systems; and manufacturability considerations when integrating unit process elements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 220 [Min Grade: D] and MEM 230 [Min Grade: D]

MEM 438 Manufacturing Process II 3.0 Credits
Covers plastics and reinforced plastics processes, theory of polymer and plastic process, simple models of polymer flows, and manufacturability of plastics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 437 [Min Grade: D]

MEM 440 Thermal Systems Design 3.0 Credits
This course covers fundamentals of thermal system design; the role of design in engineering practice; economic analysis used for design of thermal systems; advanced concepts and analysis of heat exchangers and distillation equipment; modeling of thermal systems; simulation of thermal systems; fundamentals of optimization and design of optimized thermal systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 345 [Min Grade: D]

MEM 444 Biofluid Mechanics 3.0 Credits
This course introduces flow-related anatomy and pathophysiology, and biomedical flow devices and their design challenges. Analysis methods to solve biological fluid mechanics design problems are introduced and several interdisciplinary team projects are assigned to apply fluid mechanics to practical biological or medical problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 220 [Min Grade: D] or BMES 451 [Min Grade: D]

MEM 445 Solar Energy Fundamentals 3.0 Credits
This course focuses on basic theories of solar radiation, solar thermal energy, and photovoltaics. Students will learn basic radiation heat transfer, solar radiation, solar thermal collection and storage, passive and active solar heating/cooling, physics of photovoltaic cells, and characteristics and types of solar cells.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 345 [Min Grade: C] and PHYS 210 [Min Grade: C]

MEM 446 Fundamentals of Plasmas I 3.0 Credits
Introduces the fundamentals of plasma science and modern industrial plasma applications in electronics, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include quasi-equilibrium and non-equilibrium thermodynamics, statistics, fluid dynamics and kinetics of plasma and other modern high temperature and high energy systems and processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: PHYS 201 [Min Grade: D] or TDEC 201 [Min Grade: D] or PHYS 112 [Min Grade: D] or PHYS 187 [Min Grade: D]

MEM 447 Fundamentals of Plasmas II 3.0 Credits
Continues the development of the engineering fundamentals of plasma discharges applied in modern industrial plasma applications in electronics, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include quasi-equilibrium and non-equilibrium thermodynamics, statistics, fluid dynamics of major thermal and non-thermal plasma discharges, operating at low, moderate and atmospheric pressures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 446 [Min Grade: D]

MEM 448 Applications of Thermal Plasmas 3.0 Credits
Introduces applications of modern thermal plasma processes focused on synthesis of new materials, material treatment, fuel conversion, environmental control, chemistry, biology, and medicine. Topics Include thermodynamics and fluid dynamics of high temperature plasma processes, engineering organization of specific modern thermal plasma technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: PHYS 201 [Min Grade: D] or TDEC 201 [Min Grade: D] or PHYS 112 [Min Grade: D] or PHYS 187 [Min Grade: D]

MEM 449 Applications of Non-Thermal Plasmas 3.0 Credits
Application of modern non-thermal plasma processes focused on synthesis of new materials, material treatment, fuel conversion, environmental control, chemistry, biology, and medicine. Topics Include non-equilibrium thermodynamics and fluid dynamics of cold temperature plasma processes, engineering organization of specific modern non-thermal plasma technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: PHYS 201 [Min Grade: D] or TDEC 201 [Min Grade: D] or PHYS 112 [Min Grade: D] or PHYS 187 [Min Grade: D]

MEM 453 Aircraft Flight Dynamics & Control I 3.0 Credits
Covers general equations of motion for aircraft; linearization based on small disturbance theory and modal analysis to identify longitudinal open-loop characteristics; review of classical control theory; state space analysis; and autopilot design, including classical, pole placement, and optimal.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 355 [Min Grade: D]

MEM 454 Aircarft Flight Dynamics & Control II 3.0 Credits
Covers observers; lateral dynamics; Dutch roll, roll convergence, and spiral modes; autopilot design and evaluations; and inertial cross-coupling computer simulation and analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 453 [Min Grade: D]

MEM 455 Introduction to Robotics 4.0 Credits
Introduces basic concepts in robot operation and structure, including actuators, sensors, mechanical components, robot control and robot programming.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 238 [Min Grade: D] and MEM 255 [Min Grade: D]

MEM 456 Robotics II 3.0 Credits
Covers homogeneous kinematics of robots; velocities and accelerations; and static forces in manipulators, including iterative Newton-Euler formulation of manipulator dynamics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 455 [Min Grade: D]

MEM 457 Robotics III 3.0 Credits
Covers robotic-based automated manufacturing, including robot work cell configurations, applications of robots in manufacturing, material transfer, assembly, and inspection.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: MEM 456 [Min Grade: D]

MEM 458 Micro-Based Control Systems I 3.0 Credits
Provides hands-on experience in real-time control and manipulation of hardware dynamic systems, including microcomputer, architecture, software, and device drivers. Emphasizes real-time interfacing of data acquisition and control systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 355 [Min Grade: D]

MEM 459 Micro-Based Control Systems II 3.0 Credits
Continues MEM 458. Provides real-time control and manipulation of hardware dynamic systems. Emphasizes real-time interfacing of data acquisition and control systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman
Prerequisites: MEM 458 [Min Grade: D]

MEM 462 [WI] Introduction to Engineering Management 3.0 Credits
Introduces the general theory of management, including the processes of planning, organizing, assembling resources, supervising, and controlling. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Junior or Senior.

MEM 475 Medical Robotics I 3.0 Credits
Use of robots in surgery, safety considerations, understanding robot kinematics, analysis of surgeon performance using a robotic devices, inverse kinematics, velocity analysis, acceleration analysis, various types of surgeries case study.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 238 [Min Grade: D]

MEM 476 Medical Robotics II 3.0 Credits
Force and movement for robot arms, robot dynamics, computer vision, vision based control, combining haptics, vision and robot dynamics in a cohesive framework for the development of a medical robotic system.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 475 [Min Grade: D]

MEM 477 Haptics for Medical Robotics 3.0 Credits
Introduction to haptics, physiology of touch, actuators, sensors, non-portable force feedback, portable voice feedback, tactile feedback interfaces, haptic sensing and control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 238 [Min Grade: D]

MEM 478 Computer-Aided Tissue Engr 3.0 Credits
Introduction to the engineering aspects of tissue reengineering and integrated CAD/CAE/CAM technology applied to tissue engineering with hands-on experience combing CAD, medical image processing, 3-D reconstruction software, and solid freeform fabrication of tissue scaffolding.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

MEM 491 [WI] Senior Design Project I 3.0 Credits
Introduces the design process, including information retrieval, problem definition, proposal writing, patents, and design notebooks. Includes presentations on problem areas by experts from industry, government, and education. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: MEM 230 [Min Grade: D] and MEM 238 [Min Grade: D] and MEM 355 [Min Grade: D] and MEM 345 [Min Grade: D]

MEM 492 [WI] Senior Design Project II 3.0 Credits
Continues MEM 491. Requires written and oral progress reports. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: MEM 491 [Min Grade: D]

MEM 493 [WI] Senior Design Project III 3.0 Credits
Continues MEM 492. Requires written and oral final reports, including oral presentations by each design team at a formal Design Conference open to the public and conducted in the style of a professional conference. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: MEM 492 [Min Grade: D]

Software Engineering

Courses

SE 101 Foundations of Software Engineering I 3.0 Credits
Teaches students basic programming concepts within a software engineering process that involves specification, documentation, and testing. Programming coverage includes basic programming concepts such as the declaration and assignment of variables, standard data types, constants, conditional statements, loops, introduction to classes and methods, standard and file input/output, arrays, and strings. Process concepts emphasize good internal documentation practices, specifying functional requirements, defect tracking and analysis, and "black-box" testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Corequisite: EXAM 080

SE 102 Foundations of Software Engineering II 3.0 Credits
Introduces students to additional programming concepts. Teaches students how to design, implement, and test object-oriented software applications using simple reusable components. Introduces basic techniques for creating reusable software components. Provides an overview of the software engineering as a discipline.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: SE 101 [Min Grade: D]
Corequisite: EXAM 080

SE 103 Foundations of Software Engineering III 3.0 Credits
Introduces students to issues and practices for working with medium-size software systems. Teaches students basic techniques for using application frameworks. Introduces students to software development in teams and provides an overview of the software engineering professional practice.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: SE 102 [Min Grade: D]

SE 210 Software Specification and Design I 3.0 Credits
Study of the principles, practices, and techniques used to gather system requirements and document them in a requirements specification. Includes techniques for requirements discovery such as user interviews and prototyping. Introduces approaches for organizing and expressing software requirements in a requirements specification.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Prerequisites: SE 103 [Min Grade: D] or CS 133 [Min Grade: D] or CS 172 [Min Grade: D]

SE 211 Software Specification and Design II 3.0 Credits
Continues study of requirements with increasing emphasis on converting requirements into a software system design. Presents alternate approaches, techniques for evaluating specifications, specification and design tools, and use of specifications to develop system-level tests.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Prerequisites: SE 210 [Min Grade: D]

SE 280 Special Topics in Software Engineering 4.0 Credits
This course covers topics in software engineering. Different topics may be considered in different quarters.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

SE 310 Software Architecture I 3.0 Credits
Study of macro-level software system architectures with an emphasis on approaches to interconnection and distribution of current and emerging architectural styles.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: SE 211 [Min Grade: D] and CS 265 [Min Grade: D] and CS 260 [Min Grade: D]

SE 311 Software Architecture II 3.0 Credits
Continues discussion of software architecture with a focus on micro-level architecture including patterns, frameworks, and component-based software engineering, and commercial off-the-shelf software.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: SE 310 [Min Grade: D] or CS 350 [Min Grade: D]

SE 320 Software Verification and Validation 3.0 Credits
Presents theory and practice of software testing. Covers structural testing including such topics as path testing, dataflow testing, logic based testing, syntax testing, program slicing, mutation testing, fault injection, program perturbation, and testing tools. Discusses techniques for test construction and test suite evaluation, and validation against requirements and design models. Also covers methods of inspection and review at various phases of the software lifecycle.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D]

SE 410 Software Evolution 3.0 Credits
Covers issues related to change in software systems. Addresses principles and techniques of corrective software maintenance, software enhancements, and software product family. Introduces students to issues of change in large software systems including configuration control, change and product management.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Prerequisites: CS 260 [Min Grade: D]

SE 480 Advanced Topics in Software Engineering 4.0 Credits
This course covers topics in Software Engineering selected from advanced topics from research in this field. Different topics may be considered in different quarters.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

SE 491 [WI] Design Project I 3.0 Credits
An independent project in which student teams design and implement a software system under faculty guidance. Students apply a defined software engineering process for the project including process customization as appropriate.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

SE 492 [WI] Design Project II 3.0 Credits
Continues Design Project I.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: SE 491 [Min Grade: D]

SE 493 [WI] Design Project III 3.0 Credits
Continues Design Project II.
College/Department: College of Information Science Technology
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: SE 492 [Min Grade: D]

University - Wide Courses

Courses

UNIV E101 The Drexel Experience 2.0 Credits
This course introduces first year students to university life, his/her major, our community, and Co-op.
College/Department: College of Engineering
Repeat Status: Can be repeated 5 times for 4 credits

Architectural Engineering

Courses

AE 510 Intelligent Buildings 3.0 Credits
An overview of the present and future role of Information Technology in the construction industry with emphasis on the computer tools used throughout the building life cycle by all stakeholders, primarily Building Information Modeling (BIM) and the role of networked-linked sensors and actuators.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

AE 544 Building Envelope Systems 3.0 Credits
Science and engineering fundamentals in analysis and design of building envelopes and wall systems. Architectural, structural and environmental (thermal and moisture) concerns; features of selected cladding systems; air and moisture leakage, thermal deficiency, structural distress and premature deterioration; building envelop construction, condition evaluation, maintenance and retrofit.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE.
Prerequisites: AE 391 [Min Grade: C] or CIVE 371 [Min Grade: C]

AE 550 Comfort Analysis and Indoor Air Quality 3.0 Credits
This course covers characteristics and interaction of thermal, acoustical, luminous and spatial comfort; different types and sources of indoor pollution; models for air filtration; building ventilation requirements, energy use interaction with ventilation, models and simulation programs for IAQ; monitoring and control equipment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE.

AE 551 Building Energy Systems I 3.0 Credits
This course covers inverse modeling as a scientific approach to data analysis, different types of inverse methods as applied to building & HVAC & refrigeration equipment energy use, calibrated simulation approach, current research trends.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE or major is MECH.
Prerequisites: AE 550 [Min Grade: B]

AE 552 Building Energy Systems II 3.0 Credits
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE or major is MECH.
Prerequisites: AE 550 [Min Grade: B]

AE 790 Special Topics 12.0 Credits
Covers selected advanced level topics in architectural engineering. May be repeated for credit if topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Chemical Engineering

Courses

CHE 502 Mathematical Methods in Chemical Engineering 3.0 Credits
Emphasizes formulation of differential and difference equations, both ordinary and partial, governing chemical engineering operations in the steady and unsteady state.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 513 Chemical Engineering Thermodynamics 3.0 Credits
Examines thermodynamic principles from a classical viewpoint, including properties of materials, equations of state of mixtures, and chemical and phase equilibria of complex mixtures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 525 Transport Phenomena I 3.0 Credits
Presents a unified treatment of transport rate theory, with emphasis on analogies among momentum, energy, and mass transfer, and continuum and molecular theories of matter.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 531 Fundamentals of Solar Cells 3.0 Credits
This course focuses on the fundamentals of solar cells. It will cover semiconductor materials, basic semiconductor physics, optical and electronic phenomena, and case studies of crystalline silicon, thin film, and nanostructured photovoltaics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 534 Mass Transfer Operations I 3.0 Credits
Theory and design of equilibrium stage operations. Separation processes for binary and multicomponent mixtures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 543 Kinetics & Catalysis I 3.0 Credits
Covers chemical reaction kinetics as applied to chemical engineering. Introduces chemical kinetics and mechanisms and heterogeneous kinetics and catalysis. Includes design of ideal and non-ideal chemical reactors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CHE 502 [Min Grade: C]

CHE 554 Process Systems Engineering 3.0 Credits
Covers the basic concepts of the systems engineering approach to the design and operation of processing plants. Includes methods for developing control strategies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CHE 502 [Min Grade: C]

CHE 556 Process Optimization 3.0 Credits
Focuses on optimization of processes from the viewpoint of economic return.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 560 Transport Phenomena in Biological Systems 3.0 Credits
Covers gas-liquid mass transfer in microbial systems, mass transfer in cells and biofilms, membrane transport, fluid mechanics of fermentation broth, power consumption in agitated vessels, heat transfer, and scale-up of mass transfer equipment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 562 Bioreactor Engineering 3.0 Credits
Covers growth and product formation kinetics, batch and continuous stirred tank bioreactors, tower reactors, immobilized-cell reactors, and immobilized-enzyme reactors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 564 Unit Operations in Bioprocess Systems 3.0 Credits
Covers liquid-liquid extractions, membrane separations, chromatographic separations, filtration, centrifugation, distillation, and leaching.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 566 Dynamics and Control of Biological Process Systems 3.0 Credits
Dynamics of pH and temperature control systems, dynamics of bioreactors to feed upsets, substrate feed rate control, start-up of bioreactors, dynamics of multiple microbial populations, instrumentation of bioreactors, computer interfacing and control of bioreactors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 614 Chemical Engineering Thermodynamics II 3.0 Credits
The second in a two-quarter sequence in thermodynamics for graduate students in Chemical and Biological Engineering. Students learn theory and application of statistical mechanics with emphasis on prediction of volumetric and thermal properties of pure fluids and mixtures, as well as phase equilibrium. Modern methods in applied statistical mechanics are covered, including Monte Carlo and molecular-dynamics simulations. Non-equilibrium statistical mechanics in terms of linear response theory applied to chemical kinetics is also covered. Students are evaluated on homework sets, two exams, and a term project.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CHE and program is PHD.
Prerequisites: CHE 513 [Min Grade: C]

CHE 626 Transport Phenomena II 3.0 Credits
Transport of mass, energy, and momentum of turbulent systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 631 Heat Transfer 3.0 Credits
Advanced topics in heat conduction, convection, and radiation with application to design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 635 Mass Transfer Operations II 3.0 Credits
Theory and design of continuous contact operations including fixed-bed and fluid-bed processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 644 Kinetics and Catalysis II 3.0 Credits
Advanced topics in kinetics and catalysis including: diffusion and catalysis; optimization of chemical reaction systems; analysis and treatment of kinetic data.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 658 Advanced Process Design 3.0 Credits
Covers flowsheet analysis and synthesis, batch process design and scheduling, project scheduling, and economic considerations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CHE 502 [Min Grade: C]

CHE 670 Real-Time Microcomputer Applications 3.0 Credits
Application of microcomputers in monitoring and control of external devices and processes. Topics include: digital input/output, real-time clock, analog-to-digital and digital-to-analog conversion, noise removal, signal processing, and data communications. Includes hands-on computer laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CHE 799 Independent Study in Chemical Engineering 9.0 Credits
Provides advanced independent study in chemical engineering or related interdisciplinary fields.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CHE 800 Special Topics 0.5-9.0 Credits
Covers selected advanced-level topics in chemical engineering. May be repeated for credit when topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CHE 898 Master's Thesis 9.0 Credits
Requires fundamental research in chemical engineering. Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CHE 998 Ph.D. Dissertation 1.0-9.0 Credit
Requires dissertation research in chemical engineering. Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Civil Engineering

Courses

CIVE 501 Model Analysis of Structures 3.0 Credits
Open to advanced undergraduates. Covers application of models for the analysis and design of complex structures, including development of laws of similitude, methods of fabricating, and testing and instrumentation of models.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 510 Prestressed Concrete 3.0 Credits
Open to advanced undergraduates. Covers definitions and general principles, anchorage systems, and loss of prestress; analysis and design of simple beams for flexure, shear, bond, and bearing; partial prestressed and post-tensioned reinforcement; and continuous beams.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 520 Advanced Concrete Technology 3.0 Credits
This course covers the mechanical, physical and chemical properties of concrete: characteristics of concrete in the fresh, setting and hardening states; high performance concrete. Factors influencing the mechanical performance of concrete are discussed as well as field testing methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE or major is EGEO.

CIVE 530 Geotechnical Engineering for Highways 3.0 Credits
Covers design if stable right-of-way, USDA classification, frost and swell expansion, capillary moisture retention, subgrade compaction, beam on elastic foundation pavement model, loads and resistance of buried pipes, subdrainage, basic slope stability and retaining structures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 531 Advanced Foundation Engineering 3.0 Credits
Covers design of shallow foundations (footing and mats), deep foundations (piles, augered, drilled shafts) and retaining structures for stability and deformation performance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 560 Introduction to Coastal & Port Engineering 3.0 Credits
Provides an overview of coastal engineering problems and their solution, including shoreline erosion, ocean waves and wave theories, wave generation, diffraction, refraction, harbor hydraulics, coastal currents, and tidal inlet hydraulics and sedimentation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 561 Introduction to Hydrology 3.0 Credits
Covers climate and weather, precipitation, evaporation and transpiration, drainage basins, and hydrographs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGEO 700 [Min Grade: C]

CIVE 563 Coastal Processes 3.0 Credits
This course provides a detailed presentation of hydraulic and sedimentary processes occurring in the coastal zone with a view toward applying knowledge of the processes to coastal erosion and shoreline stabilization problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 560 [Min Grade: C]

CIVE 567 Watershed Analysis 3.0 Credits
This course focuses on land use change (LUC) and the hydrologic cycle in agricultural and forest (non-urban) watersheds. Using climate, hydrology, and agricultural models, students will investigate how changes in hydroclimatology and landscape-scale land cover affect surface water flow, runoff, and water quality in selected watersheds. The course will explore emerging topics pertaining to water and energy that course through rural watersheds, with the goal of interpreting data output from models into an environmental life cycle assessment (LCA) framework. LCA is a systems analysis framework that feeds information on life cycle environmental damages/consequences back into design and decision making. In this way, this course focuses specifically on watershed analysis models and how their output feed into desig.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 320 [Min Grade: B-] and CIVE 330 [Min Grade: B-] and CIVE 240 [Min Grade: B-]

CIVE 585 Transportation Planning and Capacity 3.0 Credits
Open to undergraduates. Covers prediction of travel demand; principles of highway and transit capacity; level-of-service concepts; uninterrupted and interrupted flow; traffic characterization by volume, speed, and density; operational analysis and design of freeways, highways, and urban streets; intermodal systems, intelligent transportation systems (its), and mass transit.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 586 Geometric Design of Highways 3.0 Credits
Open to undergraduates. Covers classification of highway and transit systems with relation to function, funding, ownership, and design; characteristics of design vehicles, drivers, and traffic; elements of design including sight distance, horizontal alignment, and vertical alignment; cross-section and roadside design; and at-grade and separated intersections and interchanges.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 605 Advanced Mechanics Of Material 3.0 Credits
Open to advanced undergraduates. Covers shear flow and shear center, unsymmetrical bending, torsion of non-circular and open sections, bending of curved beams, stress at a point, and failure theories.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

CIVE 615 Infrastructure Condition Evaluation 3.0 Credits
This course covers the tools necessary for the inspection and evaluation of infrastructure. Non-destructive testing (NDT) techniques are introduced and applications and limitations of NDT techniques for a variety of structures are illustrated. Also covered are the policies for deter-mining the physical condition and maintenance needs for highway bridges.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE or major is EGEO.
Prerequisites: CIVE 250 [Min Grade: D] and CIVE 520 [Min Grade: C]

CIVE 632 Advanced Soil Mechanics 3.0 Credits
Consolidation magnitude and time rate of settlement, secondary compression, mitigating settlement problems, shear strength of cohesive and non-cohesive soils, critical state soil mechanics, undrainied pore pressure response, SHANSEP undrained strength.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 635 Slope Stability and Landslides 3.0 Credits
Slope process and mass wasting; landslide characteristics, features and terminology; limit equilibrium slope stability analysis, including Bishop, Janbu, Spenser, Morgenstern-Price methods; effects of water on slop stability; dynamic (earthquake) stability analysis methods; introduction to rock slopes, slope stability investigations, and design and repair.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 636 Ground Modification 3.0 Credits
This course covers the improvement of soil properties to meet project requirements, including surface and in situ technologies: compaction, densification, precompression, stabilization with admixtures, grouting and dewatering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 640 Environmental Geotechnics 3.0 Credits
This course covers the analysis and control of subsurface exploration, groundwater remediation, pollutant-soil interaction and waste containment barriers and drains.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 650 Geosynthetics I 3.0 Credits
Open to advanced undergraduates. Presents a basic description of the various products, relevant aspects of polymeric materials, and an overview of each category of geosynthetics. Covers geotextile testing and design on the basis of primary application function: separation, reinforcement, filtration, drainage, barrier, and combined.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

CIVE 651 Geosynthetics II 3.0 Credits
Continues CIVE 650. Covers design and testing of geogrids for reinforcement applications and geonets for drainage applications. Presents geomembrane design and testing from an applications perspective in the areas of environmental, geotechnical, transportation, and hydraulic engineering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 650 [Min Grade: C]

CIVE 652 Geosynthetics III 3.0 Credits
Continues CIVE 651. Covers design and testing of geosynthetic clay liners as a hydraulic/gas barrier and geopipes as drainage materials in numerous application. Presents geocomposites in separation, reinforcement, filtration, drainage, and barrier applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 651 [Min Grade: C]

CIVE 660 Hydrology-Stream Flow 3.0 Credits
Covers precipitation, runoff, evaporation and transpiration, streamflow, floodflow, and minimum flow. Pays special attention to factors affecting water supply and quality.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.
Prerequisites: CIVE 561 [Min Grade: C]

CIVE 661 Groundwater Hydraulics 3.0 Credits
Covers occurrence of underground flow, groundwater supply, pollution problems, and well and aquifer hydraulics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 561 [Min Grade: C]

CIVE 662 Hydrodynamics I 3.0 Credits
Covers theory of perfect fluids, Euler's equations of motion, continuity equation and energy equation, velocity potential and stream function, sources and sinks, circulation and vorticity, flow-around bodies and flow in channels, and jet flow.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 663 Hydrodynamics II 3.0 Credits
Extends the theory of perfect fluids to cover fluid forces and moments on bodies, free streamline theory, and extension of vorticity theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 662 [Min Grade: C]

CIVE 664 Open Channel Hydraulics 3.0 Credits
Covers principles of flow in open channels, conservation laws, uniform flow, critical flow, gradually varied flow, backwater computations, channel design, and numerical computation of flows having a free surface.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is Senior.

CIVE 665 Computational Hydraulics I 3.0 Credits
This course continues CIVE 664 to cover the application of mathematical and numerical techniques to model complex open channel hydraulic processes. At each stage the fundamental hydraulic principles are reviewed to assure proper construction of a modeling algorithm and to assist in interpretation of results.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE.
Prerequisites: CIVE 664 [Min Grade: C] and CIVE 330 [Min Grade: D] and CIVE 341 [Min Grade: D] and CIVE 430 [Min Grade: D]

CIVE 666 Free Surface Flows 3.0 Credits
This course extends the concepts of one-dimensional open channel flow to cover both the physical under-standing and the application of mathematical and numerical techniques to model very complex open channel hydraulics problems including transients, countercurrent flows and complex boundary conditions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE.
Prerequisites: CIVE 664 [Min Grade: C] and CIVE 665 [Min Grade: C]

CIVE 701 Structural Analysis I 3.0 Credits
Covers basic principles of structural analysis, including elastic deflection; elastic analysis of statically indeterminate structures by methods of virtual work, Castigliano's theorems, and moment distribution; and the Muller-Breslau principle and application to influence lines for continuous members and frames. Introduces numerical techniques.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CIVE 702 Structural Analysis II 3.0 Credits
Covers matrix analysis of structures using finite elements, including elastic analysis of structures by influence coefficients, Argyris force method, direct stiffness method, and the displacement method. Introduces the finite-element method for planar structures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 701 [Min Grade: C]

CIVE 703 Structural Analysis III 3.0 Credits
Covers development of stiffness functions for planar and three-dimensional finite elements, and application to frame, plate, shell, and massive structures. Introduces the general application of finite elements to continuum problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 702 [Min Grade: C]

CIVE 704 Behavior and Stability of Structural Members I 3.0 Credits
Covers development of the basic differential equations of member behavior, including second-order effects, in-plane beam-column behavior, column buckling, elastic and inelastic behavior, energy methods, and approximate methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 705 Behavior and Stability of Structural Members II 3.0 Credits
Covers general torsion of thin-walled open, closed, and combined open-and-closed cross-sections; lateral torsional buckling; biaxial bending; elastic and inelastic behavior; approximate methods; and frame buckling.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 704 [Min Grade: C]

CIVE 710 Design and Structure of Integrity Building Systems 3.0 Credits
Covers integration of design and building cycle, building envelope, structural morphology, composite structures, thermal and moisture design, fire and smoke, sound and vibration, building failure, and repair and restoration.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 711 Engineered Masonry I 3.0 Credits
Covers masonry materials, structural behavior of masonry assemblages, and deformational characteristics of brick and block masonry; performance of load-bearing wall systems and design of unreinforced masonry elements; and special design and construction topics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 712 Engineered Masonry II 3.0 Credits
Covers fundamental concepts of reinforced masonry, reinforced wall design, column and pilaster design, seismic resistance of masonry structures, prestressed masonry, and applied design of low-and high-rise buildings.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 714 Behavior of Concrete Structures I 3.0 Credits
Covers reinforced concrete members; relationship between results of research and current specifications for design of members subjected to axial loads, flexure, combined axial load and flexure, combined shear and flexure, long columns, bond and anchorage, and limit design; application to design of determinate and indeterminate reinforced concrete frames; and development of current code provisions for design of floor slabs in buildings.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 715 Behavior of Concrete Structures II 3.0 Credits
Continues CIVE 714.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 714 [Min Grade: C]

CIVE 717 Behavior of Metal Structures I 3.0 Credits
Covers load and resistance factor design, including tension, bolted and welded connections, block-shear, compression, built-up compression members, lateral-torsional instability, light-gauge metal buckling and post-buckling strength, and behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 605 [Min Grade: C]

CIVE 718 Behavior of Metal Structures II 3.0 Credits
Covers load and resistance factor design, including design and behavior of metal structural members and connections, flexural members including plate girders, bracing and lateral-torsional buckling resistance, torsion and other combined loading, and composite beams and columns.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 717 [Min Grade: C]

CIVE 719 Behavior of Metal Structures III 3.0 Credits
Covers load and resistance factor design, including idealization and design of structures and their connections, frame bracing and sway, frame design philosophy, optimization, fatigue, and fracture.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 718 [Min Grade: C]

CIVE 730 Experimental Soil Mechanics I 3.0 Credits
Covers methods and techniques of soil testing, including interpretation and evaluation of test data, and fundamentals of soil behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 731 Experimental Soil Mechanics II 3.0 Credits
Continues CIVE 730.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 730 [Min Grade: C]

CIVE 732 Experimental Soil Mechanics III 3.0 Credits
Continues CIVE 731.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 731 [Min Grade: C]

CIVE 737 Seismic Geotechnics 3.0 Credits
Introduction to earthquake hazards and seismology; strong ground motion parameters, deterministic and probabilistic seismic hazard analysis, influence of subsurface conditions and topography and ground motion, soil liquefaction, and brief coverage of seismic slop stability, design of retaining structures, and soil-structure interaction.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 632 [Min Grade: C]

CIVE 752 Coastal Structures 3.0 Credits
This course briefly reviews the functional design of costal and port structures and deals in detail with forces on those structures. Forces caused by waves and currents, and mooring and vessel impacts are addressed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 563 [Min Grade: C]

CIVE 754 Properties and Processes of Polymeric Construction Materials 3.0 Credits
This course focuses on the uses and characteristics of polymeric materials used in civil and architectural engineering infrastructure. Also covered are micro-structure, physical and chemical properties and mechanical behavior. and the effects of manufacturing on the properties of the products.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is AE or major is CIVE or major is MATE.
Prerequisites: CIVE 250 [Min Grade: D] and TDEC 211 [Min Grade: D]

CIVE 755 Durability of Polymeric Construction Materials 3.0 Credits
This is a continuation of CIVE 754 and concentrates on protecting and predicting service lifetimes. It covers physical aging, mechanical stabilization and chemical degradation of polymeric materials and the products in which they are incorporated for field use. Covered in this course is the fundamental degradation mechanisms of different polymeric materials commonly used in Civil Engineering practice. Also covered are test methods and extrapolation methodologies for predicting long-term performance.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 754 [Min Grade: C]

CIVE 756 Evaluation of Polymeric Construction Materials 3.0 Credits
This lab course is designed to integrate and extend the coverage of CIVE 754 and 755 so that students have a full concept of the behavior of polymeric construction materials. A series of thermal analysis and physical, chemical, and mechanical tests are included. The stress relaxation, stress cracking, oxidation, and applications of test results in infrastructure and environ-mental applications are discussed, including problems in comparative analysis of test results and their implications in design and specification.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 754 [Min Grade: D] and CIVE 755 [Min Grade: D]

CIVE 767 Surface Water Mixing Processes 3.0 Credits
This course covers hydrodynamic mixing and transport processes in free-surface flows. Basic mixing processes including molecular diffusion, turbulent diffusion, and dispersion are also covered. Emphasis will be on the solution of the advection-diffusion equation with various boundary conditions. Additional topics include boundary exchanges, non-ideal mixing in rivers, and analysis of jets and plumes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE or major is ENVE.
Prerequisites: CIVE 664 [Min Grade: C]

CIVE 768 Sediment and Contaminate Transport 3.0 Credits
This course covers the transport of sediments and reactive solutes in surface waters. Reviewed is the classic theory for bed-load and suspended sediment transport; interplay of stream flow, frictional resistance and sediment transport. Biogeochemical processes that influence contaminant mobility and integration of physical and chemical processes in contaminant transport models are also discussed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE or major is ENVE.
Prerequisites: ENVE 767 [Min Grade: C] or CIVE 767 [Min Grade: C]

CIVE 790 Special Topics 9.0 Credits
Covers selected advanced-level topics in civil engineering. May be repeated for credit if topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CIVE 799 Independent Study 12.0 Credits
Independent study on a topic selected by the student. Independent study is supervised by a faculty member and guided by a plan of study.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CIVE 801 Dynamics of Structures I 3.0 Credits
Covers formulation of equations of motion, including generalized single-degree-of-freedom systems, free vibration response, undamped and damped systems, harmonic analysis, resonance and vibration isolation, response to periodic loading, impulsive loading, response to general dynamic loading, non-linear structural response, and Rayleigh's method and other variational techniques. Introduces multi-degree-of-freedom systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 802 Dynamics of Structures II 3.0 Credits
Covers formulation of multi-degree-of-freedom equations of motion, including evaluation of structural property matrices; elastic properties, mass properties, damping, and external loading; geometric stiffness; undamped free vibrations; analysis of dynamic response; practical vibration analysis; Stodola method; Holzer method; reduction of degrees of freedom; matrix iteration and other techniques; analysis of non-linear systems; variational formulation of the equations of motion; partial differential equations of motion; and free vibrations of beams.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 801 [Min Grade: C]

CIVE 803 Dynamics of Structures III 3.0 Credits
Covers distributed parameter dynamic systems, equations of motion, free and forced vibrations, analysis of structural response to earthquakes, seismological background, deterministic analysis of single-degree-of-freedom and multi-degree systems, multi-degree-of-freedom and distributive parameter systems, soil-structure interaction, non-linear response to earthquakes and current design code requirements, dynamics of complex structures, modeling, and use of large computer codes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 811 Plates and Shells I 3.0 Credits
Covers analysis of circular, rectangular, and continuous plates by classical and approximate methods, including the folded plate theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 812 Plates and Shells II 3.0 Credits
Covers the general theory of thin shells, cylindrical shells, surfaces of revolution, hyperbolic paraboloids, and other shells of double curvature.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 811 [Min Grade: C]

CIVE 813 Plates and Shells III 3.0 Credits
Covers buckling and vibration analysis, including application of finite-elements methods and anisotropic behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 812 [Min Grade: C]

CIVE 831 Deep Foundations 3.0 Credits
Covers topics including mat foundation design using plate theory, continuous beam design using beam-on-elastic foundation theory, and pile design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 833 Earth Retaining Structures 3.0 Credits
Covers lateral earth pressure theories, analysis and design of temporary and permanent retaining structures, surcharge load, excavations, and loads on buried conduits.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 838 Soil Behavior 3.0 Credits
Particle-scale behavior of soil and assemblages; clay mineralogy; soil formation, composition, structure and properties; soil water interaction; clay-water-electrolyte systems, adsorption-desorption and ion exchange; conduction phenomena; micromechanics; volume change behavior; strength and deformation behavior.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 632 [Min Grade: C]

CIVE 839 Geomechanics Modeling 3.0 Credits
This course covers constitutive laws in goemechanics, including linear elastic, quasi-linear (hyperbolic) elastic, linear elastic-perfectly plastic and elasto-plastic models based on critical state soil mechanics. The finite element method is used to solve geotechnical boundary value problems incorporating different constitutive models.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CIVE 632 [Min Grade: C]

CIVE 898 Master's Thesis 0.5-20.0 Credits
Involves investigation of an approved topic. Required of full-time master's degree students.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CIVE 997 Research 1.0-12.0 Credit
Research.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CIVE 998 Ph.D. Dissertation 1.0-12.0 Credit
Involves investigation of an approved topic. Required of Ph.D. students.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Computer Science

Courses

CS 500 Database Theory 3.0 Credits
Introduces relational and knowledge base data models and contrasts the expressiveness of the two models. Covers semantics of knowledge bases, negation, dependencies, Armstrong's axioms, decompositions, and normal forms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 510 Introduction to Artificial Intelligence 3.0 Credits
Well-formed problems; state spaces and search spaces; Lisp and functional programming; uniformed search; heuristic search; stochastic search; knowledge representation; propositional logic; first order logic; predicated calculus; planning; partial order planning; hierarchical planning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 511 Robot Laboratory 3.0 Credits
Building and programming machines built out of construction pieces, a micro-controller, actuators, motors, sensors, that interact with the world using limited computational resources. Issues in mechanics, physics, electronics, real-time control, uncertainty, map building, path planning, and other topics in introductory robotics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 510 [Min Grade: C] or CS 583 [Min Grade: C]

CS 520 Computer Science Foundations 3.0 Credits
Survey of basic mathematics concepts needed for the study of computer science at the graduate level: induction, iteration, recursion; analysis of program running time; elementary probability and combinatorics; relations, graphs and trees; regular expressions and finite automata; propositional and predicate logic.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 521 Data Structures and Algorithms I 3.0 Credits
Techniques for analyzing algorithms: asymptotic notation, recurrences, and correctness of algorithms; divide and conquer: quick sort, merger sort, median and order statistics; elementary data structures: hashing, binary heaps, binary search trees, balanced search trees; graph algorithms: Depth and Breadth first searches, connected components, minimum spanning trees, shortest paths in graphs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 522 Data Structures and Algorithms II 3.0 Credits
Discussion of algorithm design techniques, augmented data structures including Binomial and Fibonacci heaps and Splay tree; Amortized analysis of data structures, topics in pattern and string matching, network flow problem, matching in bipartite graphs, and topics in complexity theory including reduction and NP-completeness, and approximation algorithms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 521 [Min Grade: C]

CS 525 Theory of Computation 3.0 Credits
Theory of computation introduces basic mathematical models of computation and the finite representation of infinite objects. These topics covered in the course include: finite automata and regular languages, context free languages, Turning machines, Partial recursive functions, Church's Thesis, undecidability, reducibility and completeness, and time complexity.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 521 [Min Grade: C]

CS 530 Developing User Interfaces 3.0 Credits
This course examines the implementation of multimodal user interfaces within the context of interface design and evaluation. The course involves both practice implementing interfaces using current technologies and study of topical issues such as rapid prototyping, advanced input, and assistive technology.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 536 Computer Graphics 3.0 Credits
An introduction to the basic concepts of computer graphics, including the graphics pipeline, 2D drawing, 3D viewing, mathematical representations of objects (lines, curves, surfaces and solids), color, and how these concepts are implemented.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 540 High Performance Computing 3.0 Credits
Covers basic von Neumann architectural concepts involving memory organization, instruction, and data representations, including computer number systems, assembler and linker operations, character codes, floating point numbers, IEEE standard, subroutines and coroutines, macros, traps and interrupts, and overview of virtual memory concepts. Includes assembly language programming and laboratory exercises.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 543 Operating Systems 3.0 Credits
Covers the classical internal algorithms and structures of operating systems, including CPU scheduling, memory management, and device management. Considers the unifying concept of the operating system as a collection of cooperating sequential processes. Covers topics including file systems, virtual memory, disk request scheduling, concurrent processes, deadlocks, security, and integrity.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 544 Computer Networks 3.0 Credits
To examine computer networks using networking models (TCPIIP, OSI and ATM) and break down computer networking, examine each layer and its duties and responsibilities. To analyze networking protocols and understand the design. To use the Internet and other example protocols to illustrate the theory and operation of each layer.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 550 Programming Languages 3.0 Credits
Covers basic concepts of the design and implementation of programming languages, including data representation and types, functions, sequence control, environments, block structure, subroutines and coroutines, storage management. Emphasizes language features and implementation, not mastery of any particular languages.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 551 Compiler Construction I 3.0 Credits
Provides a thorough study of modern compiler techniques. Topics include scanners, parsers with emphasis on LR parsing, and syntax-directed translation. Requires students to use a parser generator to write a compiler for a non-trivial language. Examines several advanced topics in depth, such as automatic code generation, error recovery, and optimization techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 525 [Min Grade: C]

CS 552 Compiler Construction II 3.0 Credits
Continues CS 551. Examines several advanced topics in depth, such as automatic code generation, error recovery, optimization techniques, data flow analysis, and formal semantics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 551 [Min Grade: C]

CS 567 Applied Symbolic Computation 3.0 Credits
For users of symbolic computation (maple, mathematica, derive, macsyma) who wish to gain an understanding of fundamental symbolic mathematical methods. Includes introduction to a symbolic mathematical computation system and application to problems from mathematics, science and engineering. Also included programming and problems specific to symbolic computation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 571 Programming Tools and Environments 3.0 Credits
Covers UNIX operating system, Shell programming, PERL, JAVA, and advanced features of C++ from the viewpoint of efficient software development.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 575 Software Design 3.0 Credits
This course introduces fundamental software design principles and methodologies, covers: software architecture design in general, and focuses on service-oriented architecture in particular. Students will learn most influential papers in software engineering realm, design and implement a service-oriented project, and explore how to apply well-established theoretical principles into modern software design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 576 Dependable Software Systems 3.0 Credits
Intended for CS and MSSE students; others must obtain departmental permission to enroll. Offers an in-depth treatment of software testing and software reliability, two components of developing dependable software systems. Testing topics include path testing, data-flow testing, mutation testing, program slicing, fault interjection and program perturbation, paths and path products, syntax testing, logic-based testing, testing within the software development process, test execution automation and test design automation tools. Reliability topics include reliability metrics, fault avoidance, cleanroom software development, fault tolerance, exception handling, N-version programming, recovery blocks, formal methods, functional specifications, and Z notation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 583 Introduction to Computer Vision 3.0 Credits
Theoretical and algorithmic foundation and applications of computer vision. Covered topics include image formation, image sensing, image filtering, lightness, radiometry, motion, image registration, stereo, photometric stereo, shape-from-shading, and recognition with an emphasis on the underlying mathematics and computational models and complexity as well as computational implementation of representative applications through multiple programming assignments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 610 Advanced Artificial Intelligence 3.0 Credits
Representation, reasoning, and decision-making under uncertainty; dealing with large, real world data sets, learning; and solving problems with time-varying properties; how to apply AI techniques toward building intelligent machines that interact with dynamic, uncertain worlds.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 510 [Min Grade: C]

CS 612 Knowledge-based Agents 3.0 Credits
Fundamentals of agent-based computing; distributed AI; representations; agent communication languages; reasoning (expert, rule-based, case-based, production systems); network communication protocols; emergent behavior; swarm intelligence.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 510 [Min Grade: C]

CS 613 Machine Learning 3.0 Credits
This course studies modern statistical machine learning with emphasis on Bayesian modeling and inference. Covered topics include fundamentals of probabilities and decision theory, regression, classification, graphical models, mixture models, clustering, expectation maximization, hidden Markov models, Kalman filtering, and linear dynamical systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 510 [Min Grade: C]

CS 620 Advanced Data Structure and Algorithms 3.0 Credits
This course studies how advanced topics are used in the real world and generates an appreciation of where algorithms are used to understand various considerations that make a good algorithm. Topics: data compression, geometrical algorithms in search and indexing, pattern matching, sparse linear systems, applications of linear programming, and computational gene recognition.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 522 [Min Grade: C]

CS 621 Approximation Algorithms 3.0 Credits
Study of techniques for designing approximation solution to NP-hard problems. Classification of problems into different categories based on the difficulty of finding approximately sub-optimal solutions for them. The techniques will include greedy algorithms, sequential algorithms, local search, linear and integer programming, primal-dual method, randomized algorithms, and heuristic methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 522 [Min Grade: C]

CS 623 Computational Geometry 3.0 Credits
Introduction to algorithms and Data Structures for computational problems in discrete geometry (for points, lines and polygons) primarily in finite dimensions. Topics include triangulation and planar subdivisions, geometric search and intersections, convex hulls, Voronoi diagram, Delaunay triangulation, line arrangements, visibility, and motion planning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 521 [Min Grade: C]

CS 630 Cognitive Systems 3.0 Credits
This course explores the principles of cognition and intelligence in human beings and machines, focusing in how to build computational models that, in essence, think and act like people. The course reviews existing frameworks for such models, studies model development within one particular framework, and discusses how models can be employed in real-world domains.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 510 [Min Grade: C] or CS 530 [Min Grade: C]

CS 631 HCI: Computing Off The Desktop 3.0 Credits
This course discussed the use of the computers "off-the-desktop," focusing in particular on design and implementation aspects of the user experience. The course is taught as a graduate seminar: while there are minimal lectures to introduce important concepts, the majority of the time is spent presenting and discussing research papers in each class session. The course also involves a multi-week individual project in which students design, implement, and evaluate an "off-the-desktop" interface.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 530 [Min Grade: C]

CS 634 Advanced Computer Vision 3.0 Credits
A research-intensive course on advanced topics that reflect the state-of-the-art of current research activities in computer vision. The course alternates between lectures on the fundamentals of, and paper presentations by the students on, selected topics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 583 [Min Grade: C]

CS 636 Advanced Computer Graphics 3.0 Credits
Texture and Bump maps; rendering techniques (phong, gourand, radiosity); particle systems; hierarchical models; photorealism; non-photorealistic rendering; geometric compression; mathematical structures for graphics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 536 [Min Grade: C]

CS 637 Interactive Computer Graphics 3.0 Credits
This is a project-oriented class that covers the concepts and programming details of interactive computer graphics. These include graphics primitive, display lists, picking, shading, rendering buffers and transformations. Students will learn an industry-standard graphics system by implementing weekly programming assignments. The course culminates with a student-defined project.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 536 [Min Grade: C]

CS 643 Advanced Operating Systems 3.0 Credits
In-depth examination of operating systems issues expanding on topics covered in CS 543 (Operating Systems) including: Kernal services, memory management, input/output, file systems, interprocess communication, networking, device drivers, system initialization. Included discussion of production systems such as BSD Unix and Microsoft Windows.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 543 [Min Grade: C]

CS 645 Network Security 3.0 Credits
The purpose of this course is to cover the principles and practice of cryptography and network security. The first half of the course covers cryptography and network security techniques. The second part deals with the practice of network security, i.e. with the processes and application that have to be in place to provide security.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 543 [Min Grade: C] and CS 544 [Min Grade: C]

CS 647 Distributed Systems Software 3.0 Credits
In-depth discussion of fundamental concepts of distributed computer systems. Covers development techniques and runtime challenges, with a focus on reliability and adaptation concerns. Subjects discussed include: interprocess communication, remote procedure calls and method invocation, middleware, distributed services, coordination, transactions, concurrency control and replication. Significant system-building term project in Java or similar language.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 543 [Min Grade: C]

CS 650 Program Generation and Optimization 3.0 Credits
This course introduces the student to the foundations and state-of-the-art techniques in high performance software development for numeric libraries and other important kernels. Topics include: 1) fundamental tools in algorithm theory, 2) optimizing compilers, 3) effective utilization of the memory hierarchy and other architectural features, 4) how to use special instruction sets, and 5) an introduction to the concepts of self-adaptable software and program generators.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 550 [Min Grade: C] and CS 540 [Min Grade: C]

CS 668 Computer Algebra I 3.0 Credits
Introduction to Foundations of Symbolic Computation. Typical topics : Arithmetic with large integers, rational numbers, polynomials, modular arithmetic, greatest common divisors, chinese remainder algorithm.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 521 [Min Grade: C]

CS 669 Computer Algebra II 3.0 Credits
The course continues the introduction to symbolic computation. Typical topics include polynomial root computation, exact arithmetic with real algebraic numbers and the solution of polynomial systems of equations using groebner or elimination methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 668 [Min Grade: C]

CS 675 Reverse Software Engineering 3.0 Credits
Expose students to the challenges of understanding large legacy software systems. Course approach is based on hands-on practical experience, where teams of students work on real software using state of the art reverse engineering tools for source code analysis, dynamic analysis and profiling, software clustering, and visualizations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 575 [Min Grade: C]

CS 676 Parallel Programming 3.0 Credits
Covers a variety of paradigms and languages for programming parallel computers. Several tools for debugging and measuring the performance of parallel programs will be introduced. Issues related to writing correct and efficient parallel programs will be emphasized. Students will have ample opportunity to write and experiment with parallel programs using a variety of parallel programming environments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 521 [Min Grade: C] and CS 543 [Min Grade: C]

CS 680 Special Topics in Computer Science 12.0 Credits
Special Topics Covers topics of special interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CS 690 Independent Study in Computer Science 1.0-6.0 Credit
Independent study in computer science under faculty supervision. After finding a willing Computer Science Department faculty supervisor and working out the term of study, students obtain approval to take this course from the department?s graduate advisor.
College/Department: College of Engineering
Repeat Status: Can be repeated 3 times for 18 credits

CS 741 Computer Networks II 3.0 Credits
Continues CS 740.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 544 [Min Grade: C]

CS 751 Database Theory II 3.0 Credits
Covers topics in database theory and implementation, varying yearly. May include physical data organization, transaction management, concurrency, distributed data-bases, and semantics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 500 [Min Grade: C]

CS 759 Complexity Theory 3.0 Credits
Introduces formal models of computation, including inherent difficulty of various problems, lower bound theory, polynomial reducibility among problems, Cook's theorem, NP-completeness, and approximation strategies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: CS 525 [Min Grade: C]

CS 770 Topics in Artificial Intelligence 3.0 Credits
Covers issues in robotics, vision, and pattern recognition.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Prerequisites: CS 610 [Min Grade: C]

CS 780 Advanced Topics in Software Engineering 3.0 Credits
A research-intensive course on advanced topics in software engineering suitable for students who are either pursuing or intend to pursue an advanced degree (M.Sc or Ph.D.) in software engineering. Although the specific topics in the course will vary, students will be asked to survey and study the academic literature in an area of software engineering, and work toward projects that have the potential to evolve into long-term research efforts.
College/Department: College of Engineering
Repeat Status: Can be repeated 3 times for 9 credits
Prerequisites: CS 575 [Min Grade: C] or CS 576 [Min Grade: C]

CS 898 Master's Thesis 1.0-12.0 Credit
Master's thesis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

CS 997 Research in Computer Science 1.0-12.0 Credit
Research.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

CS 998 Ph.D. Dissertation 1.0-12.0 Credit
Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated 20 times for 45 credits

Electrical & Computer Engineering

Courses

ECE 501 Topics in Circuits and Systems 3.0 Credits
Circuit laws, transfer functions, convolution, transform techniques, systems engineering. This series of courses may be used to meet the admission prerequisites to ECE graduate program. One credit per term is creditable to the M.S.E.E. degree.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 502 Topics In Communications, Controls and Computers 3.0 Credits
Modulation theory, noise, feedback theory, stability, computer engineering fundamentals, computers in communication and controls. This series of courses may be used to meet the admission prerequisites to the ECE graduate program. One credit per term is creditable to the M.S.E.E. degree.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 503 Topics in Mathematical Techniques In Electrical and Computer Engineering 3.0 Credits
Complex variables in communication and control, matrix methods in circuits and systems, vector calculus in fields, two-dimensional image processing. This series of courses may be used to meet the admission prerequisites to the ECE graduate program. One credit per term is creditable to the M.S.E.E. degree.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 571 Introduction to Electrical and Computer Engineering Research 0.0 Credits
Topics of departmental research. Thesis selection. Required of all full-time graduate students.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 572 Techniques of Electrical and Computer Engineering Research 0.0 Credits
Techniques for making technical presentations: oral and written modes. Meeting organization, audience awareness. Writer-to-reader communication. Required of all full-time graduate students.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 573 Presentation of Electrical and Computer Engineering Research 0.0 Credits
Conference attendance and critique. Student presentation and critique. Topics of concern: professional ethics, liability, etc. Required of all full-time graduate students.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECE 695 Research Rotations in Cybersecurity 1.0-12.0 Credit
The research rotation course allows students to gain exposure to cybersecurity-related research that cuts across conventional departmental barriers and traditional research groups, prior to identifying and focusing on a specific interdisciplinary project or thesis topic. Students selecting to participate in research rotations would participate in the research activities of two labs for each three credits of research rotation they undertake.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Electrical & Computer Engineering - Computers

Courses

ECEC 500 Fundamentals Of Computer Hardware 3.0 Credits
Covers computer organization and architecture; elements of computer hardware, processors, control units, and memories; hardware for basic mathematical operations; tradeoffs between speed and complexity; examples of embedded systems; microcontrollers; systems modeling.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 501 Computational Principles of Representation and Reasoning 3.0 Credits
This course presents fundamentals of discrete mathematics as applied within the computer engineering and manufacturing environment. Students are given the theoretical background in representation and reasoning for a broad variety of engineering problems solving situations. Entity-relational techniques of representation are demonstrated to evolve into the object-oriented approach. Various search techniques are applied in the cases of representing engineering systems by using theory of automata techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 502 Principles of Data Analysis 3.0 Credits
This course presents theoretical methods and techniques of model development applicable within the computer engineering design and manufacturing environment. Students are given the theoretical background in data analysis (including "data mining"). Emphasis is on hybrid systems and discrete events systems. Various methods of recognizing regularities in data will be presented. Elements of the theory of clustering and classification will be dealt with for the paradigm of software and hardware problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 503 Principles of Decision Making 3.0 Credits
This course presents theoretical fundamentals and engineering techniques of decision making and problem solving applicable within the computer engineering design and manufacturing environment. Students are given the theoretical background in optimization methods for a broad variety of situation. Elements of the theory of planning and on-line control of systems are presented within the scope of software and hardware computer design and control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 511 Combinational Circuit Design 3.0 Credits
Representing arithmetic. Logic and syntax data for machine processing. Switching algebra: Boolean and multiple values. Identification and classification of functions. Realizing completely specified and incompletely specified Boolean functions. Issues in designing large communication/control Boolean functions. Fault and testing of Boolean function.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 512 Sequential Circuit Design 3.0 Credits
Finite automata and their realization by sequential machines, capabilities, transformation, and minimization of finite automata, linear finite automata. Clocked pulsed and level mode sequential circuits. Malfunctions in sequential circuits: hazards, races, lockouts, metastability. Issues of state assignment. Evolution of memory elements design: ROM vs. RAM vs. associative memory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 511 [Min Grade: C]

ECEC 513 Design for Testability 3.0 Credits
Economics vs. Complexity vs. Strategy of Testing; Fault Models; Test Generation; Testability Analysis & Designing Testable Circuits; Testing Microprocessors, Memories and Computer Components; Test Data Compression; Fault Tolerant Hardware; Reliably vs. Availability; Redundancy and Error Correcting Codes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 511 [Min Grade: C] and ECEC 512 [Min Grade: C]

ECEC 520 Dependable Computing 3.0 Credits
Fundamental design issues involved in building reliable, safety-critical, and highly available systems. Topics include testing and fault-tolerant design of VLSI circuits, hardware and software fault tolerance, information redundancy, and fault-tolerant distributed systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 541 Robotic Computer Interface Controls I 3.0 Credits
Covers sensors, actuators, mechanical components of robots, kinematics, inverse kinematics, dynamics, and equations of motion.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 542 Robotic Computer Interface Controls II 3.0 Credits
Covers the robot control problem, including PD, PID, position, force and hybrid controllers, resolved rate and acceleration control, and multiprocessor architecture.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 641 [Min Grade: C] and ECES 643 [Min Grade: C] and ECEC 541 [Min Grade: C]

ECEC 543 Robotic Computer Interface Controls III 3.0 Credits
Covers non-linear control techniques, FLDT, and advanced topics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 542 [Min Grade: C]

ECEC 600 Fundamentals of Computer Networks 3.0 Credits
Fundamentals design principles of ATM, Internet and local area networks; protocol layers and the Internet Architecture; medium access protocols; application protocols and TCP/IP utilities; basic principles and virtual circuit switching; naming and addressing; flow and congestion control protocols; routing algorithms; Quality-of-Service in computer networks; security issues in networks.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 621 High Performance Computer Architecture 3.0 Credits
Maximizing single processor performance. Concepts and techniques for design of computer systems. Processor design, instruction set architecture design and implementation, memory hierarchy, pipelines processors, bus bandwidth, processor/memory interconnections, cache memory, virtual memory, advanced I/O systems, performance evaluation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 622 Parallel Computer Architecture 3.0 Credits
Advanced techniques of computer design. Use of parallel processing to achieve high performance levels. Fine and coarse grained parallelism. Multiple CPU parallelism, through multiprocessors, array and vector processors. Dataflow architectures and special purpose processors. Design implications of memory latency and bandwidth limitations. Speedup problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 621 [Min Grade: C]

ECEC 623 Advanced Topics in Computer Architecture 3.0 Credits
This course teaches advanced concepts of modern computer architecture and introduces the current challenges faced by computer architects. These challenges include power consumption, transistor variability, and processor heterogeneity. Students develop their research skills through a self directed research project with a final presentation and conference style writeup.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 621 [Min Grade: C]

ECEC 631 Principles of Computer Networking 3.0 Credits
Principles of circuit switching, packet switching and virtual circuits; protocol layering; application layer protocols for e-mail and web applications; naming and addressing; flow control and congestion avoidance with TCP; Internet Protocol (IP); routing algorithms; router architectures; multicast protocols; local area network technologies and protocols; issues in multimedia transmissions; scheduling and policing; Quality-of-Service and emerging Internet service architectures; principles of cryptography.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 632 Performance Analysis of Computer Networks 3.0 Credits
Covers probability theory and its applications to networks, random variable and random processes; Markov chains, multi-dimensional Markov chains; M/M/1, M/M/m, M/M/m/m, M/G/1 and G/G/1 queueing systems and their applications in computer networks; analysis of networks of queues: Kleinrock Independence Approximation; Time-reversibility and Burke's theorem; Jackson's theorem; the phenomenon of long-range dependence and its implications in network design and traffic engineering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 631 [Min Grade: C]

ECEC 633 Advanced Topics in Computer Networking 3.0 Credits
perspectives in the areas of switch/router architectures, scheduling for best-effort and guaranteed services, QoS mechanisms and architectures, web protocols and applications, network interface design, optical networking, and network economics. The course also includes a research project in computer networking involving literature survey, critical analysis, and finally, an original and novel research contribution.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 631 [Min Grade: C] and ECEC 632 [Min Grade: C]

ECEC 654 Knowledge Engineering I 3.0 Credits
Covers conceptual modeling, including an overview of knowledge representation. Includes semantic networks, reduced semantic networks, logic of incomplete knowledge bases, extensional semantic networks, and applications of conceptual models.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 655 Knowledge Engineering II 3.0 Credits
Covers expert systems, including language and tools of knowledge engineering. Includes reasoning about reasoning, design and evaluation, heuristics in expert systems, expert systems for decision support, and expert systems in conceptual design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 654 [Min Grade: C]

ECEC 656 Knowledge Engineering III 3.0 Credits
Covers information-intensive systems, including information representation in autonomous systems. Includes clauses and their validation; clustering in linguistic structures; linguistic and pictorial knowledge bases; discovery in mathematics, including am; and methods of new knowledge generation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 655 [Min Grade: C]

ECEC 661 VLSI Design 3.0 Credits
Covers CMOS design styles, techniques, and performance; VLSI computer hardware, arithmetic units, and signal processing systems; and cat tools for layout design and simulation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 662 VLSI Array Processors I 3.0 Credits
Covers VLSI testing, including design for testability and parallel computer architectures; signal and image processing algorithms and mapping algorithms onto array structures; and systolic array processors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 661 [Min Grade: C]

ECEC 663 VLSI Array Processors II 3.0 Credits
Covers wavefront array processors; matching hardware to arrays; hardware design, systems design, and fault-tolerant design; and implementations and VLSI design projects.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 662 [Min Grade: C]

ECEC 671 Electronic Design Automation for VLSI Circuits I 3.0 Credits
This course focuses on the electronic design automation problems in the design process of VLSI integrated circuits. In this first quarter of the course, algorithms, techniques and heuristics structuring the foundations of contemporary VLSI CAD tools are presented. Boolean algebra, graph theory, logic minimization and satisfiability topics are presented.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEC 672 Electronic Design Automation for VLSI Circuits II 3.0 Credits
This course focuses on the electronic design automation problems in the design process of VLSI integrated circuits. In this second quarter of the course, physical VLSI design steps of technology mapping, floor planning, placement, routing and timing and presented individual and team-based small-to-medium scale programming projects are assigned.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 671 [Min Grade: C]

ECEC 673 Deep Sub-Micron Integrated Circuit Design 3.0 Credits
This course focuses on the design challenges of digital VLSI integrated circuits in deep sub-micron manufacturing technologies. Automation challenges and high-performance circuit design techniques such as low-power and variation-aware design are presented. The course material is delivered in a lecture format structured on recent presentations, articles, and tutorials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEC 671 [Min Grade: C]

ECEC 690 Special Topics Computer Engineering 9.0 Credits
Covers special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 697 Research in Computer Engineering 1.0-12.0 Credit
Research in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 699 Supervised Study in Computer Engineering 9.0 Credits
Supervised study in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 890 Advanced Special Topics in Computer Engineering 1.0-9.0 Credit
Covers advanced special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 891 Advanced Topics in Computer Engineering 0.5-9.0 Credits
Advanced topics in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 898 Master's Thesis in Computer Engineering 1.0-12.0 Credit
Master's thesis in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 997 Dissertation Research in Computer Engineering 1.0-12.0 Credit
Graded Ph.D. dissertation in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEC 998 Ph.D. Dissertation in Computer Engineering 1.0-12.0 Credit
Ph.D. dissertation in computer engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Electrical & Computer Engineering - Electroph

Courses

ECEE 501 Physical Principles of Electrical Engineering I 3.0 Credits
Core course. Covers classical mechanics, including generalized coordinates, Lagrangian and Hamiltonian formulation, and variational principle. Introduces quantum mechanics, including Schrodinger equation, wave functions, operators, expectation values, and hydrogen atom.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 502 Physical Principles of Electrical Engineering II 3.0 Credits
Core course. Continues ECEE 501. Covers atomic orbitals, angular momentum, oscillators, time-independent and time-dependent perturbation theories, many-particle wave functions, and optical transitions. Also covers statistical mechanics, including distributions, ensembles, and thermal properties of solids.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 501 [Min Grade: C]

ECEE 507 Electromagnetic Field Analysis I 3.0 Credits
Core course. Covers Maxwell's equations; solutions of Laplace's equation, Green's function, and scalar and vector potentials; energy and momentum in electromagnetic fields; and interaction of fields and material media.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 508 Electromagnetic Field Analysis II 3.0 Credits
Core course. Continues ECEE 507. Covers em waves, including reflection, refraction, polarization, and dispersion. Includes metallic and dielectric guiding structures, guides, and waveguide circuits and applications to stripline, microstrip, and optical fiber transmission systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 507 [Min Grade: C]

ECEE 510 Scattering & Diffraction of Electromagnetic Waves 3.0 Credits
Boundary value problems of EM theory. Exact and approximate methods for scattering by spheres, half plane, slit; radar cross-section theory. Quasi-optical theory, scattering, diffraction coefficients. Applications to radio propagation around the earth.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 517 Microwave Networks & Transmission Media 3.0 Credits
Core course. Atmospheric wave propagation, solution of wave equation without sources in isotropic media, plane-waves, polarization, dispersion surfaces, wave admittance and impedance, wave propagation in free-space and various media, waves at interfaces, solution of wave equation with sources, duality principle, arrays analysis, metallic waveguides, modes in cylindrical waveguides, rectangular and circular, resonant cavities and perturbational methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 518 Microwave Passive Components 3.0 Credits
Core course. V-I and E-H analogy, Kirchoff's Law, Telegrapher's EQ, voltage and current waves, reflection coefficient and impedance relationship, Smith Chart, impedance matching techniques, Bode-Fano theoretical limit, Broadband Quarter-wave Transformer, N-port linear networks, Z, Y, and S parameters, ABCD and T matrices, signal flow-graph and transfer functions, synthesis of two-port and unitary properties, even-odd mode analysis and dual directional couplers (design and synthesis), periodic structures and Flouke modes, filter design and synthesis using insertion loss and image methods, prototype LO filter and transformation to LP, BP, HP, and BS filters, Richards transform and Kuroda identities.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 519 Microwave Active Subsystems 3.0 Credits
Core course. Overview of physics of P-N junction and Schottky junctions, pin, varactor, and step recovery diodes and their applications, transistors, MESFET and HEMT, BJT and HBT passive microwave circuits: switches, detectors, attenuators, modulators, and phase shifter, active microwave circuits: LNA, power amplifier, distributed amplifier, oscillators (fixed and VCO) power budget and link performance calculations for telecommunication, radar, and EW systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 520 Solid-State Electronics 3.0 Credits
This course familiarizes the students with the fundamental properties of semiconductor materials leading to the students of electronic and photonic devices. Covered topics include: atomic structure, crystal structure, theories of electron conduction, scattering, pn junctions, heterojunctions, metal-semiconductor contacts, and junction devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 521 Bipolar and FETs 3.0 Credits
This is the second course in a sequence of three on electronic and photonic devices. The course covers families of electronic devices. The course covers various families of electronic devices based on silicon and compound semiconductors. Bipolar transistors such as BJTs and HBTs and field-effect devices such as MOSFETs, MESFETs, and MODFETs are studied.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 520 [Min Grade: C]

ECEE 522 Photonic Devices 3.0 Credits
Covers fundamentals of absorption, spontaneous, and stimulated emission, photodetectors, light emitting diodes, laser oscillation, semiconductor laser diodes, RIN and phase noise, quantum well lasers, optical receivers, and quantum effect devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 521 [Min Grade: C]

ECEE 523 Integrated Circuits 3.0 Credits
Covers growth of single-crystal silicon, growth of oxide and epitaxial layers, photolithography, diffusion of impurities, fabrication of bipolar and unipolar integrated circuits, and interconnections and packaging.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 521 [Min Grade: C]

ECEE 525 Digital IC and CMOS Technology 3.0 Credits
Covers digital ICs using CMOS technology. Transistor level building blocks, -NOT, NAND, NOR, XOR, OAI, and AOI ? are designed using industry standard CAD tools, e.g. Cadence. Circuit topologies such as CPL, transmission gates are explored. CMOS technology/fabrication and layout are discussed to optimize speed, power, and area.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 526 Custom VLSI Design 3.0 Credits
Course covers advanced design styles such as dynamic CMOS circuits, low power circuit concepts, bi-CMOS circuits and the design of VLSI sub-systems. A major category is memory design, both DRAM. VLSI design styles, system integration aspects are discussed. Project design involves a fair amount of layout.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 525 [Min Grade: C]

ECEE 541 Photonic Systems 3.0 Credits
Introduction to Optical principles through EM theory. Covers the mathematics of wave motion, as well as the idea of light propagating as particles. The course shows how ray (or geometrical) optics and Gaussian optics are derived from the wave theory. The course also introduces the polarization of light, and how this effects optical propagation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 542 Optical Applications of Diffraction and Interference 3.0 Credits
Optical Applications of Diffraction and Interference. This course is an introduction to optical principles through EM theory. Covered topics include wave motion and superposition. Introduction to optical interference, or the interaction of light with itself. Topics include interference and interferometers, diffraction, and Fourier Optics. Diffraction topics include, far (Fraunhofer), near (Fresnel), and the near-near field diffraction. The course includes coding of some of the classical diffraction algorithms for the use in a project.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 603 Cooperative Phenomena 3.0 Credits
Covers dielectrics, ferroelectrics, diamagnetism, paramagnetism, ferromagnetism, and antiferromagnetism; superconductivity, London's equations, BCS theory, and Josephson effect; and flux quantization, hard superconductors, GLAG theory, flux dynamics, and high-temperature superconductors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 502 [Min Grade: C] and ECEE 503 [Min Grade: C]

ECEE 607 Nanoscale Fields 3.0 Credits
Course covers essentials of electric and magnetic fields, including thermodynamics of polarizable media. Emphasis is on nano-and micro-scale effects like Van der Waals and double layer interactions, plasmon resonance and others. Examples from colloids and other areas of nanotechnology are used to illustrate main ideas.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 619 Radio Frequency Integrated Circuit Design 3.0 Credits
This course introduces concepts in design of radio frequency (microwave and millimeter wave) integrated circuits. Optimum transistor technologies based on unipolar (MOS, FET, HEMT) and bipolar (BJT.HBT) are discussed for various RFIC applications. Performance of devices and circuits are evaluated in terms of gain, noise, and linearity. Active circuits and systems used in a variety of communications, imaging, and sensing are discussed in terms of standards and applications. IC design projects are integral to this course.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 518 [Min Grade: C]

ECEE 621 Thin Film Technology I 3.0 Credits
Covers vacuum technology, plasma processing, VLSI fabrication, and thin film technologies (e.g., plasma etching, thin film deposition, and thin film characterizations).
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 622 Microfabrication Technology 3.0 Credits
The course provides an overview of basic technological processes typically involved in microfabrication of Micro-Electro-Mechanical Systems (MEMS). The course includes several demonstration laboratories involving basic photolithography, thin film depositions and electroplating.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 623 Thin Film Technology III 3.0 Credits
Presents speakers on state-of-the-art practice and future applications of thin film deposition and processing technology.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 622 [Min Grade: C]

ECEE 641 Fiber Optics & Optical Communications I 3.0 Credits
Covers propagation in guided and unguided media, including step and graded fibers, dispersion, guide deformations, and mode coupling. Involves design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 642 Fiber Optics & Optical Communications II 3.0 Credits
Covers coupling devices, multimode guides, sources, lasers, and radiation patterns. Includes reliability, detectors, circuit models, and noise.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 641 [Min Grade: C]

ECEE 671 Seminar in Electro-Physics I 2.0 Credits
Advanced graduate seminar. Focuses on recent developments in microwaves, electro-optics, and solid-state devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 672 Seminar in Electro-Physics II 2.0 Credits
Continues ECEE 671.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 673 Seminar in Electro-Physics III 2.0 Credits
Continues ECEE 672.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 690 Special Topics in Electrophysics 9.0 Credits
Covers special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 697 Research in Electrophysics 1.0-12.0 Credit
Research in electrophysics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 699 Supervised Study in Electrophysics 0.5-9.0 Credits
Supervised study in electrophysics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 811 Microwave & THZ Photonics I 3.0 Credits
This course focuses on high speed photonic components for microwave and terahertz fiber-optic links, namely high speed lasers, external modulators and photodetectors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEE 812 Microwave & THZ Photonics II 3.0 Credits
This course focuses on high speed analog and digital fiber-optic links including loss and dynamic range calculations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 811 [Min Grade: C]

ECEE 813 Microwave & THZ Photonics III 3.0 Credits
This course focuses on the applications of fiber-optic links; antenna remoting, optically fed and controlled phased array antennas and fiber radio.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 811 [Min Grade: C] and ECEE 812 [Min Grade: C]

ECEE 820 Carrier Transport Fundamentals 3.0 Credits
This course introduces the fundamentals of carrier transport in semiconductors, beyond the common drift-diffusion description functions and Boltzmann transport equations are covered. Monte Carlo simulations are used for low field and high field transport studies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 520 [Min Grade: C]

ECEE 821 Nanoelectronics 3.0 Credits
Focus is on current transport when the size of electronic medium reaches nanometer scales, that is, deBrogile wavelength. Topics include: characteristic lengths, magneto-electric subbands, conductance from transmission, resistance in a ballistic conductor, quantum Hall effect, electron scattering in quantum structures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEE 820 [Min Grade: C]

ECEE 890 Advanced Special Topics in Electrophysics 1.0-9.0 Credit
Covers advanced special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 898 Masters Thesis in Electrophysics 9.0 Credits
Master's thesis in electrophysics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 997 Dissertation Research in Electrophysics 1.0-12.0 Credit
Graded Ph.D. dissertation in electrophysics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEE 998 Ph.D. Dissertation in Electrophysics 1.0-12.0 Credit
Ph.D. dissertation in electrophysics.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Electrical & Computer Engineering - Power Engineering

Courses

ECEP 501 Power System Analysis 3.0 Credits
Core course. Covers modeling of power systems, including: symmetrical components, transmission lines, transformers, per-unit values and one-line diagrams. Introduces power flow. Required of first-year power majors; equivalent undergraduate credits may be substituted.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 502 Computer Analysis of Power Systems 3.0 Credits
Core course. Covers digital computation methods, including load flow, fault, and transient stability problems. Required of first-year power engineering majors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 501 [Min Grade: C]

ECEP 503 Synchronous Machine Modeling 3.0 Credits
Core course. Covers two-reaction theory, Park's synchronous machine models, modeling of the synchronous machine excitation and governor systems, and the effects on power system stability. Required of first-year power engineering majors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 502 [Min Grade: C]

ECEP 601 Modeling & Analysis of Power Distribution Systems 3.0 Credits
Modeling and Analysis of Power Distribution Systems. Introduction to power distribution system; balanced and unbalanced systems, component and load modeling, radial and weakly meshed topologies; algorithms for unbalanced power flow studies including radial and general structure solver.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Corequisite: ECEP 501

ECEP 602 Power Distribution Automation and Control 3.0 Credits
Power Distribution Automation and Control. Focuses on distribution management systems and their application: including optimizing network operation -capacitor placement and control, network reconfiguration, service restoration. Modern solution technology will be addresses.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Corequisite: ECEP 502

ECEP 603 Service and Power Quality in Distribution Systems 3.0 Credits
Service and Power Quality in Distribution Systems. Focus power distribution systems: service and power quality assessment including stat estimation, voltage quality, trouble call analysis, service restoration, component and system reliability assessment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 610 Power System Dynamics 3.0 Credits
Covers system parameters and dynamics, swing equation and solutions for two-machine and multimachine systems, equal area criterion, computer solution techniques, system effects due to dynamic behavior of particular system components, and load characteristics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 503 [Min Grade: C]

ECEP 611 Power System Security 3.0 Credits
Covers contingency analysis, including operating and security constraints and network sensitivities; corrective dispatch using linear programming; and state estimation, including network observability, detection, and identification of bad data.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 610 [Min Grade: C]

ECEP 612 Economic Operation of Power Systems 3.0 Credits
Covers unit characteristics and economic operation, including
transmission loss coefficients, general loss formula, and automatic
economic load dispatch.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 501 [Min Grade: C]

ECEP 613 Advanced Power System Design 3.0 Credits
Covers components, functions, application, and performance; relative cost
and scaling parameters; overall planning problem considering present-
worth and cost-benefit principles; system reliability; intersystem pooling;
and growth.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 641 Protective Relaying 3.0 Credits
Covers relay principles and types, instrumentation of system parameters,
relay characteristics and response, system component protection, solid-
state relaying, underfrequency relays, and load shedding.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 503 [Min Grade: C]

ECEP 642 Protective Relay Laboratory 3.0 Credits
Covers electromechanical and static relays. Emphasizes application
based on observed performance. Includes testing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 641 [Min Grade: C]

ECEP 643 Solid State Protective Relaying 3.0 Credits
Covers solid-state protective relays as applied to power system stability
and protection, including comparisons with electromechanical relays.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 641 [Min Grade: C]

ECEP 661 High Voltage High Power Phenomena 3.0 Credits
Covers corona, corona losses, electromagnetic noise, dielectric strength,
lightning, impulse testing and safety practices, elements of high-power
circuit interruption, circuit and physical phenomena, and circuit breakers.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

**ECEP 671 AC-DC and DC-AC Power Electronic Converters 3.0
Credits**
AC-DC and DC-AC Power Electronic Converters. Study of basic power
electronic converter circuits: diode and phase controlled rectifiers and
inverters; switch-mode converters. Applications to DC and AC power
supplies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 501 [Min Grade: C] and ECEP 601 [Min Grade: C]

**ECEP 672 Power Electronic Experiments: Hardware and Software 3.0
Credits**
Hardware and Software Lab-Intensive course. Additional lectures on:
Study of DC-DC switch-mode converters; Study of power electronic
circuitry in residential, industrial and electric utility applications; Optimizing
utility interfaces with power electronic systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 671 [Min Grade: C]

ECEP 673 Power Electronic Applications 3.0 Credits
Electric Utility Applications with emphasis on DC Transmission,
Optimizing the Utility interface. Resonant converters. Fundamentals
of motor drives and their controls: induction, DC, synchronous and
specialized motors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 671 [Min Grade: C]

ECEP 690 Special Topics in Power Engineering 9.0 Credits
Covers special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 697 Research in Power Engineering 0.5-9.0 Credits
Research in power engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 699 Supervised Study in Power Engineering 9.0 Credits
Supervised study in power engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 801 Advanced Topics in Power Systems I 0.5-9.0 Credits
Discusses the latest innovations, theories, and methodologies for the
design, planning, and operation of power systems. Requires students to
read and discuss technical articles published in the IEEE Transactions on
pas, the Journal of Electric Energy and Systems, and other publications.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 802 Advanced Topics in Power Systems II 3.0 Credits
Continues ECEP 801.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 803 Advanced Topics in Power Systems III 3.0 Credits
Continues ECEP 802.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECEP 821 Load Forecasting & Probability Methods 3.0 Credits
Reviews probability methods. Covers probabilistic generation and load models; forecasting methodologies; load classification and characterization; energy and peak demand forecasting; weather-and-non-weather-sensitive forecast; and annual, monthly, weekly, and daily forecast.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 610 [Min Grade: C]

ECEP 822 Power System Planning 3.0 Credits
Covers deterministic planning, including automated transmission system expansion planning and network sensitivities, and probabilistic planning, including generation and load models, generation cost analysis, production costing, and energy production cost models for budgeting and planning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 821 [Min Grade: C]

ECEP 823 Power System Reliability 3.0 Credits
Covers basic reliability concepts, including probabilistic generation and load models, loss of load probability (LOLP), static and spinning generating-capacity reliability, transmission system reliability, and composite system and interconnected system reliability.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECEP 822 [Min Grade: C]

ECEP 890 Advanced Special Topics in Power Engineering 1.0-9.0 Credit
Covers advanced special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 898 Master's Thesis Power Engineering 1.0-12.0 Credit
Master's thesis in power engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 997 Dissertation Research in Power Engineering 1.0-12.0 Credit
Graded Ph.D. dissertation in power engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECEP 998 Ph.D. Dissertation in Power Engineering 1.0-12.0 Credit
Ph.D. dissertation in power engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Electrical & Computer Engineering - Systems

Courses

ECES 510 Analytical Methods in Systems 3.0 Credits
This course is intended to provide graduate student in the field of signal and image processing with the necessary mathematical foundation, which is prevalent in contemporary signal and image processing research and practice.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 511 Fundamentals of Systems I 3.0 Credits
Core course. Covers linear operators, including forms and properties (differential equations, transfer function, state space, causality, linearity, and time invariance); impulse response, including convolution, transition matrices, fundamental matrix, and linear dynamical system; definition, including properties and classification; representation, including block diagrams, signal flow, and analog and digital; properties, including controllability and observability; and eigenstructure, including eigenvalues and eigenvector and similarity transformations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 512 Fundamentals of Systems II 3.0 Credits
Core course. Covers realization and identification, including minimal realization, reducibility and equivalence of models, and identification of systems; stability, including bounded input-bounded output, polynomial roots, and Lyapunov; and feedback compensation and design, including observers and controllers and multi-input/multi-output systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 511 [Min Grade: C]

ECES 513 Fundamentals of Systems III 3.0 Credits
Core course. Covers multivariable systems, numerical aspects of system analysis and design, design of compensators, elements of robustness, and robust stabilization.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 512 [Min Grade: C]

ECES 521 Probability & Random Variables 3.0 Credits
Probability concepts. Single and multiple random variables. Functions of random variables. Moments and characteristic functions. Random number and hypothesis testing. Maximum likelihood estimation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 522 Random Process & Spectral Analysis 3.0 Credits
Random Process. Poisson Process, Shot Noise. Gaussian Process. Matched Filters. Kalman Filters. Power Spectral Density. Autocorrelation and cross correlation. PSD estimation. Entropy. Markov Processes. Queuing Theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 521 [Min Grade: C]

ECES 523 Detection & Estimation Theory 3.0 Credits
Detection of signals in noise. Bayes criterion. NP criterion. Binary and M_ary hypotheses. Estimation of signal parameters. MLE and MAP estimation. 1D and 2D signals. ROC Analyses. Decision fusion.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 521 [Min Grade: C] and ECES 522 [Min Grade: C]

ECES 558 Digital Signal Processing for Sound & Hearing 3.0 Credits
Introduction to the computational modeling of sound and the human auditory system. Signal processing issues, such as sampling, aliasing, and quantization, are examined from an audio perspective. Covers applications including audio data compression (mp3), sound synthesis, and audio watermarking.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 631 [Min Grade: C]

ECES 559 Processing of the Human Voice 3.0 Credits
Introduction to the computational modeling of the human voice for analysis, synthesis, and recognition. Topics covered include vocal physiology, voice analysis-synthesis, voice data coding (for digital communications, VoIP), speaker identification, speech synthesis, and automatic speech recognition.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 631 [Min Grade: C] and ECES 558 [Min Grade: C]

ECES 561 Medical Robotics I 3.0 Credits
This course will introduce the emerging, multidisciplinary field of medical robotics. Topics include: introduction to robot architecture, kinematics, dynamics and control; automation aspects of medical procedures; safety, performance limitations; regulatory and economics and future developments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 512 [Min Grade: C]

ECES 562 Medical Robotics II 3.0 Credits
This course will continue the introduction to the emerging, multidisciplinary field of medical robotics. Topics include: medical procedure automation; robot testing and simulation techniques; This is a project based course that will afford students the opportunity to work with existing medical robotic systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 561 [Min Grade: C]

ECES 604 Optimal Estimation & Stochastic Control 3.0 Credits
Introduction to control system problems with stochastic disturbances; linear state space filtering, Kalman Filtering, Non-linear systems; extended Kalman Filtering. Robust and H-infinity methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 512 [Min Grade: C] and ECES 521 [Min Grade: C]

ECES 607 Estimation Theory 3.0 Credits
General characteristics of estimators. Estimators: least squares, mean square, minimum variance, maximum a posteriori, maximum likelihood. Numerical solution. Sequential estimators.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 614 Passive Network Synthesis 3.0 Credits
An introduction to approximation theory; driving point functions; realizability by lumped-parameter circuits; positive real functions; properties of two and three element driving point functions and their synthesis; transfer function synthesis; all-pass networks.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 615 Analysis & Design of Linear Active Networks 3.0 Credits
DC and AC models of bipolar transistors and FETs; design of differential operational amplifiers; optimal design of broad-band IC amplifiers; design of tuned amplifiers; design for optimal power gain, distortion, and efficiency; noise in transistor circuits.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 621 Communications I 3.0 Credits
Covers modulation techniques: baseband PAM, passband PAM, QAM, and PSK; orthogonal signaling: FSK; symbol/vector detection: matched filter and correlation detector; sequence detection: ISI; equalization: adaptive and blind; carrier synchronization; and timing recovery.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 622 Communications II 3.0 Credits
Covers shot noise, noise in detectors, analog fiberoptic systems, carrier and subcarrier modulation, digital systems bit error rates for NRZ and RZ formats, coherent optical communication systems-heterodyne and homodyne systems, wavelength division multiplexing, system design concepts, power budgets, rise time budgets, and optical switching networks.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 623 Communications III 3.0 Credits
Covers fundamentals of information theory: information measure, entropy, and channel capacity; source encoding and decoding; rate distortion theory; linear codes; block codes; convolutional codes, Viterbi algorithm; encryption and decryption; and spread spectrum communications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 631 Fundamentals of Deterministic Digital Signal Processing 3.0 Credits
Fundamentals of Deterministic Digital Signal Processing. This course introduces the fundamentals of deterministic signal processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 632 Fundamentals of Statistical Digital Signal Processing 3.0 Credits
Fundamentals of Statistical Deterministic Digital Signal Processing.
The course covers topics on statistical signal processing related to data modeling, forecasting and system identification.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 631 [Min Grade: C]

ECES 640 Genomic Signal Processing 3.0 Credits
This course focuses on signal processing applied to analysis and design of biological systems. This is a growing area of interest with many topics ranging from DNA sequence analysis, to gene prediction, sequence alignment, and bio-inspired signal processing for robust system design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 642 Optimal Control 3.0 Credits
Introduces the concept of optimal control first by static optimization for state space formulated systems. The concept is expanded as the linear quadratic regulator problem for dynamic systems allowing solution of the optimal control and suboptimal control problems for both discrete and continuous time. Additional topics include the Riccati equation, the tracking problem, the minimum time problem, dynamic programming, differential games and reinforcement learning. The course focuses on deriving, understanding, and implementation of the algorithms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 512 [Min Grade: C]

ECES 643 Digital Control Systems Analysis & Design 3.0 Credits
Covers analysis and design of sampled-data control system using Z-transform and state-variable formulation, sampling, data reconstruction and error analysis, stability of linear and non-linear discrete time systems by classical and Lyapunov's second method, compensator design using classical methods (e.g., rootlocus) and computer-aided techniques for online digital controls, optimal control, discrete-time maximum principle, sensitivity analysis, and multirate sampled-data systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 513 [Min Grade: C]

ECES 644 Computer Control Systems 3.0 Credits
Introduction to the fundamentals of real-time controlling electromechanical dynamic systems, including modeling, analysis, simulation, stabilization and controller design. Control design approaches include: pole placement, quadratic and robust control performances.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 651 Intelligent Control 3.0 Credits
Concepts of Intelligence in Engineering Systems, Learning Automation, Principles of Knowledge Representation. Levels of Resolution and Nestedness. Organization of Planning: Axioms and Self-Evident Principles.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 660 Machine Listening and Music IR 3.0 Credits
This course introduces methods for the computational analysis, recognition, and understanding of sound and music from the acoustic signal. Covered applications include sound detection and recognition, sound source separation, artist and song identification, music similarity determination, and automatic transcription.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 631 [Min Grade: C]

ECES 670 Seminar in Systems I 2.0 Credits
Involves presentations focused on recent publications and research in systems, including communications, controls, signal processing, robotics, and networks.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 671 Seminar in Systems II 2.0 Credits
Continues ECES 670.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 672 Seminar in Systems III 2.0 Credits
Continues ECES 671.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 681 Fundamentals of Computer Vision 3.0 Credits
Develops the theoretical and algorithmic tool that enables a machine (computer) to analyze, to make inferences about a "scene" from a scene's "manifestations", which are acquired through sensory data (image, or image sequence), and to perform tasks.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 682 Fundamentals of Image Processing 3.0 Credits
The course introduces the foundation of image processing with hands-on settings. Taught in conjunction with an imaging laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 631 [Min Grade: C]

ECES 684 Imaging Modalities 3.0 Credits
This course is intended to produce students and image processing with a background on image formation in modalities for non-invasive 3D imaging. The goal is to develop models that lead to qualitative measures of image quality and the dependence of quality imaging system parameters.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 685 Image Reconstruction Algorithms 3.0 Credits
This course is intended to provide graduate students in signal and image processing with an exposure to the design and evaluation of algorithms for tomographic imaging.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 684 [Min Grade: C] and BMES 621 [Min Grade: C]

ECES 690 Special Topics in Systems Engineering 9.0 Credits
Covers special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 697 Research In Systems Engineering 1.0-12.0 Credit
Research in systems engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 699 Supervised Study in Systems Engineering 9.0 Credits
Supervised study in systems engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 801 Advanced Topics in Systems I 3.0 Credits
Familiarizes students with current research results in their field of interest, specifically in works reported in such journals as The IEEE Transactions.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 802 Advanced Topics in Systems II 3.0 Credits
Continues ECES 801.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 803 Advanced Topics in Systems III 3.0 Credits
Continues ECES 802.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 811 Optimization Methods for Engineering Design 3.0 Credits
Applications of mathematical programming and optimization methods in engineering design problems such as networks, control, communication, and power systems optimization. Optimization problem definition in terms of objective function, design variables, and design constraints. Single variable and multivariable search methods for unconstrained and constrained minimization using Fibonacci, gradient, conjugate gradient, Fletcher-Powell methods and penalty function approach. Classical optimization--Lagrange multiplier, Kuhn-Tucker conditions. Emphasis is on developing efficient digital computer algorithms for design.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 812 Mathematical Program Engineering Design 3.0 Credits
Approximation theory projection theorem. Solution of nonlinear equations by Newton-Raphson method. Resource allocation, linear programming, and network flow problems. Integer programming for digital filter design and power system expansion problems. Gamory's algorithm.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 813 Computer-Aided Network Design 3.0 Credits
Simulation and circuit analysis programs: PCAP, MIMIC, GASP. Data structures. Algorithms. Languages. Interactive I/O. Integration of subroutines for simulation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 817 Non-Linear Control Systems 3.0 Credits
Covers key topics of feedback linearization, sliding mode control, model reference adaptive control, self-tuning controllers and on-line parameter estimation. In addition additional no n-linear topics such as Barbalat's Lemma, Kalman-Yakubovich Lemma, passivity, absolute stability, and establishing boundedness of signals are presented. The focus of the course is the understanding each of these algorithms in detail through derivation and their implementation through coding in Matlab and Simulink.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 513 [Min Grade: C]

ECES 818 Machine Learning & Adaptive Control 3.0 Credits
System identification and parameter estimation, gradient search, least squares and Neural Networks methods. Closed loop implementation of system learning and self-organizing controllers. Random searching learning systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 512 [Min Grade: C]

ECES 821 Reliable Communications & Coding I 3.0 Credits
Covers fundamentals of information theory, including measures of communication, channel capacity, coding for discrete sources, converse of coding system, noisy-channel coding, rate distortion theory for memoryless sources and for sources with memory, and universal coding.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 521 [Min Grade: C] and ECES 522 [Min Grade: C]

ECES 822 Reliable Communications & Coding II 3.0 Credits
Introduces algebra of coding, including groups, rings, fields, and vector fields. Covers finite fields, decoding circuitry, techniques for coding and decoding, linear codes, error-correction capabilities of linear codes, dual codes and weight distribution, important linear block codes, perfect codes, and Plotkin's and Varshamov's bounds.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 821 [Min Grade: C]

ECES 823 Reliable Communications & Coding III 3.0 Credits
Continues techniques for coding and decoding. Covers convolutional codes; Viterbi algorithm; BCH, cyclic, burst-error-correcting, Reed-Solomon, and Reed-Muller codes; and elements of cryptography.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 822 [Min Grade: C]

ECES 890 Advanced Special Topics in Systems Engineering 1.0-9.0 Credit
Covers advanced special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 898 Master's Thesis in Systems Engineering 1.0-12.0 Credit
Master's thesis in systems engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 921 Reliable Communications & Coding I 3.0 Credits
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECES 997 Dissertation Research in Systems Engineering 1.0-12.0 Credit
Graded Ph.D. dissertation in systems engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECES 998 Ph.D. Dissertation in Systems Engineering 1.0-12.0 Credit
Ph.D. dissertation in systems engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Telecommunications

Courses

ECET 501 Fundamentals of Communications Engineering 3.0 Credits
Fundamentals of Communications Engineering. This course introduces basic modulation, deletion and coding techniques in modern telecommunications systems, including PAM and FSK, spread-spectrum and OFDM, ML receiver, ISI and equalization, compression code and coded modulation. May be repeated once for credit.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ECES 521 [Min Grade: C] and ECES 522 [Min Grade: C]

ECET 511 Physical Foundations of Telecommunications Networks 3.0 Credits
Physical Foundations of Telecommunications Networks. Introduction to wired and wireless telecommunication systems. Review of wave propagation. Review of wireline transmission media. Modeling wireline and wireless point-to-point communication links. N-port linear networks and network analysis/parameters. Review of passive RF components, semiconductor devices. Optical communication devices: optical switches, couplers, isolators, sources, modulators, detectors, amplifiers. Overview of active circuits.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECET 512 Wireless Systems 3.0 Credits
Fundamentals of modern wireless systems. Fundamentals of radio propagation and link performance. Cellular concept: interference, base stations and cell sites, handoffs, system capacity. Fading environments: multipath propagation, delay spread, Doppler Spread, statistically fading channel models. Multiple-access schemes: FDMA, TDMA, CDMA, SDMA. Emerging methodologies: phases/adaptive antenna array, multi-array (MIMO) communication systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECET 513 Wireless Networks 3.0 Credits
Introduction to Wireless Networks, Evolution: 1G, 2G, 3G, Next-G. Wireless Networks Operation: Mobility and Resource Management, Security. Wireless WANs: GSM, CDMA, IS-95, and IMT-2000, Mobil Data Networks, Wireless LANs: 802.11, HIPERLAN, Ad Hoc Networks, Mobil IP. Next Generation Wireless Systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ECET 602 Information Theory and Coding 3.0 Credits
This course introduces fundamental information theory and source and channel coding technology. Major topics include: entropy and mutual information, source coding theorem, Huffman code, rate-distortion function and vector quantization, channel capacity, channel coding theorem, linear block code, cyclic code, convolution code, Turbo code, LDPC code, trellis coded modulation, space-time code. May be repeated once for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated 1 times for 3 credits
Prerequisites: ECES 521 [Min Grade: C]
Corequisite: ECES 522

ECET 603 Optical Communications and Networks 3.0 Credits
This course introduces fiber-optic based transmission and networking technology. Major topics include: Loss and dispersion characters of fiber, shot noise, modulation, line code, direct receiver, coherent receiver, link budget, optical layer, SONET, WDM, photonic packet switch, Hybrid systems (CATV).
College/Department: College of Engineering
Repeat Status: Can be repeated 1 times for 3 credits
Prerequisites: ECET 501 [Min Grade: C] and ECET 511 [Min Grade: C]

ECET 604 Internet Laboratory 3.0 Credits
This course aims to prepare the next generation of Internet engineers for the challenges of understanding, maintaining, and participating in an ever-evolving Internet through hands-on experiments on real networking equipment. The long term objective of the internet Laboratory course is to graduate students who can maintain, update, improve, and even redesign the Internet.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CE or major is CS.

ECET 690 Special Topics in Telecommunications 3.0 Credits
Allows faculty to present material of current research or industrial interest relevant to graduate telecommunications. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 697 Research in Telecommunications 1.0-12.0 Credit
Research credits in telecommunications. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 699 Supervised Study in Telecommunications 3.0 Credits
Supervised Study in Telecommunications Engineering. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 890 Advanced Special Topics in Telecommunications 1.0-9.0 Credit
Covers advanced special topics of interest to students and faculty.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 898 Master's Thesis in Telecommunications 1.0-12.0 Credit
Master's thesis in telecommunications. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 997 Dissertation Research in Telecommunications 1.0-12.0 Credit
Graded Ph.D. dissertation in telecommunications engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

ECET 998 Ph.D. Dissertation in Telecommunications 1.0-12.0 Credit
Ph.D. Dissertation in Telecommunications. May be repeated for credit.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Engineering Geology

Courses

EGEO 620 Structural Geology 3.0 Credits
Covers basic principles of structural geology, including deformation and failure of the earth's crust; folded and faulted structures; orthogonal and stereographic solutions of structural geology problems; construction and interpretation of geologic maps, cross-sections, and block diagrams; and subsurface mapping and graphic presentation of subsurface data.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGEO 630 Engineering Geology 3.0 Credits
Covers origin and engineering properties of earth materials; engineering testing, alteration, and use of earth materials; and special geologic hazards and problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGEO 650 Rock Mechanics 3.0 Credits
Involves field and laboratory evaluation of rock properties, stress analysis and measurement, stability of rock masses, design of underground openings, and permeability and seepage in jointed rock.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGEO 630 [Min Grade: C]

EGEO 700 Introduction to Hydrology 3.0 Credits
Covers climate and weather, precipitation, evaporation and transpiration, drainage basins, and hydrographs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGEO 701 Hydrology-Ground Water 3.0 Credits
Covers geologic and hydrologic occurrence of groundwater, underground flow, groundwater supply, and pollution problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGEO 710 Introduction to Geophysics 3.0 Credits
Applies geophysical techniques to the problems of the earth's planetary structure, local subsurface conditions, and mineral prospecting. Examines the principles of geophysical measurement and interpretation, with emphasis on gravity measurement, isostasy, geomagnetism, earthquake seismology, seismic refraction and reflection, and electrical prospecting.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGEO 750 Hydrology-Stream Flow 3.0 Credits
Covers precipitation, runoff, evaporation and transpiration, stream flow, flood flow, and minimum flow. Pays special attention to factors affecting water supply and quality.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGEO 700 [Min Grade: C]

EGEO 790 Special Topics 0.5-9.0 Credits
Covers topics of interest in the field of engineering geology.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

EGEO 799 Independent Study 0.5-9.0 Credits
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

EGEO 898 Master's Thesis 0.5-20.0 Credits
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

EGEO 998 Ph.D. Dissertation 1.0-12.0 Credit
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Engineering Management

Courses

EGMT 501 Engineering Management I 3.0 Credits
Covers the principles and practices of administration of engineering and science activities, including nature of management, organization, planning, controlling action and measuring results, management of human resources, communication, and decision-making.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 502 Engineering Management II 3.0 Credits
Covers principles and procedures of creative problem-solving, including the use of brainstorming sessions and a step-by-step formulation of the practical techniques by which creative imagination can be more productively utilized. Pays special attention to the development of professional creativity habits through formulating basic plans, investigating directions, developing methods, and optimizing and completing solutions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C]

EGMT 504 Communications 3.0 Credits
Provides a thorough review of the essentials of usage and a study of methods of organization and style of both written and spoken communication. Pays special attention to the communication demands of engineers.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 515 Infrastructure Systems & Performance Evaluation 3.0 Credits
Characterization of transportation, building, urban water resources and power distribution infrastructure. Capacity, functional performance and serviceability metrics. Risk and vulnerability concepts. Physical deterioration mechanisms. Asset management principles. Data management supporting scoping and sequencing of facility maintenance,repair, upgrading, interconnection, expansion or replacement.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 516 Infrastructure Project & Program Planning 3.0 Credits
Coordination of infrastructure systems with multiple integrated projects through concept development, regulatory, environmental and economic screening, and then through design, construction, commissioning, operation and maintenance. Includes definition of program objectives and geographic limits; assessing asset conditions; sustainability and stakeholder analysis, team assembly and governance; defining performance and status reporting metrics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C]

EGMT 517 Public Value & Participation in Infrastructure Decision 3.0 Credits
Adjusting sponsoring agency plans and program for external statutory and informal inputs, including regulatory approvals, environmental assessment, interested and affected party stakeholder concerns, life cycle sustain ability, and resource allocation. Includes communication of and transparent ratification of tradeoffs in expectations of project performance and reliability.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 516 [Min Grade: C]

EGMT 520 Infrastructure Capstone Project 3.0 Credits
Group project to produce an engineering- intensive submission for approval by a regulatory agency, addressing compliance with regulatory, codes and professional standards and resource requirements. The student team, with diverse backgrounds, will prepare and present the report to the designated entity, following the procedures and protocols that it has published.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C] and EGMT 515 [Min Grade: C] and EGMT 516 [Min Grade: C]

EGMT 531 Economics for Engineering Management 3.0 Credits
Provides a review of economic analysis, with emphasis on those phases of major interest to engineering administration. Covers the calculation of economic equivalence, inflation and the purchasing power of money, decision-making among alternatives, evaluation of public activities, and estimation of costs.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 535 Financial Management I 3.0 Credits
Studies the features of accounting data essential to the interpretation and evaluation of engineering operations and financial position of the engineering enterprise. Analyzes financial statements and reports from the point of view of management.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 531 [Min Grade: C]

EGMT 536 Financial Management II 3.0 Credits
Covers advanced problems in planning, controlling, and directing engineering and other operating costs through budgeting and analysis of cost data. Studies judging of profitability, liquidity, and the organizational structure of the engineering functions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 535 [Min Grade: C] and EGMT 531 [Min Grade: C]

EGMT 537 Problems In Engineering Administration 3.0 Credits
Uses the case method to provide a thorough study of engineering management and administrative procedures in recognizing and solving engineering problems. Emphasizes strategic planning and policy decisions that affect the image and success of the whole organization in its domestic and global environments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C], EGMT 502 [Min Grade: C], EGMT 531 [Min Grade: C], EGMT 535 [Min Grade: C], EGMT 536 [Min Grade: C] (Can be taken Concurrently)

EGMT 571 Managerial Statistics I 3.0 Credits
Covers probability, including random variables and probability distributions, mathematical expectation, discrete probability distributions, continuous probability distributions, sampling and sampling distribution, and estimators and confidence intervals. Includes applications to engineering and industrial problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 572 Managerial Statistics II 3.0 Credits
Continues EGMT 571. Covers hypothesis testing, linear regression and
correlation, multiple regression, and some topics from analysis of variance
and non-parametric statistics. Introduces quality control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 571 [Min Grade: C]

EGMT 573 Operations Research I 3.0 Credits
Covers deterministic modeling, including linear programming; the
Simplex Method; theory of the Simplex Method; duality and sensitivity
analysis; transportation, transshipment, and assignment problems;
problem formulation; goal programming; network analysis; dynamic
programming; and integer and non-linear programming. Discusses case
study applications of engineering and management problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 572 [Min Grade: C]

EGMT 574 Operations Research II 3.0 Credits
Continues EGMT 573. Concentrates on probabilistic modeling, including
Markov chains, queuing theory and applications, inventory theory,
forecasting, and decision analysis and simulation. Discusses case study
applications of engineering and management problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 573 [Min Grade: C] and EGMT 572 [Min Grade: C]
and EGMT 571 [Min Grade: C]

EGMT 581 Problems in Human Relations 3.0 Credits
Covers morale and discipline in management situations. Includes case
studies stressing the prevention of and solution to employee problems
by means of appropriate policies, techniques, practices, and procedures.
Examines group dynamics from the point of view of both psychological
and sociological factors under varying situations, especially industrial.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 605 Research & Development Management I 3.0 Credits
Analyzes the issues and concepts involved in strategic and corporate
development planning in the modern technologically oriented company.
Pays particular attention to the fundamentals of corporate planning as
they relate to the research and development product planning of the
corporation. Includes some case studies. May be taken independently of
EGMT 606.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 606 Research & Development Management II 3.0 Credits
Analyzes the issues and concepts involved in the management of
research and development and its functional relationship to other
elements of the corporate structure. Pays particular attention to the
functional characteristics of the product line, company growth by
technological innovation, application of systems engineering concepts
to the corporate organization, and changing concepts in management
structures to accommodate advances in science and technology. May be
taken independently of EGMT 605.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 607 Marketing for Engineers 3.0 Credits
Focuses on the marketing of engineering services and engineered
products to industrial and governmental customers. Explores the
interdependence of engineering marketing, manufacturing, and finance
through strategic business planning. Covers industrial and government
procurement, sales techniques, costs, pricing, marketing research,
proposal preparation, and client relationships.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C] and EGMT 531 [Min Grade: C]

**EGMT 610 Engineering Ethics & Business Practices for Engineers
3.0 Credits**
Course will raise level of awareness and sensitivity of and teach how
to create a workplace valuing ethical behavior and business conduct.
Discusses engineering ethics, how to establish and administer an
effective corporate compliance program, case studies and application of
the case method, ethical implications of business practice issues in the
workplace.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 620 Project Management for Engineers 3.0 Credits
This course provides a comprehensive treatment of project management
by examining concepts, theories and applications. Emphasis is placed on
planning and control for technology based organizations. Upon successful
completion of course, students should be able to use the tools and
concepts in project management.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C] and EGMT 531 [Min Grade: C]

EGMT 625 Project Planning and Control 3.0 Credits
This course provides a basic understanding of project planning and
control by examining concepts and theories. Emphasis is placed on
planning and control of technology based organizations. Upon successful
completion of this course, students should be able to use the tools and
concepts of project control and apply them.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 572 [Min Grade: C] and EGMT 573 [Min Grade: C]

EGMT 630 Global Engineering Project Management 3.0 Credits
This course will focus on strategies and techniques needed for managing
a global project in an engineering environment. Develop concepts
of leadership for diverse global teams comm. strategies, cultural
considerations, organizational structure, collaborative tools & techniques,
risk mitigation and contracting strategies, legal and financial issues
when executing a global engineering project. Highlight techniques used
in design/construction, prod, devpt and technology transfer projects.
Essential in today's environmentt of global competition.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is EMGT.

EGMT 635 Visual System Mapping 3.0 Credits
Visual System Mapping (VSM) through whole-brain thinking is a powerful technique based on more than 40 years of research. VSM was inspired by a technique known as "Mindmapping", which is the technique developed by Tony Buzan in the late 1960's, designed to lead to enhanced creativity and better results in technology based organizations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C] and EGMT 502 [Min Grade: C]

EGMT 650 Systems Engineering Leadership 3.0 Credits
Course will explore concepts related to effective leadership within practice of systems engineering. Equips practicing engineers to move beyond engineering training focus on algorithms and analysis and develop a broad understanding of leadership effectiveness in a technically oriented work place. Course will include models related to sustainable, high performance and topics related to living, learning, effectiveness, power, influence, networking, and systems thinking. Emphasis on developing systems thinking.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is EMGT.

EGMT 652 Engineering Law 3.0 Credits
Examines the influence of contract, tort, and property law on engineering and construction activities. Includes legal principles relating to management of engineering organizations and governmental departments, and legal procedures of interest to engineers. Covers contracts, professional malpractice, expert testimony, intellectual property law, and business organizations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 660 Sustainable Business Practices for Engineers 3.0 Credits
The course will give students a broad and practical understanding of various environmental issues as well as sustainability concepts. The challenges associated with sustainable development are multifaceted involving economic, social and environmental concerns. These concerns are altering business strategies and practices and are leading to new opportunities.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: EGMT 501 [Min Grade: C]

EGMT 680 Special Topics in Engineering Management 3.0 Credits
Covers selected advanced-level topics in the field of engineering management. Specific topics for each term will be announced prior to registration.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

EGMT 685 Systems Engineering Management 3.0 Credits
Course teaches the art of systems engineering. Students will learn SE processes and skills to integrate user needs, manage requirements, conduct technological evaluation and build elaborate system architecture, to assess risk, establish financial and schedule constraints. Course provides pedagogically sound approach to the subject matter. Any graduate students involved with new product development, technology development and/or integration will find this course useful.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is EMGT.

EGMT 688 Systems Engineering Analysis 3.0 Credits
Introduces multiple System Engineering Analysis practices used to execute systems engrineering processes. Provides foundation to execute, monitor, and manage the traditional practices and also develops ability to modify and establish new practices based on this massive foundation. Instills confidence so student can contribute, lead, monitor or manage any systems effort.
College/Department: College of Engineering
Repeat Status: Can be repeated 0 times for NaN credits
Prerequisites: EGMT 685 [Min Grade: C]

EGMT 699 Independent Study 0.5-9.0 Credits
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

EGMT 799 Research 0.5-20.0 Credits
Involves the selection and solution of a problem in the field of engineering management. Expects students to conduct independent research and demonstrate the ability to employ one or more of the managerial tools to which they were exposed. Emphasizes the composition and organization of the paper, the logical development of a solution to the problem, and the contribution of the solution to knowledge.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

EGMT 898 Master's Thesis 0.5-20.0 Credits
Involves the study and investigation of a research or development problem in the area of the student's major elective. Requires the problem to be reported in a dissertation under the direction of a faculty adviser. No credit will be granted until thesis is completed and approved.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

Engineering, General

Courses

ENGR 701 Career Integrated Education 3.0 Credits
Industrial and practical training for engineers.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENGR 702 Career Integrated Education II 3.0 Credits
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Environmental Engineering

Courses

ENVE 529 Environmental Noise 3.0 Credits
Covers the fundamentals of acoustic propagation, instrumentation, noise descriptors, hearing damage and other health effects, occupational noise, noise abatement techniques, modeling the noise near highways and airports, and EPA strategy for reducing environmental noise exposure.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 534 Industrial Ventilation 3.0 Credits
Covers principles of air movement related to ventilation and air-conditioning facilities for the maintenance of suitable environmental conditions in work areas. Includes principles of industrial processes and air pollution abatement equipment, including air flow, ducts, fans, motors, and hoods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 535 Industrial Safety 3.0 Credits
Examines the impact of accidents, liability considerations, legislation and regulation of safety, osha codes and standards, hazards and their analysis and control, risk assessment, major types of accidents and their impacts, and accident investigation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 546 Solid Waste Systems 3.0 Credits
Analyzes the public health, economic, and political aspects in the operation and design of storage, collection, and disposal of solid waste materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 555 Geographic Information Systems 3.0 Credits
The course provides grounding in fundamental principles of GIS, and achieves understanding through hands on practical laboratories. Course topics include: spatial reference systems, geographic data theory and structures, structures, spatial analysis tools, functions and algorithms, GIS data sources, compilation and quality, and GIS project design and planning.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 560 Fundamentals of Air Pollution Control 3.0 Credits
Fundamental topics with regard to the formation and control of air pollutants are studied. This course provides strong foundation for engineers who will be involved in the development of engineering solutions for industrial air pollution prevention and design, development or selection of air pollution control devices and systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 602 Water Quality Control Lab 3.0 Credits
Introduces analytical procedures in the assessment of water quality as applied to the analysis of natural waters and wastewaters, and to the control of water and waste treatment processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C]

ENVE 603 Hazardous Waste Analysis Lab 3.0 Credits
Introduces methods of sampling and analysis of hazardous environmental pollutants. Emphasizes inorganic and organic pollutants found at hazardous waste disposal sites. Includes application of leachability and extraction tests.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C]

ENVE 604 Solid Waste Analysis 3.0 Credits
Uses chemical and physical techniques to analyze the composition of solid waste material. Emphasizes combustible, organic, and toxic fractions of solid wastes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C]

ENVE 607 Environmental Systems Analysis 3.0 Credits
Surveys system concepts, theories, and analytical techniques, and their application to urban and environmental problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 642 Control of Gas and Vapor Pollutants From Industrial and Mobile Sources 3.0 Credits
In this course, students will learn how different physical and chemical mechanisms can be used to prevent, separate, recover or destroy the gas/vapor air pollutants. The control mechanisms are studied in detail. Students then learn how to apply those mechanisms in the design of conventional, or new, devices and systems for control of gas/vapor air pollutants.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if classification is PhD or Senior.
Prerequisites: ENVE 460 [Min Grade: D]

ENVE 644 Design of Particulate Control Devices 3.0 Credits
Students will learn how different mechanisms can control characteristics, formation, transport, separation and destruction of airborne particulate pollutants. Students learn how to apply the studied material in the first part of this course to design conventional or new devices and systems for control of particulate air pollutants.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVE 460 [Min Grade: D]

ENVE 646 Advanced Solid Waste Systems 3.0 Credits
Introduces and analyzes the newest advances in solid waste technology,
with an emphasis on design, treatment, and processing techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C] and ENVR 546 [Min Grade: C]
and ENVR 636 [Min Grade: C]

ENVE 657 Incineration 3.0 Credits
Covers destruction of solid and liquid hazardous wastes at high
temperature in a combustion device, including requirements for
destruction of toxic materials and control of discharges to the atmosphere.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C]

**ENVE 660 Chemical Kinetics in Environmental Engineering 3.0
Credits**
Covers chemical and biological kinetics, mass-transfer considerations and
hydraulic regimes in water and wastewater treatment, and water quality
management. Includes absorption and stripping of gases and volatile
organics and applications to aeration and ozonation processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C] or ENVE 501 [Min Grade: C]
and ENVR 506 [Min Grade: C]

ENVE 661 Env Engr Op-Chem & Phys 3.0 Credits
Provides a theoretical study of the chemical and physical unit operations
of environmental engineering, including sedimentation, coagulation,
precipitation, adsorption, oxidation-reduction, ion exchange, disinfection,
membrane processes, and filtration.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVE 660 [Min Grade: C]

ENVE 662 Enviro Engr Unit Oper-Bio 3.0 Credits
Provides a systematic study of the microbiological and biochemical
processes for the treatment of aqueous and solid wastes, including
aerobic and anaerobic processes and composting.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 516 [Min Grade: C] and ENVE 660 [Min Grade: C]

ENVE 665 Hazardous Waste & Groundwater Treatment 3.0 Credits
Covers principles of hazardous waste and groundwater treatment
and in situ technologies. Presents application of processes, including
solvent extraction, steam and air stripping, adsorption, ion exchange,
oxidation, dechlorination, stabilization, wet air and supercritical oxidation,
incineration, soil washing, and soil vapor extraction.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 660 [Min Grade: C]

ENVE 681 Groundwater Hydrology 3.0 Credits
This course covers the effects of natural spatially-and emporally-varying
hydrologic and geologic processes on groundwater flow and solute
transport in aquifers. Covered are concepts and applications of geostatics,
spectral tech-niques, and Monte Carlo simulations to subsurface
hydrologic processes. Comparisons are made of recent theoretical
developments to field data from research sites in North America.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 682 Subsurface Contaminant Transport 3.0 Credits
This course covers principles governing contaminant movement in
aquifers. It includes advection, dispersion, reactive transport, microbial
and colloidal transport, matrix diffusion, density-coupled transport, and
multiphase flow. It also emphasizes field-scale applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVE 681 [Min Grade: C]

ENVE 683 Stochastic Subsurface Hydrology 3.0 Credits
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVE 682 [Min Grade: C]

ENVE 684 Water Resource Systems Analysis 3.0 Credits
This course covers mathematical optimization techniques as applied
to water resource systems. Example applications include water
supply management, irrigation planning and operation, water quality
management and ground water management.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 702 Adv Enviro Instrumentatn 3.0 Credits
Uses instrumental analysis to assess environmental quality.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 602 [Min Grade: C] and ENVR 604 [Min Grade: C]

ENVE 726 Environmental Assessment 3.0 Credits
Examines the National Environmental Policy Act of 1969 and its
implemen-tation according to the regulations of the Council on
Environmental Quality. Discusses air, water, noise, biological, cultural,
and socioeconomic impacts. Includes methods of impact analysis and
means to compare alternative actions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

ENVE 727 Risk Assessment 3.0 Credits
Covers quantitative relations between environmental exposures and
effects. Includes computer methods for risk analysis and development of
environmental guidelines and standards.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 501 [Min Grade: C] or ENVE 501 [Min Grade: C]
and ENVR 506 [Min Grade: C]

ENVE 750 Data-based Engineering Modeling 3.0 Credits
This course covers empirical methods to understand and model
engineering systems. Students will learn to develop evaluate statistical
models and use three common statistical software packages, Excel,
SPSS, and R.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Cannot enroll if classification is Freshman or Junior or Pre-
Junior or Sophomore
Prerequisites: ENGR 361 [Min Grade: D] or CHE 335 [Min Grade: D] or
MEM 361 [Min Grade: D] or MATH 311 [Min Grade: D]

ENVE 761 Enviro Engr Unit Oper Lab 3.0 Credits
Covers application of unit operations including filtration, adsorption,
oxidation, coagulation, and biodegradation to the treatment of potable
water, wastewater, and hazardous waste.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 661 [Min Grade: C] and ENVR 662 [Min Grade: C]

ENVE 766 Waste Wtr Treat Plant Des 3.0 Credits
Covers application of principles of environmental engineering unit
operations to the treatment of municipal, industrial, and hazardous wastes
by biological, physical, and chemical means. Includes applications of
computers to the design process.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: ENVR 662 [Min Grade: C] and ENVR 751 [Min Grade: C]

ENVE 767 Surface Water Mixing Processes 3.0 Credits
This course covers the hydrodynamic mixing and transport processes in
free-surface flows. Basic mixing processes including molecular diffusion,
turbulent diffusion and dispersion are also covered. Emphasis will be on
the solution of the advection-diffusion equation with various boundary
conditions . Additional topics include boundary exchanges, non-ideal
mixing in rivers, and analysis of jets and plumes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE or major is ENVE.
Prerequisites: CIVE 664 [Min Grade: C]

ENVE 768 Sediment & Contamin Trnsport 3.0 Credits
This course covers the transport of sediments and reactive solutes in
surface waters as well as the classic theory for bed-load and suspended
sediment transport. The interplay of stream flow, frictional resistance,
and sediment transport is also covered. The biogeochemical processes
that influence contaminant mobility and the integration of physical and
chemical processes in contaminant transport models are also discussed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Restrictions: Can enroll if major is CIVE or major is ENVE.
Prerequisites: CIVE 767 [Min Grade: C] or ENVE 767 [Min Grade: C]

ENVE 865 Spec Topics Envr Engineering 12.0 Credits
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

Materials Engineering

Courses

MATE 500 Structure and Properties of Metals 3.0 Credits
Covers crystallography, crystal defects, dislocation mechanisms, phase
transformations, recovery and recrystallization, diffusional processes, and
strengthening mechanisms.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 501 Structure and Properties of Polymers 3.0 Credits
Covers step and free radical polymers, copolymerization, molecular
weight characteristics, polymer morphology, thermodynamics,
viscoelasticity, yielding and crazing, and Boltzmann and T-T
superpositions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

**MATE 502 Structure and Properties of Ceramic and Electronic
Materials 3.0 Credits**
Covers bonding; crystal structure; defects; diffusion; electrical
conductivity; and mechanical, electrical, dielectric, magnetic, and thermal
properties.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 503 Introduction to Materials Engineering 3.0 Credits
This course provides an introductory overview of materials science and
engineering at the graduate level. The fundamental linkages between
processing, structure and properties will be addressed with emphasis on
micro- and nano-structural impacts on properties.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 505 Phase Equilibria 3.0 Credits
Covers thermodynamic concepts of phase equilibria, including unary,
binary, and ternary systems; pressure effects; and relationships between
phase diagrams and structure.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 506 Diffusion 3.0 Credits
Covers atomic migration in solids, self-diffusion, concentration gradients,
mathematical analysis of diffusion, and applications of numerical methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 507 Kinetics 3.0 Credits
Covers nucleation phenomena in homogeneous and heterogeneous
metallic and ceramic systems, strain energy analysis, composition
fluctuation analysis, growth and solution kinetics of second phases,
coarsening processes, martensitic transformations, and crystallization of
glass.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 510 Thermodynamics of Solids 3.0 Credits
Covers classical thermodynamics, introduction to statistical mechanics, solution theory, thermodynamics of interfaces and crystal defects, and phase diagrams and reaction equilibrium.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 512 Introduction to Solid State Materials 3.0 Credits
This course is a graduate level introduction to solid-state materials. The effects of crystal structure and bonding on properties will be discussed. Quantum theory of solids will be used to elucidate the electronic transport, magnetic, dielectric and optical properties of solid state materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 514 Structure, Symmetry, and Properties of Materials 3.0 Credits
Structure–property relationships form a cornerstone for performance-engineering in nearly all materials. Condensed matter systems, including inorganic or organic materials, are defined by their internal structure—the distribution of atoms, defects, and large scale domains with preferred microstructures. This class aims to familiarize materials science students with the real space and k-space structural description of both ideal (defect free) and realistic (imperfect) crystalline materials and the properties derived from the underlying point and transitional symmetry.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 503 [Min Grade: C]

MATE 515 Experimental Technique in Materials 3.0 Credits
Covers electron microscopy techniques, scanning transmission and Auger analysis, x-ray diffraction, x-ray wavelength dispersive and energy dispersive analysis, thermal analysis, statistics and error analysis, and design of experiments.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 525 Introduction to Composite Materials 3.0 Credits
Covers classification and definition of composite materials; properties of fibers, matrices, and their interfaces; structural geometry of reinforcing materials; formation and testing of composites; and properties and analysis of composite materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 530 Solidification Processing I 3.0 Credits
Covers principles of solidification processing, heat flow during solidification, thermodynamics and kinetics of nucleation and growth, solute redistribution, interfacial stability and morphology, transport phenomena: continuum treatments and structural effects, and rapid solidification.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 531 Solidification Processing II 3.0 Credits
The technology of solidification processing is covered in this course; clean metal processing; crystal growth; squeeze casting; thixo-and compo-casting; diffusion solidification and rheocasting; continuous casting processes, VM, VAR, ESR, and VADER processing; structural control via MDH; rapid solidification processes (RSP); microgravity casting.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 535 Numerical Engineering Methods 3.0 Credits
Covers numerical solution of non-linear equations, linear systems, and integration of ordinary differential equations. Introduces finite differences and finite elements. Provides a user's perspective of finite elements, element selection, convergence, and error estimation. Applications to heat transfer, diffusion, stress analysis, and coupled problems. Maple and ABAQUS (a commercial non-linear finite element program) are used in this course. A term project using ABAQUS is required. Emphasis is placed on materials engineering examples.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 536 Materials Seminar Series 1.0 Credit
MSE hosts visitors from materials and materials-related academic departments, national laboratories and industry to visit and interact with students and to present a seminar. Students will interact with visitors. Lectures on other selected topics: safety and health, ethics in science & engineering research, and writing and presentation skills.
College/Department: College of Engineering
Repeat Status: Can be repeated 12 times for 12 credits

MATE 540 Polymer Morphology 3.0 Credits
Covers crystallography, crystallization, single crystals, bulk crystallization, orientation, amorphous polymers, and experimental techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 541 Introduction to Transmission Electron Microscopy and Related Techniques 3.0 Credits
This course covers fundamentals of electron optics, electron-specimen interaction, and transmission electron microscopy (TEM). Elastic (high resolution and in situ TEM) and inelastic scattering techniques (energy dispersive spectroscopy, electron energy loss speciroscopy) are reviewed. An introduction to scanning electron microscopy (SEM), focused ion beam (FIB), and sample preparation is provided.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 542 Nuclear Fuel Cycle & Materials 3.0 Credits
This course encompasses the nuclear fuel cycle, including extraction, enrichment, transmutation in a nuclear reactor, reprocessing, waste processing, repository performance, materials for nuclear reactors, mechanical and thermal performance will be discussed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 543 Thermal Spray Technology 3.0 Credits
Thermal spray technology and coatings provides "solutions" to a large number of surface engineering problems - wear, corrosion, thermal degradation. This course will [i] be of interest and use to students majoring in materials, mechanical, chemical, electrical & environmental engineering; [ii] provide a thorough grounding and understanding of thermal spray processes, their principles and applications; [iii] integrate this knowledge with practical engineering applications and current industrial surfacing practice.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 544 Nanostructured Polymeric Materials 3.0 Credits
This course is designed to address the role of polymer science in Nanotechnology. Topics that will be covered include block copolymer templated self assembly, polymer thin and thick films, LBL, self assembly, soft lithography and polymer nanocomposites.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 501 [Min Grade: C]

MATE 545 Fracture of Polymeric Materials 3.0 Credits
Theoretical strength; defects; brittle fracture;fracture surfaces; fracture mechanics; creep failure; fatigue failure; environmental stress cracking; composite failure; crazing; impact and high-speed failure.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 560 Powder Metallurgy I 3.0 Credits
Covers commercial and near-commercial methods of powder making, material and process variables, atomization mechanisms, powder properties and characterization, powder compaction, and properties in the green state.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 561 Powder Metallurgy II 3.0 Credits
Covers powder consolidation: pressing and sintering; preform forging, rolling, extrusion, and hot isostatic pressing; innovative powder processing techniques, including spray forming; and structure-property relationships in press and sinter and fully dense materials.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 563 Ceramics 3.0 Credits
This course deals with the structure and bonding of ceramics. The fundamental role of point defects on electric and diffusional properties is discussed. Sintering, both solid and liquid phase, is explored. What affects strength, creep, subcritical crack growth and fatigue of ceramics is elucidated. Glasses and their properties are examined.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 565 Crystal Mechanics I 3.0 Credits
Covers crystal plasticity, texture development, continuum aspects of dislocations, interaction and intersection of dislocations, dislocation multiplication, dislocations in crystalline solids, and dislocation boundaries and configurations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 566 Crystal Mechanics II 3.0 Credits
Covers Peierls-Nabarro stress, thermally activated flow, work hardening, creep, superplasticity, ductile and brittle fracture, and fatigue.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 570 Materials Processing I 3.0 Credits
Covers metal deformation processes: slab and deformation work analyses; slip line theory; and upper bound analysis applied to upsetting, drawing, extrusion, rolling, and deep drawing.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MATE 571 Materials Processing II 3.0 Credits
Manufacture of objects from powder--atomization, compaction, sintering, and liquid phase consolidation techniques; deformation processing of powder preforms; manufacture of shapes by high-strength cold deformation-preferred orientation, substructure, strengthening mechanisms.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MATE 572 Materials for High Temperature and Energy 3.0 Credits
This graduate level introduction to high temperature materials and materials used for energy applications, deals with metals and ceramics that are used in systems that produce or store energy, such as power generation facilities, solid oxide fuel cells, batteries, photovollaics, thermoelectric generators and supercapacitors.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 573 Electronic, Magnetic and Optical Characterization of Energy Materials 3.0 Credits
This course will examine the selection criteria for component materials in each of these applications and cover how critical properties – electronic conductivity, mobility, ionic conductivity, magnetization, optical absorption, Seebeck coefficient – are measured.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 576 Recycling of Materials 3.0 Credits
This course will examine the selection criteria for recycling component materials. Recycling involves both reusing materials for energy applications and reprocessing materials into new products.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 580 Special Topics in Materials Engineering 0.5-9.0 Credits
Covers selected advanced-level topics. May be repeated for credit if topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MATE 582 Materials for Energy Storage 3.0 Credits
The course will address principles of operation of electrochemical energy storage devices and describe materials used in those devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 583 Environmental Effects on Materials 3.0 Credits
Environmental degradation is explored with focus on electrochemical corrosion reactions in metals and alloys due to atmospheric, aqueous, chemical or elevated temperature exposure. In addition, high temperature degradation of ceramics and degradation of polymers due to exposure to heat, light and chemicals will be addressed. The role of these environmental effects during service and the impact on performance and reliability will be explored.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 585 Nanostructured Carbon Materials 3.0 Credits
Covers advanced carbon materials ranging from diamond to fullerenes and nanotubes. Structure, properties and applications will be discussed.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 602 Soft Materials 3.0 Credits
This course is designed to introduce the field of Soft Materials to senior undergraduate and graduate students. Topics that will be covered include Polymers, Gels, Colloids, Amphiphiles and Liquid Crystals.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 605 Computer Simulation of Materials and Processes I 4.0 Credits
Simulation of equilibrium and transport properties of materials by Monte Carlo and molecular dynamics methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 610 Mechanical Behavior of Solids 3.0 Credits
Covers stress and strain, three-dimensional nomenclature, hydrostatic and deviatoric stresses, isotropic and anisotropic elasticity and plasticity, viscoelasticity, crack growth, and fracture.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 651 Advanced Polymer Processing 3.0 Credits
Covers continuum mechanics; heat transfer; application to extrusion, calendering, coating, injection molding, film blowing, rotational molding, and fiber spinning; powder processing; design; and equipment selection.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 661 Biomedical Materials I 3.0 Credits
This course covers biocompatibility; implantable devices; survey of materials properties; corrosion;; cardiovascular applications; orthopedic applications; kidney dialysis; artificial heart and lung devices.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 662 Biomedical Materials II 3.0 Credits
This course covers phase equilibria; strengthening of materials; dental cast alloys; denture base materials; adhesives and sealants; porcelain and glasses; dental materials laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MATE 699 Independent Study and Research 0.5-9.0 Credits
Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MATE 702 Natural Polymers 3.0 Credits
This course provides an introduction to natural and biomimetic polymers with an interdisciplinary view of biology, chemistry and macromolecular science. An understanding of natural building blocks and methods by which nature carries out polymer synthesis and modification reactions is coupled with insights into DNA; structural proteins; polysaccharides; and a wide variety of renewable resources.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MATE 501 [Min Grade: C]

MATE 897 Research 1.0-12.0 Credit
Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if major is MATE or major is MSE.

MATE 898 [WI] Master's Thesis 1.0-12.0 Credit
Hours and credits to be arranged. This is a writing intensive course.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if major is MATE or major is MSE.

MATE 998 Ph.D. Dissertation 1.0-12.0 Credit
Hours and credits to be arranged.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Restrictions: Can enroll if major is MATE or major is MSE.

Mechanical Engineering & Mechanics

Courses

MEM 503 Gas Turbines & Jet Propulsion 3.0 Credits
Covers fundamentals of thermodynamics and aerothermodynamics, and application to propulsion engines; thermodynamic cycles and performance analysis of gas turbines and air-breathing propulsion systems, turbojet, turboprop, ducted fan, ramjet, and ducted rocket; theory and design of ramjets, liquid and solid rockets, air-augmented rockets, and hybrid rockets; aerodynamics of flames, including the thermodynamics and kinetics of combustion reactions; supersonic combustion technology and zero-g propulsion problems; and propulsion systems comparison and evaluation for space missions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 504 HVAC Equipment 3.0 Credits
Covers performance of air handlers, pumps, direct expansion systems, chillers, cooling towers, and similar equipment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 505 HVAC Controls 3.0 Credits
Covers control theory and application to heating, ventilating, air conditioning, including pneumatic, fluidic, and electronic controls.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 517 Fundamentals of Nanomanufacturing 3.0 Credits
This course introduces conventional methods that emerged from microelectronics and nonconventional or alternative approaches as applied to fabricate nanometer-scale biological and solid-state devices; Preliminary concepts for nanofabrication; Conventional lithographic methods; Nonconventional methods such as nanoimprint lithography and chemical and biological approaches; Cell culturing for application in biology; The safe development and use of advanced nanotechnological manufacturing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: (MEM 417 [Min Grade: C] and ENGR 201 [Min Grade: C] and ENGR 202 [Min Grade: C]) or PHYS 201 [Min Grade: C]

MEM 530 Aircraft Flight Dynamics & Control I 3.0 Credits
Covers development of dynamic models, linearization, aerodynamic coefficients, control derivatives, longitudinal and lateral modes, and open-loop analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 545 Solar Energy Fundamentals 3.0 Credits
This course focuses on basic theories of solar radiation, solar thermal energy, and photovoltaics. Students will learn basic radiation heat transfer, solar radiation, solar thermal collection and storage, passive and active solar heating/cooling, physics of photovoltaic cells, and characteristics and types of solar cells.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 345 [Min Grade: D] or PHYS 201 [Min Grade: D]

MEM 569 Introduction to Composite Materials I 3.0 Credits
Introduces anisotropic elasticity, lamina stiffness and compliance, plane-stress and plane-strain, stress-strain relations of a lamina, testing methods, engineering elastic constants, failure criteria, and micromechanics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 570 Introduction to Composite Materials II 3.0 Credits
Covers laminated plate theory, stiffness and compliance of laminated plates, effect of laminate configuration on elastic performance, and review of research topics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 569 [Min Grade: C]

MEM 571 Introduction to Robot Technology 3.0 Credits
Covers robot configuration; components, actuators, and sensors; vision; and control, performance, and programming. Includes lectures and laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 572 Mechanics of Robot Manipulators 3.0 Credits
Covers homogeneous transformation, direct and inverse kinematic manipulators, velocities and acceleration, static forces, and manipulators' dynamics, via Lagrange and Newton-Euler formulations. Includes lectures and laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 666 [Min Grade: C]

MEM 573 Industrial Application of Robots 3.0 Credits
Covers path planning and workspace determination, robot accuracy and repeatability measurements, robot call design, application engineering and manufacturing, material transfer, processing operations, and assembly and inspection. Includes lectures and laboratory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 574 Introduction to CAM 3.0 Credits
Examines the basic elements used to integrate design and manufacturing processes, including robotics, computerized-numerical controlled machines, and CAD/CAM systems. Covers manufacturability considerations when integrating unit process elements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 591 Applied Engr Analy Methods I 3.0 Credits
Covers effective methods to analyze engineering problems. This module focuses on analytical and computational methods for problems tractable with vectors, tensors and linear algebra. Uses symbolic/numerical computational software. Examples drawn from thermal fluid sciences, mechanics and structures, systems and control, and emerging technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 592 Applied Engr Analy Methods II 3.0 Credits
Covers effective methods to analyze engineering problems. This module focuses on computational and analytical methods for complex variables and ordinary differential equations. Uses symbolic/numerical computational software. Examples drawn from thermal fluid sciences, mechanics and structures, systems and control, and emerging technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 591 [Min Grade: C]

MEM 593 Applied Engr Analy Methods III 3.0 Credits
Covers effective methods to computationally and analytically solve engineering problems. This module focuses on solution methods for partial differential equations, Fourier analysis, finite element analysis and probabilistic analysis. Uses symbolic/numerical computational software. Examples drawn from mechanical and civil engineering.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 592 [Min Grade: C]

MEM 601 Statistical Thermodynamics I 3.0 Credits
Covers probability theory; statistical interpretation of the laws of thermodynamics; systems of independent particles; systems of dependent particles; kinetic theory of dilute gases; quantum mechanics; energy storage and degrees of freedom; and thermochemical properties of monatomic, diatomic, and polyatomic gases.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 602 Statistical Thermodynamics II 3.0 Credits
Covers analysis of monatomic solids, theory of liquids, chemical equilibrium, kinetic and thermochemical description of rate processes, transport phenomena, and spectroscopy.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 601 [Min Grade: C]

MEM 603 Advanced Thermodynamics 3.0 Credits
Covers reformulation of empirical thermodynamics in terms of basic postulates; presentation of the geometrical, mathematical interpretation of thermodynamics; Legendre transforms; requirements for chemical and phase equilibrium; first-and second-order phase transitions; Onsager reciprocal relations; and irreversible thermodynamics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 611 Conduction Heat Transfer 3.0 Credits
Covers conduction of heat through solid, liquid, and gaseous media; advanced analytical methods of analysis, including integral transform and Green's functions, the use of sources and sinks, and numerical and experimental analogy methods; and variational techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 612 Convection Heat Transfer 3.0 Credits
Covers convective heat transfer without change of phase or constitution, fundamental equations, exact solutions, application of the principle of similarity and the boundary-layer concept to convective heat transfer, similarity between heat and momentum transfer, and heat transfer in high-velocity flows.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 613 Radiation Heat Transfer 3.0 Credits
Covers radiation heat transfer between surfaces and within materials that absorb and emit. Formulates and applies methods of analysis to problems involving radiation alone and radiation combined with conduction and convection.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 617 Introduction to Microfabrication 3.0 Credits
This course focuses on the fundamentals of microfabrication technologies. The materials, principles, and applications of silicon-based microfabrication technologies such as photolithography, wet/dry etching, deposition techniques, surface micromachining, and polymer micromachining will be covered. This course also includes two lab sessions through which students will have a hands-on experience in microfabrication.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 619 Microfluidics and Lab-on-a-Chip 3.0 Credits
The course explores applications of microfluidic phenomena and lab-on-a-chip technology. The topics include fluid behavior in microchannels, electrokinetic manipulation, micro-scale separation/surface sciences, transducer effects, and microactuators. Students will also have a hands-on experience through laboratory sessions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 417 [Min Grade: C] or MEM 617 [Min Grade: C]

MEM 621 Foundations of Fluid Mechanics 3.0 Credits
Covers kinematics and dynamics of fluid motion; Lagrangian and Eulerian description of motion; transport theorem; continuity and momentum equations (Navier-Stokes equations); vorticity vector and equation; three-dimensional, axisymmetric, and two-dimensional complex potential flows; constitutive equations of a viscous fluid; dynamic similarity; Stokes flow; and similarity analysis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 622 Boundry Layers-Laminar & Turbulent 3.0 Credits
Covers laminar boundary layers; approximate integral method; three-dimensional laminar boundary layer and boundary-layer control; transient boundary-layer flows; the integral momentum equation; origins of turbulence; transition to turbulent flow; Reynolds-averaged equations; Reynolds stress; measurement of turbulent quantities; study of turbulent wall bounded flows, including pipe flow, flow over a flat plate, and flow over a rotating disk; and boundary layer in a pressure gradient.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 621 [Min Grade: C]

MEM 630 Linear Multivariable Systems I 3.0 Credits
State space representation, continuous time and discrete time systems, similarity transformation, invariant subspaces, state response, stability, controllability, observability, Kalman decomposition, spectral and singular value decompositions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 631 Linear Multivariable Systems II 3.0 Credits
Pole assignment, output feedback, linear quadratic regulator, observer design, stochastic processes, state response to white noise, Kalman filter, linear quadratic Gaussian controller, evaluation of closed loop system.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 632 Linear Multivariable Systems III 3.0 Credits
Model reduction: approximation of transfer functions, modal truncations, oblique projections, component cost analysis, internal balancing; controller reduction: observer-based controller parametrization, Riccati balancing, q-COVER theory, optimal projections.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 633 Robust Control Systems I 3.0 Credits
Covers linear spaces and linear operators; Banach and Hilbert spaces; time-domain spaces; frequency-domain spaces; singular value decomposition; EISPACK, LINPACK, and MATLAB, including internal stability; coprime factorization over the ring of polynomial matrices; matrix fraction description; properties of polynomial matrices; irreducible mfds; Smith-McMillan form; poles and zeros; canonical realizations; and computation of minimal realizations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 634 Robust Control Systems II 3.0 Credits
Covers the structure of stabilizing controllers; coprime factorization over the ring of proper stable rational matrices; algebraic Riccati equation; state space computation of coprime factorization; yvb controller parametrization; linear fractional transformation; state space structure of proper stabilizing controllers; formulation of control problem, H, and H optimization problem; model matching problem; tracking problem; robust stabilization problem; inner-outer factorization; and Sarason's H interpolation theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 633 [Min Grade: C]

MEM 635 Robust Control Systems III 3.0 Credits
Covers Hankel-norm approximations, balanced realizations, two-block H optimization, generalized multivariable stability margins, structured and non-structured stability margins, structured singular values, robust stabilization and performance, and recent developments in robust control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 634 [Min Grade: C]

MEM 636 Theory of Nonlinear Control I 3.0 Credits
Provides a comprehensive introduction to the geometric theory of non-linear dynamical systems and feedback control. Includes stability, controllability, and observability of non-linear systems; exact linearization, decoupling, and stabilization by smooth feedback; and zero dynamics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 637 Theory of Nonlinear Control II 3.0 Credits
Covers systems with parameters, including bifurcation and stability; static bifurcation; local regulation of parameter-dependent non-linear dynamics; tracking; limit cycles in feedback systems; perturbation methods; frequency domain analysis; and applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 636 [Min Grade: C]

MEM 638 Theory of Nonlinear Control III 3.0 Credits
Covers high gain and discontinuous feedback systems, including sliding modes, applications, and advanced topics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 637 [Min Grade: C]

MEM 639 Real Time Microcomputer Control I 3.0 Credits
Covers discrete-time systems and the Z-transform, sampling and data reconstruction, the pulse transfer function, discrete state equations, time-domain analysis, digital simulation, stability, frequency-domain analysis, Labview programming, and data acquisition and processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 640 Real Time Microcomputer Control II 3.0 Credits
Covers design of discrete-time controllers, sampled data transformation of analog filter, digital filters, microcomputer implementation of digital filters, Labview programming techniques, using the daq library, writing a data acquisition program, and Labview implementation of pid controllers.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 639 [Min Grade: C]

MEM 646 Fundamentals of Plasmas I 3.0 Credits
Introduces the fundamentals of plasma science and modern industrial plasma applications in electronics, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include quasi-equilibrium and non-equilibrium thermodynamics, statistics, fluid dynamics and kinetics of plasma and other modern high temperature and high energy systems and processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 647 Fundamentals of Plasmas II 3.0 Credits
Continues the development of the engineering fundamentals of plasma discharges applied in modern industrial plasma applications in electronics, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include quasi-equilibrium and non-equilibrium thermodynamics, statistics, fluid dynamics of major thermal and non-thermal plasma discharges, operating at low, moderate and atmospheric pressures.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 646 [Min Grade: C]

MEM 648 Applications of Thermal Plasmas 3.0 Credits
Introduces applications of modern thermal plasma processes focused on synthesis of new materials, material treatment, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include: thermodynamics and fluid dynamics of high temperature plasma processes, engineering organization of specific modern thermal plasma technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 649 Application of Non-Thermal Plasmas 3.0 Credits
Application of modern non-thermal plasma processes focused on synthesis of new materials, material treatment, fuel conversion, environmental control, chemistry, biology, and medicine. Topics include: non-equilibrium thermodynamics and fluid dynamics of cold temperature plasma processes, engineering organization of specific modern non-thermal plasma technologies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 660 Theory of Elasticity I 3.0 Credits
Summarizes mechanics of materials courses. Covers vector and tensor analysis, indicial notation, theory of stress, equilibrium equations, displacements and small strains, compatibility, and strain energy; formulation of the governing equations and the appropriate boundary conditions in linear elasticity, and uniqueness of the solutions; elementary three-dimensional examples and two-dimensional theory; stress functions; solutions in Cartesian and polar coordinates; and Fourier series.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 661 Theory of Elasticity II 3.0 Credits
Covers two-dimensional problems by the method of Muskhelishvili, torsion problem, stress function and solutions by means of complex variables and conformal mapping, three-dimensional solutions for straight beams, energy theorems, virtual work and their applications, and Rayleigh-Ritz method.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 660 [Min Grade: C]

MEM 662 Theory of Elasticity III 3.0 Credits
Covers use of Fourier series and Green's functions for plane problems; three-dimensional problems in terms of displacement potentials; use of the Galerkin vector and the Boussinesq-Papkovitch-Neuber functions; fundamental solutions to the Kelvin, Boussinesq, Cerruti, and Mindlin problems; and elastic contact. Introduces non-linear elasticity.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 661 [Min Grade: C]

MEM 663 Continuum Mechanics 3.0 Credits
Covers kinematics, Eulerian, and Lagrangian formulations of deformation; theory of stress; balance principles; continuum thermodynamics; and constitutive relations in fluids and solids.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 664 Introduction to Plasticity 3.0 Credits
Reviews stress and strain deviators, invariants and distortional energy, principal and octahedral stresses and strains, Tresca and von Mises yield criteria, yield surface and Haigh-Westergaard stress space, Lode's stress parameter, subsequent yield surface, Prandtl-Reuss relations, work hardening and strain hardening, stress-strain relations from Tresca criteria, incremental and deformation theories, the slip-line field, slip-line equations for stress, velocity equations and geometry of slip-line field, limit analysis, simple truss, bending of beams, lower and upper bound theorems, and plasticity equations in finite-element methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 660 [Min Grade: C]

MEM 665 Time-Dependent Solid Mechanics 3.0 Credits
Part a: Covers elastodynamics, including plane, cylindrical, and spherical waves; characteristics; the acoustic tensor; polarizations and wave speeds; transmission and reflection at plane interfaces; critical angles and surface waves; and waveguides and dispersion relationships. Part b: Covers linear viscoelasticity, including relaxation modulus and creep compliance, hereditary integrals, Laplace transform, correspondence principle, creep buckling and vibrations, viscoplasticity, creep, strain-rate effects, shear bands, and shock waves.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 660 [Min Grade: C]

MEM 666 Advanced Dynamics I 3.0 Credits
Covers analytical statics (principle of virtual work), Lagrange's equations, conservation laws, stability analysis by perturbation about steady state, Jacobi first integral, ignoration of coordinates, classification of constraints, solution of constrained dynamical problems by constraint embedding (elimination) or constraint adjoining (Lagrange multipliers), generalized impulse and momentum, and formulation and solution of non-holonomic systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 667 Advanced Dynamics II 3.0 Credits
Covers vector dynamics in three dimensions, including a detailed study of rotational kinematics, motion of the mass center and about the mass center for a system of particles and a rigid body, moments of inertia, three-dimensional dynamical problems, and comparison between Lagrangian techniques and the vector methods of Euler and Newton. Includes vibrations, Euler's angles, motion of a gyroscope, and motion of an axially symmetric body under no force other than its weight.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 666 [Min Grade: C]

MEM 668 Advanced Dynamics III 3.0 Credits
Covers central forces, effect of the earth's rotation, Foucault's pendulum, variational methods, Hamilton's principle, state space techniques for the integration of equations of motion, and numerical integration of equations of motion on microcomputers through the CSMP program. Depending on student interest, includes either Hamiltonian dynamics (canonical equations, contact transformations, Hamilton-Jacobi theory) or rigid body kinematics of complex dynamical systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 667 [Min Grade: C]

MEM 670 Theory of Plates and Shells 3.0 Credits
Covers elements of the classical plate theory, including analysis of circular and rectangular plates, combined lateral and direct loads, higher-order plate theories, the effects of transverse shear deformations, and rotatory inertia; matrix formulation in the derivation of general equations for shells; and membrane and bending theories for shells of revolution.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 671 Mechanical Vibrations I 3.0 Credits
Free and forced responses of single degree of freedom linear systems; two degree of freedom systems; multiple degree of freedom systems; the eigenvalue problem; modal analysis; continuous systems; exact solutions; elements of analytical dynamics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 672 Mechanical Vibrations II 3.0 Credits
Continuous systems; approximate solutions; the finite element method; nonlinear systems; geometric theory, perturbation methods; random vibrations; computational techniques.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 673 Ultrasonics I 3.0 Credits
Basic elements of ultrasonic nondestructive evaluation, wave analysis, transducers, transform techniques, A,B,C,M,F and Doppler imaging, medical imaging, multiple element arrays, real-time imaging, calibration.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 674 Ultrasonics II 3.0 Credits
Basic elements of guided wave analysis, oblique incidence reflection factor, critical angle reflectivity, surface waves, lamb waves, plate waves, dispersion, phase and group velocity, experimental techniques for guided waves.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 675 Medical Robotics I 3.0 Credits
Use of robots in surgery, safety considerations, understanding robot kinematics, analysis of surgeon performance using a robotic devices, inverse kinematics, velocity analysis, acceleration analysis, various types of surgeries case study.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 676 Medical Robotics II 3.0 Credits
Force and movement for robot arms, robot dynamics, computer vision, vision based control, combining haptics, vision and robot dynamics in a cohesive framework for the development of a medical robotic system.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 675 [Min Grade: C]

MEM 677 Haptics for Medical Robotics 3.0 Credits
Introduction to haptics, physiology of touch, actuators, sensors, non-portable force feedback, portable voice feedback, tactile feedback interfaces, haptic sensing and control.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 681 Finite Element Methods I 3.0 Credits
Covers formulation of finite element methods for linear analysis of static and dynamic problems in solids, structures, fluid mechanics, heat transfer, and field problems; displacement-based, hybrid, and stress-based methods; variational and weighted residual approaches; effective computational procedures for solution of finite element equations in static and dynamics analyses; and pre-processing and post-processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 682 Finite Element Methods II 3.0 Credits
Covers formulation of advanced finite element methods for non-linear analysis of static and dynamic problems in solids, structures, fluid mechanics, heat transfer, and field problems; material non-linearity; large displacement; large rotation; large strain; effective solution procedures for non-linear finite element equations in static and dynamic analyses; and effective finite element methods for eigenvalue problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 681 [Min Grade: C]

MEM 684 Mechanics of Biological Tissues 3.0 Credits
Covers composition and structure of tendons, ligaments, skin, and bone; bone mechanics and its application in orthopedics; viscoelasticity of soft biological tissues; models of soft biological tissues; mechanics of skeletal muscle; and muscle models and their applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 685 Mechanics of Human Joints 3.0 Credits
Covers the structure of human joints, including experimental and analytical techniques in the study of human joint kinematics; applications to the design of artificial joints and to clinical diagnosis and treatments; stiffness characteristics of joints and their applications to joint injuries; and prosthetic design and graft replacements.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 686 Mechanics of Human Motion 3.0 Credits
Examines experimental and analytical techniques in human motion analysis and human locomotion; interdeterminacy of muscle force distribution in human motion; modeling and simulation of bipedal locomotion; energetics, stability, control, and coordination of human motion; and pathological gait.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 687 Manufacturing Processes I 3.0 Credits
Introduces basic manufacturing process technology and the mechanical properties of metals and plastics. Covers dimensional and geometry tolerancing; surface finishing; material removal processes and machine tools; processing of polymers and reinforced plastics, including general properties of plastic materials and forming, shaping, and processing of plastics; and CNC machining and programming. Combines lectures and laboratory work.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 688 Manufacturing Processes II 3.0 Credits
Covers processing of polymers and reinforced plastics, including general properties of plastic materials and forming, shaping, and processing of plastics; CNC machining and programming; casting processes; sheet-metal forming processes; bulk deformation processes; and computer integrated manufacturing systems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 687 [Min Grade: C]

MEM 689 Computer-Aided Manufacturing 3.0 Credits
Covers development of software and hardware for computer-aided manufacturing systems, basic elements used to integrate the manufacturing processes, and manufacturability studies.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 699 Independent Study and Research 0.5-9.0 Credits
Offers independent study and research in mechanical engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MEM 701 Physical Gas Dynamics I 3.0 Credits
Reviews equilibrium kinetic theory of dilute gases. Covers non-equilibrium flows of reacting mixtures of gases, flows of dissociating gases in thermodynamics equilibrium, flow with vibrational or chemical non-equilibrium, non-equilibrium kinetic theory, flow with translational non-equilibrium, and equilibrium/non-equilibrium radiation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 602 [Min Grade: C]

MEM 705 Combustion Theory I 3.0 Credits
Covers thermochemistry, including the relationship between heats of formation and bond energies, heat capacities and heats of reaction, chemical equilibrium and the equilibrium constant, calculation of adiabatic flame temperature and composition of burned gas, free energy and phase equilibrium, classical chemical kinetics, and chain reaction theory.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 706 Combustion Theory II 3.0 Credits
Covers laminar flame propagation in premixed gases, detonation and deflagration, heterogeneous chemical reactions, burning of liquid and solid fuels, and diffusion flames.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 705 [Min Grade: C]

MEM 707 Combustion Theory III 3.0 Credits
Covers advanced topics in combustion, including combustion-generated air pollution, incineration of hazardous wastes, supersonic combustion, propellants and explosives, and fires.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 706 [Min Grade: C]

MEM 711 Computational Fluid Mechanics and Heat Transfer I 3.0 Credits
Covers classification of fluid flow and heat transfer phenomena, including time-dependent multidimensional heat conduction and finite-difference and finite-element formulations; convection and diffusion; upwind, exponential, and hybrid schemes; and boundary-layer-type fluid flow and heat transfer problems.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 712 Computational Fluid Mechanics and Heat Transfer II 3.0 Credits
Covers basic computational methods for incompressible Navier-Stokes equations, including vorticity-based methods and primitive variable formulation; computational methods for compressible flows; inviscid and viscous compressible flows; finite-element methods applied to incompressible flows; and turbulent flow models and calculations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 711 [Min Grade: C]

MEM 714 Two-Phase Flow & Heat Transfer 3.0 Credits
Covers selected topics in two-phase flow, with emphasis on two-phase heat transfer problems, basic conservation equations for two-phase flows, nucleation, bubble dynamics, pool boiling, forced convective boiling, condensation heat transfer, two-phase flow equipment design, tube vibration and flow instability in two-phase flows, and fouling in heat transfer equipment.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 717 Heat Transfer in Manufacturing 3.0 Credits
Covers heat conduction fundamentals, including phase change problems (casting, welding, and rapid solidification processes) and cooling controls of rolling, forging, and extrusion processes.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 611 [Min Grade: C]

MEM 721 Non-Newtonian Fluid Mechanics and Heat Transfer 3.0 Credits
Covers the stress-strain rate relationship, simple flow, general constitutive and conservation equations, generalized Newtonian models, molecular theories, rheological property measurements, plane Couette flow, hydrodynamic theory of lubrication, helical flow, boundary layer flows, pipe flows, natural convection, thin film analysis, drag reduction phenomenon, and biorheology.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 622 [Min Grade: C]

MEM 722 Hydrodynamic Stability 3.0 Credits
Introduces stability, including discrete and continuous systems. Covers linear theory; instability of shear flows, spiral flows between concentric cylinders and spheres, thermoconductive systems, and viscous flows; global stability and non-linear theories; and time periodic and non-periodic flows, attractors, and bifurcation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 622 [Min Grade: C]

MEM 723 Vortex Interactions and Complex Turbulent Flow 3.0 Credits
Nonlinear vertex motion and interaction; motion of point vortices; generation and interaction of vortex rings and counter-rotating vortex pairs; vortex impulse, energy, pairing, bifurcation, and bursting; study of free and separating turbulent flows: mixing layers, wakes, jets, and buoyant plumes; recirculation behind bluff bodies and backsteps; longitudinal and lateral vortex waves and shear layers; sweeps and bursts in turbulent boundary layers; characteristics of turbulence: entrainment and molecular mixing, effects of buoyancy, rotation, acceleration, and heat release; the 3-D turbulent energy cascade and the 2-D inverse cascade.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 725 Compressible Fluid Dynamics 3.0 Credits
Reviews one-dimensional flows. Covers steady flow of a compressible fluid; two-and three-dimensional subsonic, transonic, supersonic, and hypersonic flow; normal and oblique shock waves; wave reflections; oblique shock wave interactions and generation vorticity; compressible boundary layers; and shock boundary-layer interactions.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 621 [Min Grade: C]

MEM 727 Fluid Dynamics in Manufacturing Processes 3.0 Credits
Covers transport of slurries, molten metals, and polymers; hydrodynamics in forming processes; resin flow model in polymer composites; shaped charge jet technology; separation and filtration; coating; lubrication; and melt-spinning process.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 730 Control of Flexible Space Structures I 3.0 Credits
Covers modeling of FSS including PDE description and finite element modeling, model errors, model reduction, component cost analysis, modal cost analysis, stability of mechanical systems, gyroscopic and non-gyroscopic systems, and rate and position feedback.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 731 Control of Flexible Space Structures II 3.0 Credits
Covers probability theory, stochastic processes, Kalman filter, LQG compensators, controller reduction, CCA theory, balancing reductions, and applications.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 730 [Min Grade: C]

MEM 733 Applied Optimal Control I 3.0 Credits
Covers necessary conditions from calculus of variations, equality and inequality constraints, fixed and free final time problems, linear-quadratic control, bang-bang control, and application to problems in flight mechanics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 734 Applied Optimal Control II 3.0 Credits
Covers neighboring extremals and the second variation, perturbation feedback control, sufficient conditions, numerical solution methods, and application to problems in flight mechanics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 733 [Min Grade: C]

MEM 735 Advanced Topics in Optimal Control 3.0 Credits
Covers singular arc control, model following control, variable structure control, singular perturbation methods, differential games, and applications.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit
Prerequisites: MEM 734 [Min Grade: C]

MEM 760 Mechanical Composite Materials I 3.0 Credits
Covers anisotropic elastic moduli, stress-strain relations of a lamina, failure criteria of a lamina, introduction to micromechanics, laminated plate theory, residual stresses, and strength of laminates.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 660 [Min Grade: C]

MEM 761 Mechanical Composite Materials II 3.0 Credits
Covers anisotropic plates and shells, boundary value problem in anisotropic heterogeneous elasticity, vibrations and buckling of laminated plates, and testing methods.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 760 [Min Grade: C]

MEM 762 Mechanical Composite Materials III 3.0 Credits
Covers classical failure criteria for orthotropic materials, fracture in
laminates, three-dimensional stress analysis, simulation of delamination
and transverse cracks, fatigue damage, and cumulative damage models.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit
Prerequisites: MEM 761 [Min Grade: C]

MEM 770 Theory of Elastic Stability 3.0 Credits
General stability criteria; beam column; the elastica; energy methods;
torsional stability; combined torsion and flexure; lateral buckling of beams
in pure bending; buckling of rings; curved bars and arches.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 777 Fracture Mechanics I 3.0 Credits
Covers fundamental mechanics of fracture, including linear elastic crack
mechanics, energetics, small-scale yielding, fully plastic crack mechanics,
creep crack mechanics, fracture criteria, mixed mode fracture, stable
quasi-static crack growth (fatigue crack growth and environmentally
induced crack growth), toughness and toughening, and computational
fracture mechanics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 782 Impact and Wave Propagation I 3.0 Credits
Governing equations for elastic waves; longitudinal waves in a bar;
transverse in a flexible string; flexural waves in a Bernoulli-Euler
beam; flexural waves in a Timoshenko beam; Rayleigh surface waves;
Pochhammer-Chree waves in circular cylinders; reflection of plane waves
at a plane boundary.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 783 Impact and Wave Propagation II 3.0 Credits
Spherical and cylindrical waves in unbounded medium; method of Laplace
transform; method of characteristics; flexural waves in a Timoshenko
plate; viscoelastic and viscoplastic waves; dispersion and phase velocity;
natural frequency in free vibration.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 784 Impact & Wave Propagation III 3.0 Credits
Governing equations for unsteady, nonisentropic fluid flows; shock waves;
method of characteristics for nonlinear system; numerical integration
along characteristics; impact and vibration of shell topics in wave
propagation.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 800 Special Topics Mechanical Engineering 0.5-9.0 Credits
Covers topics of current interest to faculty and students; specific topics
for each term will be announced prior to registration. May be repeated for
credit if topics vary.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MEM 891 Topics in Advanced Engineering I 2.0 Credits
Linear systems; control theory; vibrations and eigenvalue problems;
systems dynamics; Fourier transformation; flight dynamics.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 892 Topics in Advanced Engineering II 2.0 Credits
Separation of variables; thermodynamics; heat transfer; fluid mechanics;
boundary layer theory; elasticity; finite element methods. Solid mechanics;
aeroelasticity.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 893 Topics in Advanced Engineering III 2.0 Credits
Basic probability and statistics; communication theory; sampled data
system; digital and optical processing.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 894 Engineering Mathematics 3.0 Credits
Application of matrices, linear algebra, and complex analysis to
engineering problems. Ordinary and partial differential equations.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 897 Research 1.0-12.0 Credit
Supervised research in Mechanical Engineering.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

MEM 898 Master's Thesis 1.0-20.0 Credit
Master's thesis.
College/Department: College of Engineering
Repeat Status: Not repeatable for credit

MEM 998 Ph.D. Dissertation 1.0-12.0 Credit
Ph.D. dissertation.
College/Department: College of Engineering
Repeat Status: Can be repeated multiple times for credit

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